Net-zero targets for investment portfolios: an analysis of financed emissions metrics

April 2023

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Abstract

Financial institutions and investors aligning their investments with the objectives of the Paris Agreement, implementing the Task Force on Climate Disclosure recommendations, or seeking to reduce financial risks arising from the transition to a low-carbon economy, frequently measure, report, and set reduction targets for the emissions associated with their investments—called their 'financed emissions.' In this paper, we analyse the relationships between reductions in financed emissions and reductions in physical atmospheric emissions. We find that, unlike country-level GHG targets, reductions in a portfolio's financed emissions can have little direct relation to changes in physical emissions such that over a 95% reduction in financed emissions can be easily achieved using industry-standard methods even when physical emissions from the portfolio's companies are increasing at the same time. This creates a substantial risk of misaligning portfolios—and investment decisions—to climate mitigation efforts and net-zero commitments. We analyze the different financed emission definitions and targets currently in use, and suggest alternative means by which investors can credibly align their portfolios with the transition to a low-carbon economy.

Keywords: Climate change, net-zero, low-carbon transition, transition risks, finance
JEL: Q5, Q48, G23, G28

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1. Introduction

The climate change impetus to reduce greenhouse gas emissions is spurring substantial changes in the finance industry. These changes address the risks and opportunities for businesses created by the transition to a low-carbon economy, may proactively support climate change mitigation efforts, and help communicate such efforts to investors, government, and

[a,b] We wish to thank the Sydney Environment Institute for supporting this research.
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the public. The financial transition risks involved are substantial (Gambhir et al., 2021; Dietz et al., 2016; Campiglio et al., 2018; Battiston et al., 2017; Bolton and Kacperczyk, 2021; Cahen-Fourot et al., 2021) and a variety of approaches have been developed to quantify and communicate the changes made; these include the incorporation of Environmental, Social and Governance (ESG) factors into investing decisions, making net-zero commitments, and engaging with company Boards directly or through industry organisations. Of particular importance to such efforts is the increasingly widespread measurement and disclosure of 'financed emissions' — which are the greenhouse gas emissions arising from business activities and that are attributed to a financial institution, portfolio or product because of its lending to or investment in that business (WRI & WBCSD, 2011).

Supported by industry bodies globally, including the Task Force on Climate-Related Financial Disclosures (TCFD) (TCFD, 2021b), the UN Net Zero Coalition (UNEPFI, 2022a), and over 300 institutions (with US$81.5 trillion in assets under management (AUM)) through the Partnership for Carbon Accounting Financials (PCAF) (PCAF, 2020, 2022), the measurement and disclosure of financed emissions informs investment choices and is intended to enable the comparison of emissions across diverse companies, financial institutions, and investment products. Measuring financed emissions also provides a way for companies and financial institutions to set emission reduction targets, make net-zero commitments, or demonstrate their Paris alignment (United Nations, 2022; IIGCC, 2021b,a; UNEPFI, 2022c; Rydge, 2020) and can help direct the large investment flows these ambitions require (Polzin et al., 2021).

The measurement of financed emissions, and the defining of emission reduction targets, is done using a variety of metrics. For example, the Net-Zero Asset Owner Alliance (NZAOA) representing US$10.4 trillion AUM recommends interim absolute emissions reduction targets of 49-65% by 2030 (UNEPFI, 2022c). The UN's Net-Zero Banking Alliance similarly permits organizations to set targets based on their absolute emissions (UNEPFI, 2022b), and the European Commission defines criteria for Paris-aligned benchmarks based in part on an annual 7% decarbonization rate (European Commission, 2020). By contrast, signatories of the Net-Zero Asset Managers Initiative with $61.3 trillion AUM can use a variety of financed emission metrics to set targets (NZAMI., 2022). The choice of financed emissions metrics and targets across such initiatives undermines the reallocation of capital needed to achieve global net-zero commitments, however, by reducing the ability to critically evaluate and compare emission reduction statements made. Moreover, how reductions in financed emissions relate to changes in actual or physical emissions, and whether reductions in financed emissions can be used to measure progress towards net-zero targets, is not well understood, leaving the finance sector open to charges of greenwashing.

In this paper we study this use of financed emissions by investors. We do so by simulating investment portfolios that achieve a wide range of emission reductions and make three primary contributions. First, reductions in financed emissions – including reductions in a portfolio's absolute emissions – do not mean the actual emissions of companies invested in by a portfolio have declined. The Intergovernmental Panel on Climate Change (IPCC) argue that a 43% reduction in emissions by 2030 is needed to achieve the Paris Agreement goal of limiting warming to 1.5°C (WGIII, 2022). Targets such as the Net Zero Asset Owner

Alliance target of 49-65% reductions in financed emissions by 2030 (UNEPFI, 2022c) are therefore appealing in their similarity. Our results demonstrate, however, that a statement claiming achievement of net-zero financed emissions targets does not mean a portfolio is aligned with (or investing in companies aligned with) a genuine commitment to the emissions reductions needed to achieve the 43% reduction in emissions by 2030 the IPCC argue is needed.

Second, reductions in financed emissions are highly dependent on 1) the metrics chosen and how these are defined, 2) the Scope of emissions included and 3) how progress towards a target is measured. By systematically comparing reductions measured using different definitions of financed emissions, we show that the development of consistent standards is critical; investors measuring reductions in their emissions using one definition of financed emissions can measure increases for the same portfolio when using an alternative definition. Setting and comparing emission reduction targets is further complicated by efforts to include the indirect emissions released through the downstream use of a company's products or the upstream production of its inputs—called Scope 3 emissions—in the investee companies financed emissions (Klaaßen and Stoll, 2021; Shrimali, 2021); we directly compare emission reductions with and without these Scope 3 emissions to show how they affect emission reduction targets and investment changes. We also demonstrate that emission reductions depend significantly on whether they are measured against a past emissions baseline or against a current benchmark portfolio, both of which are commonly used to define emission targets (e.g. UNEPFI (2022a)).

Lastly, an alternative approach to improving a portfolio's climate alignment is to increase the share of companies that set or achieve Paris-aligned targets as defined by the Science-Based Targets initiative (SBTi) (SBT, 2020) or by Transition Pathway Initiative (TPI) ratings (Dietz et al., 2021). We compare portfolios' financed emissions to their share of assets under management with SBTi targets and TPI ratings to show that all three approaches measure substantially different aspects of a portfolio's potential climate alignment.

The remaining parts of this paper are organized as follows. Section 2 discusses how financed emissions are measured. Section 3 presents our methodology and information on financed emissions data. Section 4 systematically presents and discusses the results of how different carbon metric definitions, emission scopes, and measuring targets against baselines versus benchmarks affect reductions in financed emissions. Section 5 concludes.

2. Measuring financed emissions

An investor's 'financed emissions' are the absolute or physical emissions of the portfolio of companies they hold investments in. These companies' emissions are deemed attributable to the investor as they own, through their company shares, the activities that cause those emissions. As already discussed, financed emissions can be measured and attributed to investors in a variety of ways which, as we show below, can substantially affect the stringency of emission reduction targets and comparisons of financed emissions across companies and portfolios. A note on terminology is in order. With methods under active development much of the terminology around financed emissions is not yet standardized. It is not uncommon for practitioners to refer to the same concept using several different terms, and to use the same term to refer to multiple concepts, so it is important to consult the underlying definitions each practitioner uses. For example, 'carbon footprint' and 'carbon emissions' are both used by industry practitioners to mean 'carbon emissions per million dollars invested' (Trucost ESG Analysis, 2020; MSCI, 2016). Also note that 'carbon footprint' or 'carbon footprint metrics' as used by the finance industry do not have a well-defined meaning and do not refer to the lifecycle emissions of a product or service or imply that Scope 3 emissions are included (CRO Forum, 2020; Frankel et al., 2015; Raynaud, 2015; Dupre et al., 2015). To avoid confusion we refer to the metrics below using what we think are the clearest definitions. Measuring the emissions from a portfolio of companies requires three key and independent decisions, and we consider each in turn: 1) choosing a carbon metric for measuring emissions, 2) choosing an emissions scope and 3) choosing whether to use a baseline or a benchmark to track the progress of emission reductions and compare differences in emissions.

	Absolute Emissions (AE)	Normalized Emissions (NE)	Carbon Intensity (CI)
Description	The sum of each company's (annual) emissions attributed to a portfolio based on equity ownership (e.g., an investor owning 1% of a company is attributed 1% of that company's emissions.)	The portfolio-weighted average of each company's emissions divided by its market capitalization. This is equivalent to dividing absolute emissions by the current portfolio value.	The portfolio-weighted average of each company's emissions divided by its sales.
Pros	- Is unaffected by financial changes in stock prices or company sales. - Reflects the size of an investment portfolio.	Allows emissions attributed to an investor to be compared across portfolios of different sizes.	- Allows portfolios of different sizes to be compared. - Reflects the carbon emissions associated with a company's output.
Cons	Is dependent on a portfolio's total value.	Changes in the market capitalization of a company are conflated with changes in physical emissions.	Changes in a company's sales are conflated with changes in physical emissions.
Equation	$= \sum_i \left(V_t \cdot w_{it} \cdot \frac{Z_{it}}{M_{it}} \right)$	$= \sum_i \left(w_{it} \cdot \frac{Z_{it}}{M_{it}} \right)$	$= \sum_i \left(w_{it} \cdot \frac{Z_{it}}{S_{it}} \right)$

Table 1: Common methods used to measure portfolio-level financed emissions

V_t is the total portfolio value in year t, w_{it} are portfolio weights for company i, M_{it} is market capitalization, S_{it} are annual sales, and Z_{it} are annual emissions.

2.1. Choosing a carbon metric

A carbon or emissions metric is a method of measuring emissions across a portfolio of companies and attributing them to an investor. Metrics must account for the fact that investors typically hold, and regularly change shares in, hundreds to thousands of the approximately 50,000 companies listed on global exchanges (World Federation of Exchanges, 2020). These companies are heterogeneous in kind, differing in size, in what they produce, as well as in where they are located. Reflecting this complexity several metrics were developed, and we analyse the three that are commonly used—see Table 1 for their definitions and a summary of each metric.

The first metric is a portfolio's 'Absolute Emissions' (AE) measured in tonnes of CO_2e. A portfolio's AE are measured by attributing emissions from companies to investors based on shares owned and aggregating these emissions across all investments in a portfolio; an investor owning 1% of a company is attributed 1% of that company's annual emissions. As a physical quantity, AE have the advantage of reflecting the actual scale of emissions associated with a portfolio; larger, more valuable portfolios will tend to have larger AE. This is also a disadvantage; a bank or exchange traded fund (ETF) may have larger AE than a competitor or alternative fund simply because they are larger in value, even if each of their constituent investments individually have lower emissions. Because of this limitation it is common for financed emissions to also be measured using intensity metrics, that normalize for the size of company operations or an investment fund's value. The second metric is a portfolio's Normalized Emissions (NE), defined as the portfolio-weighted average of each company's emissions divided by that company's current value[1]. Value is typically measured by market capitalization, although enterprise value is also used (Blood and Levina, 2020; UNEPFI, 2022c). When market capitalization is used to measure value, a portfolio's NE are equivalent to the portfolio's total absolute emissions divided by its current total portfolio value. NE allows direct comparisons of the emissions associated with a dollar of investment made in differently sized companies and portfolios. The third metric is recommended by the TFCD (TCFD, 2021a) and is called Weighted Average Carbon Intensity or Carbon Intensity (CI), which normalizes each companies' emissions by their sales instead of value. CI is defined as the portfolio-weighted average carbon intensity across a portfolio's constituent companies and is the weighted average emissions per dollar of sales. As with NE, CI also allows for comparisons to be made between portfolios of different sizes.

2.2. Choosing an emissions scope

The second choice made in determining how financed emissions are measured and defined is the Scope of company emissions included in a portfolio. The Greenhouse Gas Protocol (WBCSD and WRI, 2012; WRI & WBCSD, 2011) defines three mutually exclusive Scopes of emissions for a company. Scope 1 emissions are those emitted directly by activities under their direct control, Scope 2 are those emitted indirectly through a company's consumption of electricity, steam, heat or cooling, and Scope 3 are all other emissions emitted indirectly through the downstream use of a company's products or the upstream production of its inputs. As data on Scope 3 emissions is comparably limited, investors typically measure their financed emissions by aggregating a company's Scope 1 and 2 emissions only. The industry is moving towards incorporating Scope 3 emissions as data improves, and we show results with and without including Scope 3 emissions.

2.3. Choosing a baseline versus benchmark

Measuring financed emissions requires the choice of a carbon metric and emissions Scope only. However, to measure changes in financed emissions, e.g., to measure progress in

[1] This carbon metric is frequently called just 'carbon emissions.' To avoid confusion, we call this Normalized Emissions.

reducing emissions or in achieving emission reduction targets, requires a reference point from which the change is measured. Two methods are commonly used in practice (e.g. UNEPFI (2021) and European Commission (2020)) and are illustrated in Table 2. The first compares a portfolio's current financed emissions to a baseline of the same portfolio's emissions at an earlier point in time e.g., a portfolio's 2020 CI is 30% below its 2015 CI. 'Same portfolio' here refers to the portfolio by ownership, as constituent companies within a portfolio typically change. The second method compares a portfolio's current financed emissions to an alternative benchmark portfolio e.g., a portfolio's 2020 CI is 30% below a benchmark of the All Country World Index's 2020 CI.

	Target measured against a **Baseline**	Target measured against a **Benchmark**
Description	A portfolio's emission reductions are measured relative to a previous emissions baseline, such as the portfolio's AE in 2015.	A portfolio's emission reductions are measured relative to a current benchmark portfolio, such as the 2020 AE of the All Country World Index.
Pros	A portfolio's target does not depend on ongoing reductions in benchmark carbon metrics; a portfolio's emission reductions cannot regress due to de-carbonization in the rest of the economy.	- Targets are not sensitive to the initial portfolio held. - Portfolio's are not penalized for early decarbonization efforts.
Cons	Reported reductions and target stringency may be sensitive to the initial portfolio held.	A portfolio's reported reductions will depend on changes in the benchmark's carbon metrics.

Table 2: Two methods for measuring emissions reductions

3. Methodology

To analyze the use of financed emissions we create – and compare – a wide range of portfolios that use 1) the three different carbon metrics, 2) either Scopes 1 and 2 only, or Scopes 1, 2 and 3, and 3) either the baseline or benchmark reference points described above. We use industry-standard emissions and financial data and create portfolios that continue to track overall market returns. This allows us to demonstrate how financed emission metrics work on average, without the results being sensitive to the performance of any one company or investment portfolio.

3.1. Data

We combine data on annual firm-level emissions as compiled by MSCI from public and private sources (MSCI, 2022), with company sales, market capitalization and prices obtained from Refinitiv Eikon (Refinitiv, 2022). MSCI's emissions database is one of the largest and most widely used sources of company emissions. As of 2022 reports, 10,739 unique companies either disclosed or have estimated emissions data for at least one year.[2] Figure 1 shows how emissions are concentrated in the GICS Utilities, Materials, and Energy sectors and this remains true after normalizing for company value or sales.[3] Scope 1 emissions are substantially larger than Scope 2 emissions, and Scope 3 emissions (see Appendix) are larger than both Scope 1 and 2 combined. These emissions are also concentrated in a few highly emitting companies: the 10% of companies with the highest Scope 1 carbon metrics contribute 95.8% of total AE, 97.0% of the total NE, and 88.4% of the total CI across all companies. This concentration of emissions means that a portfolio can realize substantial reductions in financed emissions by excluding a relatively small number of highly emitting companies. Conversely, a substantial share of portfolio assets could be individually Paris aligned, even if overall portfolio emissions and carbon metrics are rising over time, as long as the individually Paris-aligned companies tend to be low-emitting.

3.2. Creating low-carbon portfolios

To study financed emissions we simulate 15,400 diversified portfolios that achieve a range of 5-year financed emission reductions while continuing to closely track market returns. These portfolios allow us to systematically analyze the effects of different carbon metrics, emission scopes, and the use of baselines versus benchmarks for portfolios that achieve the full range of possible emission reductions up to a nearly 100% decarbonization. We start by creating 200 market-capitalization weighted benchmark portfolios that are representative of an internationally diversified investor. These benchmark portfolios are created by drawing 500 equities at random from the 1,562 mid and large cap companies that are listed in MSCI's All Country World Index at any point between 2015 and 2020, andf that have complete Scope 1 and 2 emissions and financial data for this period—see the Appendix for details. For each benchmark portfolio we then create a range of 'low-carbon' portfolios that achieve lower financed emissions than their benchmark. We create these low-carbon portfolios using a non-linear optimization routine that closely matches how low-carbon funds available in the market are created. This optimization routine selects portfolio weights for low-carbon portfolios by minimizing the standard deviation of past portfolio returns (the tracking error) relative to their benchmark portfolios, subject to several constraints. These constraints include achieving lower emissions and constraints on sector and individual constituent weights. The most important constraint is that the low carbon portfolio must

[2]Including companies with estimated emissions is important for both investors disclosing their portfolio's emissions, and our analysis, due to the self-selection of companies into voluntarily disclosing emissions (Nguyen et al., 2021).

[3]Note that 'Energy' as defined in the GICS sector definitions is fossil fuels and does not include renewable and other non-fossil fuel energy sources (S&P Global, 2022).

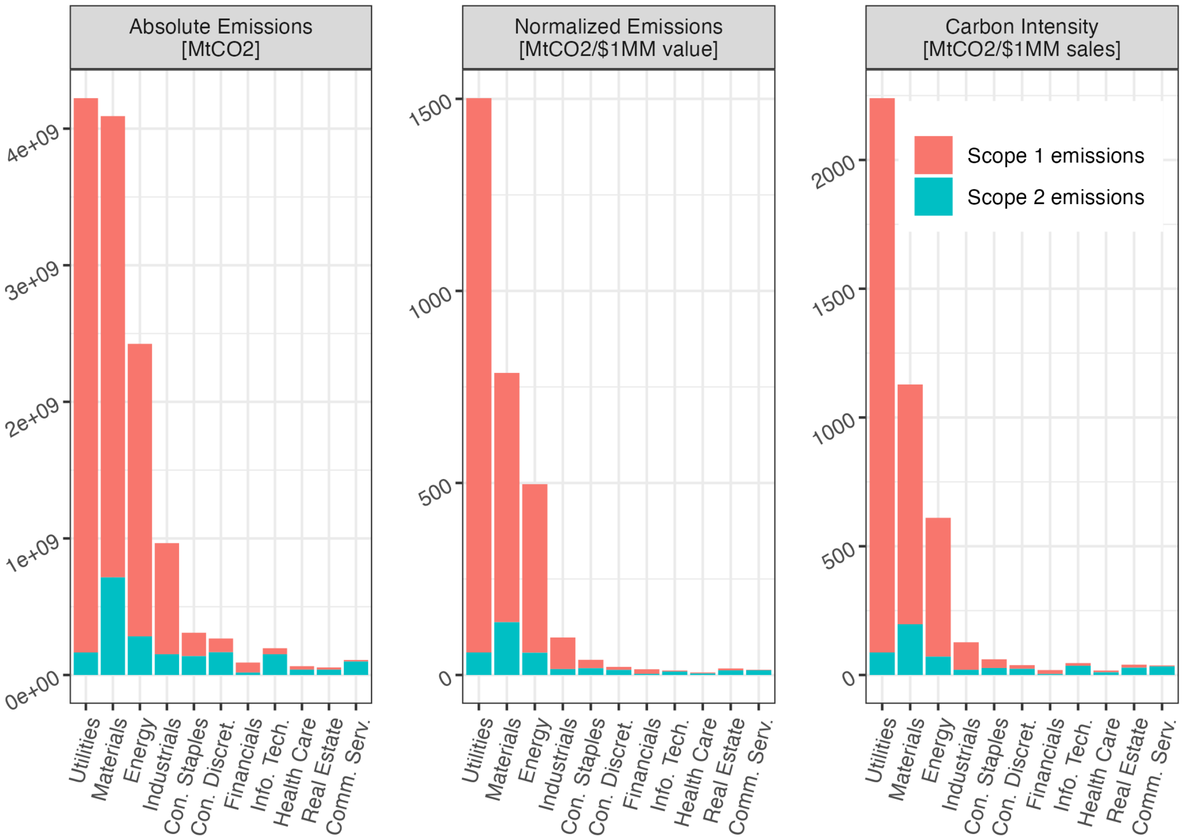

Figure 1: Average carbon metrics by sector
Average 2020 carbon metrics by GICS sectors. AE are measured in metric tonnes of CO_2e. NE and CI are measured in metric tonnes of emissions per million USD of market capitalization or sales, respectively. Con. Staples are Consumer Staples, Info. Tech. are Information Technology, Con. Discret. are Consumer Discretionary, and Comm. Serv. are Communication Services.

achieve a specified reduction (in the carbon metric being analyzed) ranging in 5% increments from 5% to 95%. We perform this optimization for the end of year 2015 with the calendarized tracking error calculated from weekly returns over 2013-2015. The portfolio returns over 2015-2020 (see Figure 2) show that low carbon portfolios continue to closely track the returns of their benchmark portfolios; as a result, low-carbon portfolios achieve similar returns to the benchmark despite their substantially lower financed emissions. This supports the analysis of Anderson et al. (2016) who find investors can achieve substantially lower financed emissions with little impact on returns and financial risk compared to industry benchmarks.

We calculate each low-carbon portfolio's 2020 financed emissions and compare these to their own baseline emissions in 2015, as well as to their benchmark portfolio's 2020 emissions. We repeat this portfolio simulation and analysis procedure separately for each metric of AE, NE, and CI, and for each metric using Scope 1 plus Scope 2 emissions, and using Scope 1 plus 2 plus 3 emissions. While we use a quantitative approach that creates portfolios which track average market returns, our results apply to investors who use other approaches—including qualitative approaches—to create portfolios with lower financed emissions, or who simply measure their own emissions without actively reducing them; this is because an investor can always trade off additional risk—higher variance to average market returns—in exchange for lower financed emissions. In addition, as we consider the full range of potential emission targets, metrics, and scopes, our results apply broadly to the use of financed emissions and are not specific to the particular way portfolios are constructed.

4. Results

A portfolio's financed emissions depend on the carbon metric chosen, whether Scope 3 emissions are included, and — for emission reduction targets — whether reductions are measured against an emissions baseline or current benchmark. In this section we show the consequences of each of these choices for a full range of emission targets ranging from 0% to a 95% reduction in financed emissions.

Emission reductions depend only on the portfolio's final (here, 2020) financed emissions through the companies held at that time, and the level of emissions that reductions are measured from—such as a baseline of their 2015 financed emissions, or an alternative benchmark portfolio's 2020 emissions. The reductions achieved do not depend on when, how, or through what path changes in investments and companies occurred along the way to the final holdings. For example, an investor who in 2015 made a 2020 emission reduction target can reduce their emissions gradually through many small investment changes in the years leading up to 2020. Or they can take no action for several years before substantially changing their investments in 2020. Or they can achieve their target immediately in 2015 through immediate and aggressive investment changes. In Figure 3 we show an example of one such emission reduction trajectory. Figure 3 shows the trend in emissions corresponding to investors who gradually achieve a 2020 target of a 75% reduction in their financed emissions measured relative to their initial 2015 emissions. We separately consider 75%

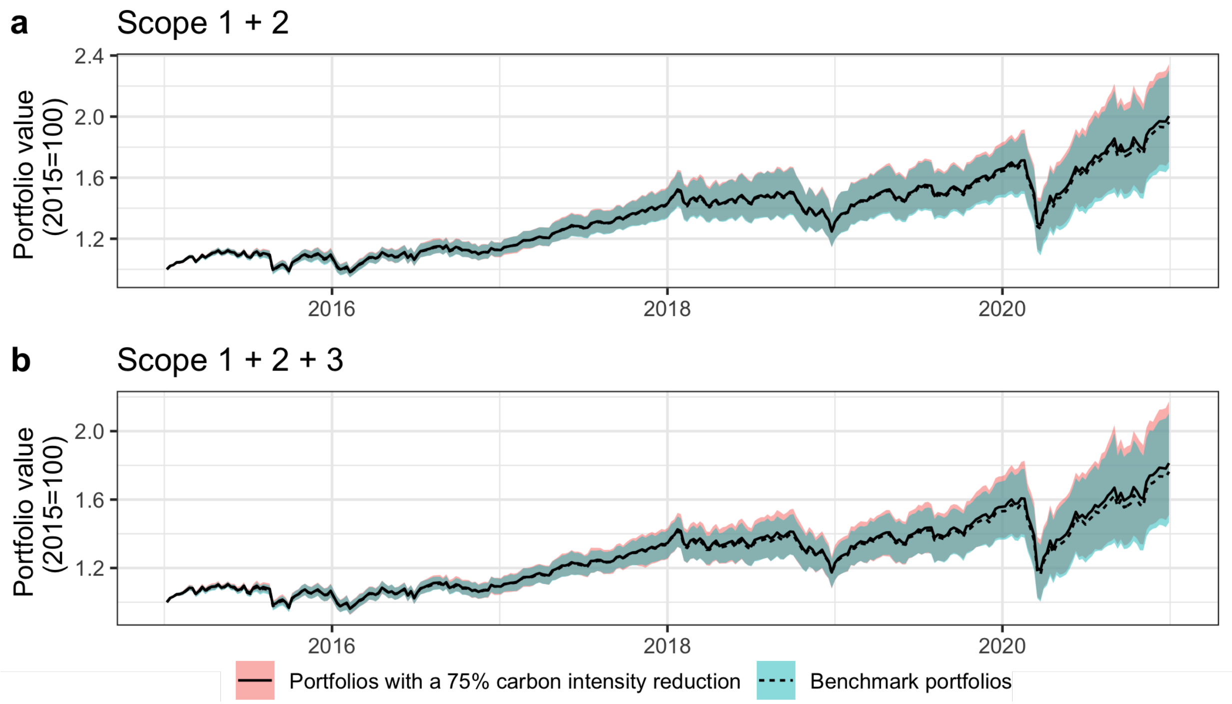

Figure 2: Low carbon and benchmark portfolio returns
Average portfolio returns for low-carbon portfolios achieving 75% reductions in their CI (solid line) compared to average returns for their benchmark portfolios (dashed line.) 5th-95th percentile of portfolio returns are shown by the shaded regions. Portfolio values indexed to 1 in 2015. Both the

reductions defined using each of the three carbon metrics and two sets of emission scopes. These portfolios achieve their 75% targets through annual 15% reductions and we plot the average reduction by year across all low carbon portfolios. Also shown in Figure 3 are the average emissions among the benchmark portfolios, and the emissions of several major stock market indexes. Benchmark portfolios are the initial 2015 portfolios, had the investor not set an emission reduction target. Our benchmark portfolios closely follow the emission trends among these major market indexes across the different carbon metrics and emission scopes, indicating results are broadly representative for a wide variety of investors.

Figure 3 shows that while the low-carbon portfolios have, by construction, achieved a 75% reduction relative to their 2015 baseline across all carbon metrics and scopes, their benchmark emissions (and the emissions of the market indexes) evolve differently over time depending on the carbon metric and emissions scope used. For example, the NE of the benchmark portfolios decline substantially more over time than the AE of the same portfolio. That the benchmark emissions evolve differently over time depending on the carbon metric and emissions scope has important implications for measuring reductions in financed emissions, which we expand upon below where we consider a full range of emission reductions from 0% to 95%.

4.1. Results — Changes in physical emissions

An investor can achieve financed emission reductions from two sources: changes in financed emissions within the companies held, or changes in the companies held. These each have very different implications for actual changes in physical emissions and climate mitigation. First, as the formulas in Table 1 show, financed emissions within companies can fall (rise) when a) the actual physical emissions of the portfolio companies fall (rise) or b) when the market capitalization (for NE) or sales (for CI) of companies increase (decrease) at a higher (lower) rate than their physical emissions do. Second, the portfolio's financed emissions can change as a) portfolio weights change through routine updating of a portfolio's holdings, b) stock prices change (for NE and CI), and c) investors actively alter portfolios to achieve emission reduction targets. As has been previously noted (e.g., European Commission (2020)), changes in the companies invested in is, by definition, a change in the attribution of emissions and is not a change in actual physical emissions; every stock sold or bought is purchased or sold by a counterparty.

Importantly, this means that reductions in financed emissions—including reductions in a portfolio's AE—do not mean that physical emissions from the portfolio of companies held are necessarily decreasing. Figures 4 and 5 panel a) show the 2015-2020 change in physical emissions within those companies of the 2020 low carbon portfolios. As portfolios achieve larger financed emission reduction targets, the physical emissions released by their constituent companies show increasingly smaller emission declines over time. In particular, for every 1 percentage point (pp) increase in the Scope 1 + 2 financed emissions target, the 2015-2020 decline in physical emissions shrinks by 0.20pp for an AE target, 0.37pp for a NE

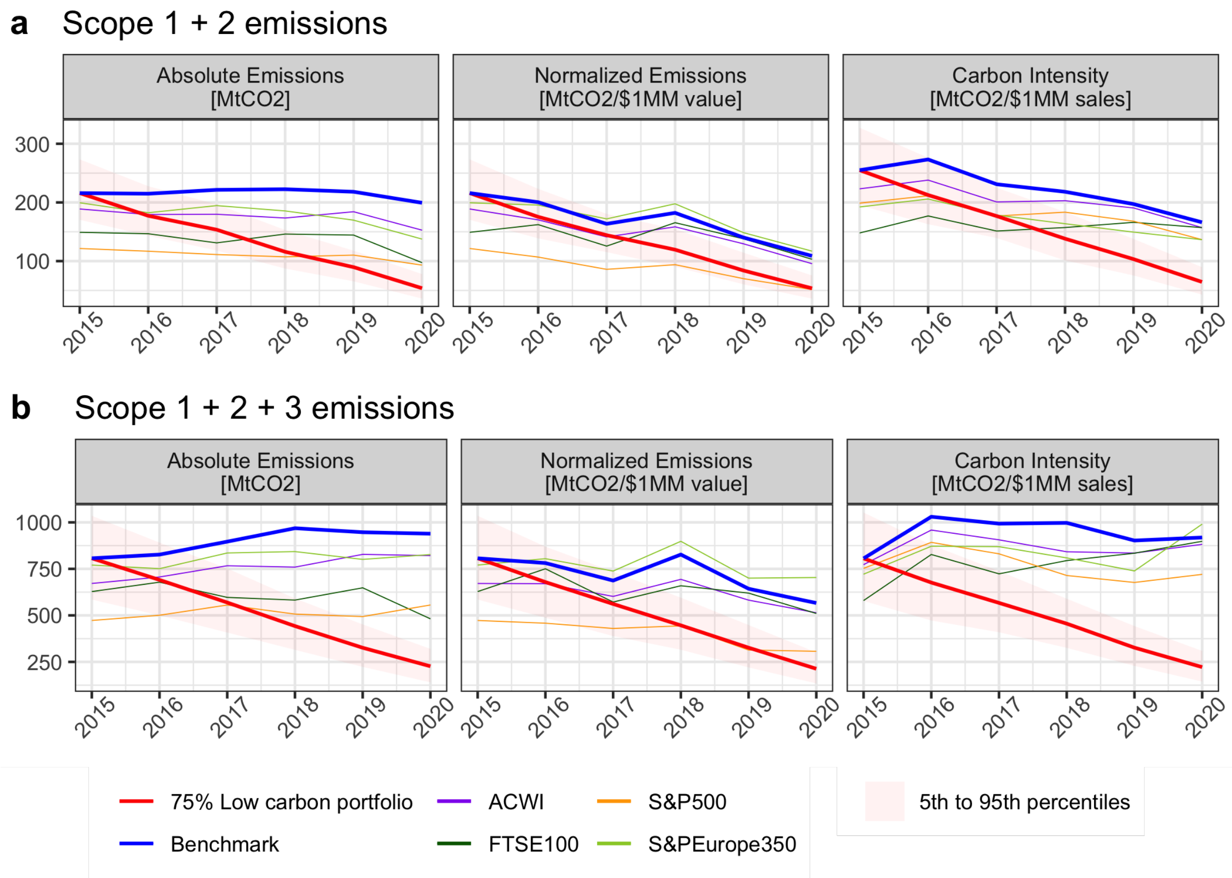

Figure 3: Financed emission trends

The *75% low carbon portfolio* is the average carbon metric of portfolios that achieve 15% annual reductions in order to reach a 75% reduction over 2015-2020. Each panel shows the given carbon metric and emissions scope. *Benchmark* is the average trend in the given carbon metric across all benchmark portfolios. Trends in carbon metrics for four example ETFs are included; details are available in the Appendix.

target, and 0.34pp for a CI target.[4] This is expected; portfolios with large financed emission reductions are those that have invested in cross-sectionally lower-emission companies, and as a result invest in companies with less potential for decreases in emissions over time. For Scope 1 + 2 targets over approximately 80% a portfolio's physical emissions increase on average, and for a wide range of targets the 95th percentile of portfolios includes portfolios with increases in physical emissions. This shows investors can report large reductions of up to and over 95% in their AE, NE, and CI even when their companies' physical emissions continue to rise. As a result, using industry standard financed emissions metrics allows investors to report seemingly Paris and net-zero aligned emission reductions even under the extreme situation if emissions from every company in the world were simultaneously increasing. This is because investors can report financed emission reductions, despite rising physical emissions, whenever they shift a sufficient share of their investments from currently high emissions to currently low emission companies—a change in the attribution of emissions across investors—to offset rising physical emissions within the companies they invest in.

In Figures 4 and 5 panel b) we demonstrate this further by decomposing the portfolios' emission reductions into their two constituent components: changes in financed emissions within companies, and changes in the companies held. See the Appendix for the decomposition formula and detailed method. The decompositions in Figure 4 panel b) demonstrate that as portfolios achieve increasingly larger 5-year reduction targets defined using Scope 1 + 2 emissions, an increasing share of their reductions come from changes in the companies held and not from a reduction in financed emissions within companies. These decompositions are closely related to the trends in benchmark financed emissions shown previously in Figure 3; declines in the market's average financed emissions are due to changes within companies and contribute to an investors reduction target, and lower the amount of their target they must achieve through changing their portfolio holdings.

For example, the large decline in benchmark's average NE in Figure 3 means that a substantial share of a NE reduction target will be achieved from changes in financed emissions within companies, and in Figure 4 we see a correspondingly smaller share of the total reduction target comes from portfolio changes compared to similar AE or CI targets. In contrast, Figure 3 also shows there is almost no decline over the same period in the market's average AE. Correspondingly, the decomposition of AE targets in Figure 4 shows nearly all reductions are achieved through changes in portfolio holdings and a negligible contribution comes from AE reductions within companies. These decompositions are particularly stark when Scope 3 emissions are included in Figure 5: CI and AE targets are only achieved due to changes in the companies held, as CI and AE financed emissions are increasing over time within the companies held. Similarly, Figure 5 a) shows that physical emissions including Scope 3 are increasing over time within companies regardless of the carbon metric and emission reduction target used to create portfolios.

4.2. Results — Choice of carbon metric

[4] Linear fits to the change in physical emissions in Figure 4 a). See the Appendix for the linear fit details.

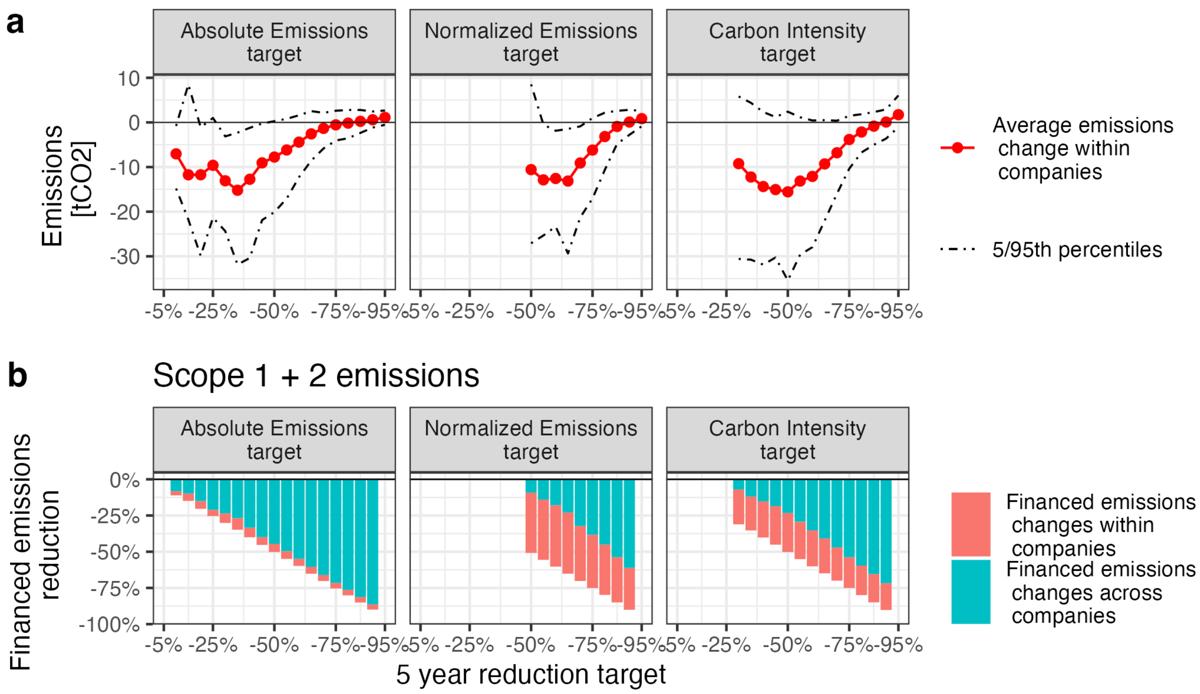

Figure 4: Scope 1 + 2 within- and across-company changes in financed emissions Panel a) Red dots [dashed lines] show the average [5th and 95th percentile] 5-year change in physical emissions among the companies held in the final low-carbon portfolio. Panel b): Each panel displays 5-year changes in financed emissions decomposed into the within-company and across-company changes. Within-company changes show the average change in a portfolio's financed emissions if the investments were unchanged. Across-company changes show the average changes in financed emissions if the investments held changed, but each company's financed emissions remained unchanged. The decomposition shown is for investors who achieve their 5 year target through gradual changes in each year. See the Appendix for the decomposition formula and details.

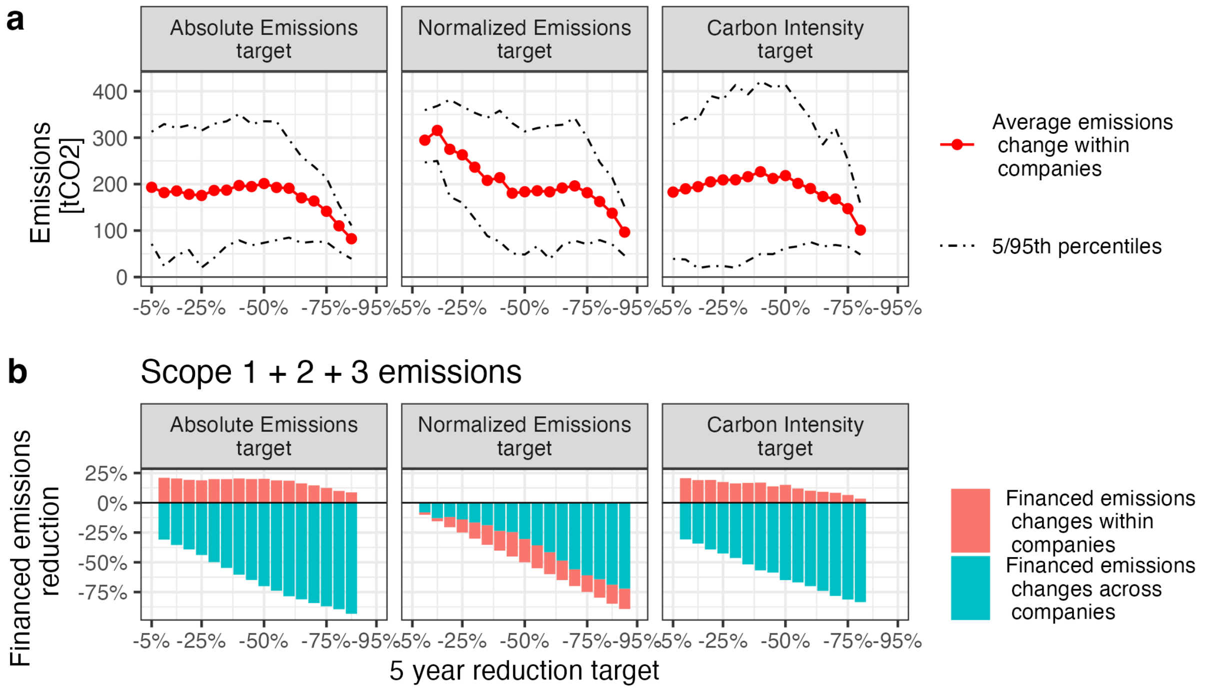

Figure 5: Scope 1 + 2 + 3 within- and across-company changes in carbon metrics
Panel a) Red dots [dashed lines] show the average [5th and 95th percentile] 5-year change in physical emissions among the companies held in the final low-carbon portfolio. Panel b): Each panel displays 5-year changes in financed emissions decomposed into the within-company and across-company changes. Within-company changes show the average change in a portfolio's financed emissions if the investments were unchanged. Across-company changes show the average changes in financed emissions if the investments held changed, but each company's financed emissions remained unchanged. The decomposition shown is for investors who achieve their 5 year target through gradual changes in each year. See the Appendix for the decomposition formula and details.

In Figure 6 we show how the choice of carbon metric between Absolute Emissions, Normalized Emissions, and Carbon Intensity affects the reductions measured. Each panel of Figure 6 shows portfolios that achieve a range of 5-year emission reduction targets defined by the carbon metric stated in the panel name, and using the given Scope of emissions. For these portfolios we then measure the ex-post 5-year change in financed emissions using all three carbon metrics. For example, panel Absolute Emissions in a) shows portfolios that achieve a range of 5-year reduction targets in their AE defined using Scope 1 + 2 emissions. The ex-post reductions in AE realized for these portfolios closely match their reduction targets—as expected—and as a result their AE lie on the downward sloping 45-degree line denoted by the grey line. However, measuring the 5-year change in NE and CI for the same portfolios — denoted by the green and blue lines — finds larger percentage reductions than for AE; a portfolio with a 50% AE reduction would have a 55% reduction in CI and a 72% reduction in NE. This pattern is consistent across carbon metrics and almost the entire range of emission reduction targets; Scope 1 + 2 reductions are largest when measured with NE, followed by CI, then AE. The pattern is different when using Scope 1 + 2 + 3 emissions, where reductions are typically largest when using NE, followed by AE and CI. This shows how the ease with which an emission reduction target is achieved, like a 30% reduction by 2030, is highly dependent on the choice of carbon metric used.

Across all carbon metrics and whether Scope 3 emission are included or not, reductions in portfolio emissions come primarily from shifts in investments out of the high-emitting GICS sectors of Utilities, Materials, and Energy and into the low-emitting sectors like Financial and Health Care — see Appendix E. Note that changes in sector shares as a portfolio decarbonizes will depend on the specific way low-carbon portfolios are created. A portfolio that requires its sector shares to closely match those of the benchmark portfolio will experience smaller changes in sector shares for a given emission reduction target, compared to a portfolio created with no constraint on sector shares. In Appendix Section I we show that the results of this paper remain closely similar when portfolios are created with the constraint that sector shares remain within ± 10% of the benchmark portfolio.

4.3. Results - Choice of Scopes 1 and 2 versus Scopes 1, 2 and 3 emissions

Figure 7 compares reductions measured with only Scope 1 + 2 emissions to reductions measured when Scope 3 emissions are also included. Across all three carbon metrics and all targets we find that emission reductions, in percentage terms, are substantially smaller when Scope 3 emissions are included.

4.4. Results — choice of benchmark or baseline

As mentioned previously, financed emission reductions can be measured against a past baseline or a current benchmark portfolio and both approaches are used in practice. In Figure 8 we compare reductions measured from their 2015 emissions baseline against reductions measured from their 2020 benchmark portfolio's emissions. Figure 8 shows the choice

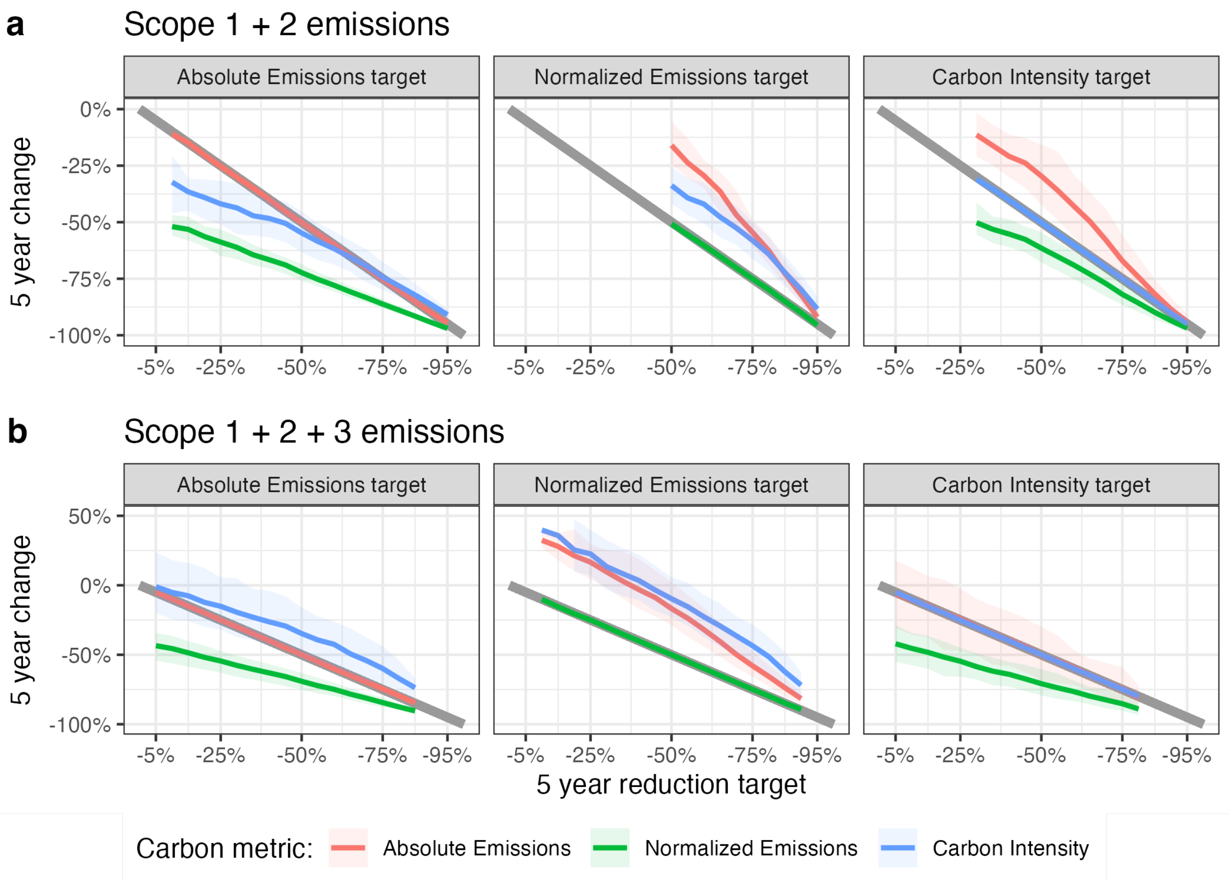

Figure 6: Carbon metric comparisons

Each panel shows the change in financed emissions for portfolios that achieve a given emission reduction target set using that panel's carbon metric. Financed emission changes are measured using all three carbon metrics for the same portfolios. Panel a) uses Scope 1 + 2 emissions, panel b) uses Scope 1 + 2 + 3 emissions. The 5 year reduction target is measured relative to the 2015 baseline. The 45 degree line denoted by the grey line and shows the line of equivalence where the measured reductions in financed emissions are the same as the 5 year reduction target. Solid lines are the average carbon metric and shaded regions are the 5th-95th percentile.

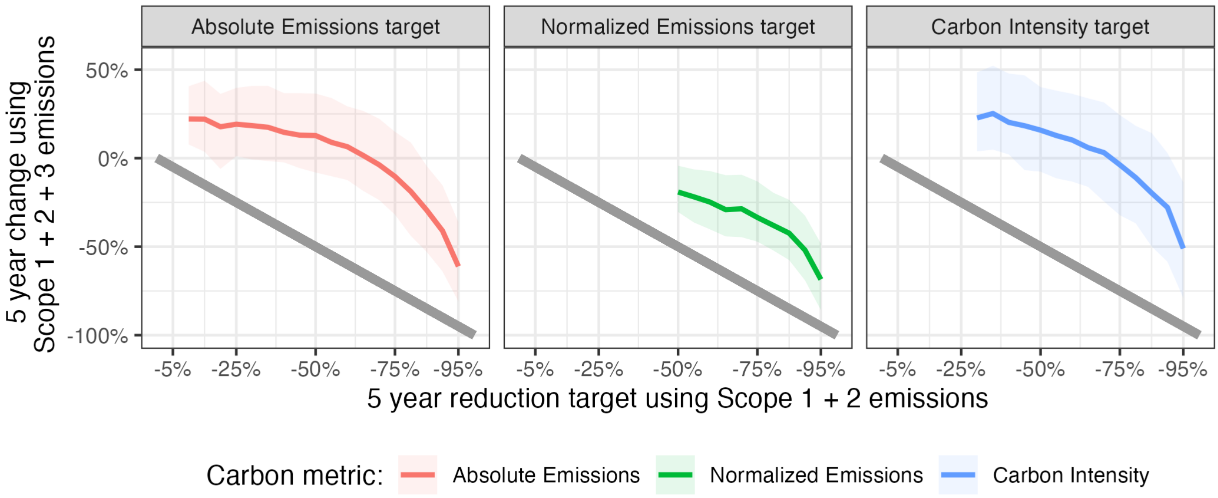

Figure 7: Emission scope comparison
Each panel shows the change in financed emissions measured using Scope 1 + 2 + 3 emissions for portfolios that set and achieved their 5 year emission reduction target using only Scope 1 + 2 emissions. The 45 degree line denoted by the grey line and shows the point of equivalence where reductions are the same when measured with and without Scope 3 emissions.

of benchmark or baseline can have a large effect; a portfolio measuring 5-year NE reductions against their 2015 baseline would report a 50% reduction, while measuring reductions for the same portfolio but against the market benchmark would report only a 12% reduction. Unsurprisingly, the larger the ongoing carbon metric emission reductions—such as seen in Figure 3—the easier a given target measured against a past baseline will be to achieve. Conversely, a similar sounding target of the same percentage reduction—but measured against a current market benchmark—will find their target gets harder to achieve the greater the ongoing emission reductions in the economy. A further implication of measuring emission reductions relative to a benchmark index is that a low-carbon portfolio's emission reductions can appear to be regressing over time, such as from 70% to 60% to 50% below the benchmark, even when their portfolio's financed emissions continue to decline; this occurs whenever the benchmark has larger declines in emissions than the portfolio being assessed.

4.5. Results — Implications for Science-Based Targets and Transition Pathway Initiative ratings

In Figure 9 we show how reductions in financed emissions affect the share of assets under management that have set Paris-Aligned targets as defined by the Science-Based Targets initiative or that are rated as Paris-Aligned by the Transition Pathway Initiative. Panels a and c show that decarbonising a portfolio bares almost no relation to the share of assets under management that have set SBTi reduction targets compatible with a Paris outcome of 2°C or better. By contrast, both the shares of firms rated by TPI as Aligned, and Not Aligned, with

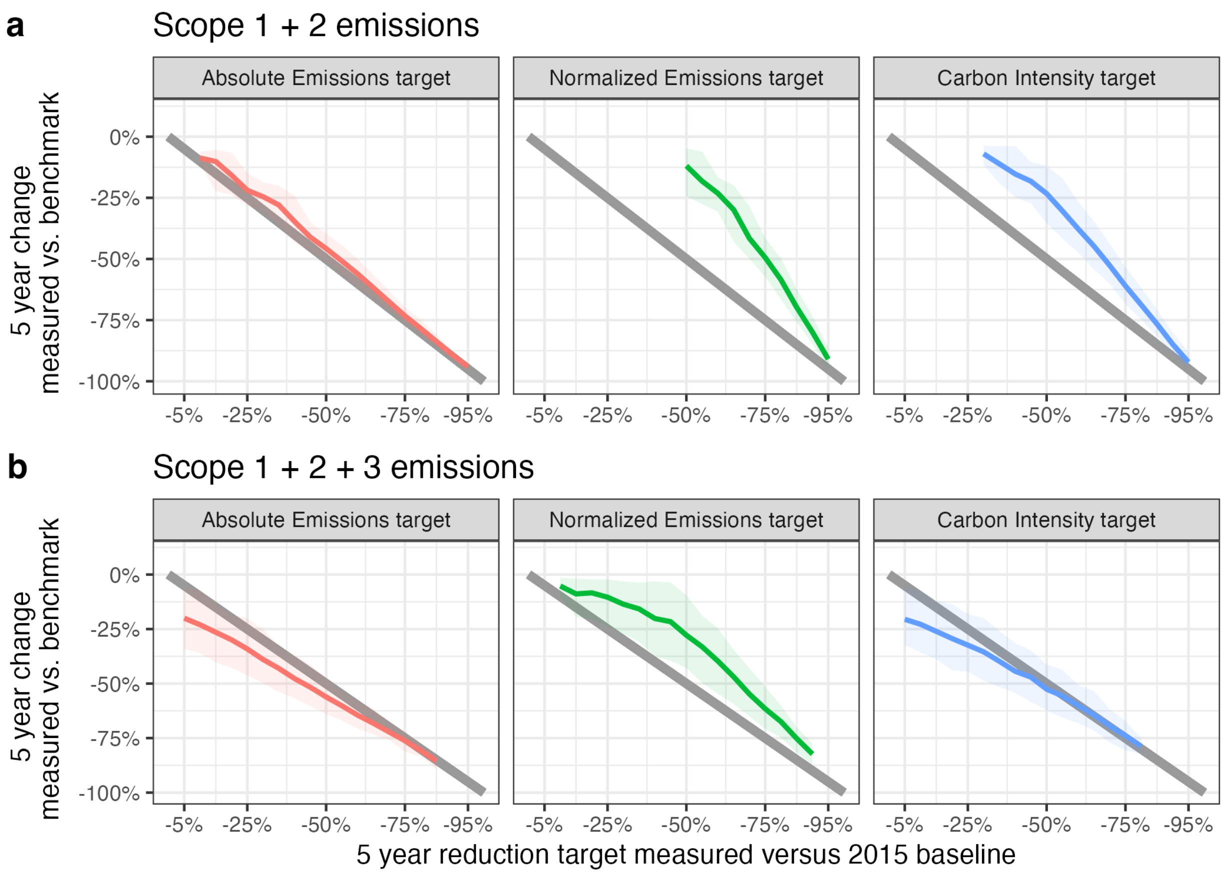

Figure 8: Comparing reductions measured with benchmarks versus baselines
Each panel shows the change in financed emissions measured from the benchmark portfolio's 2020 emissions, as a function of the emissions reduction target measured from the portfolio's 2015 emissions baseline. The grey line denotes where emission reductions are the same when measured against a past emissions baseline and current emissions benchmark.

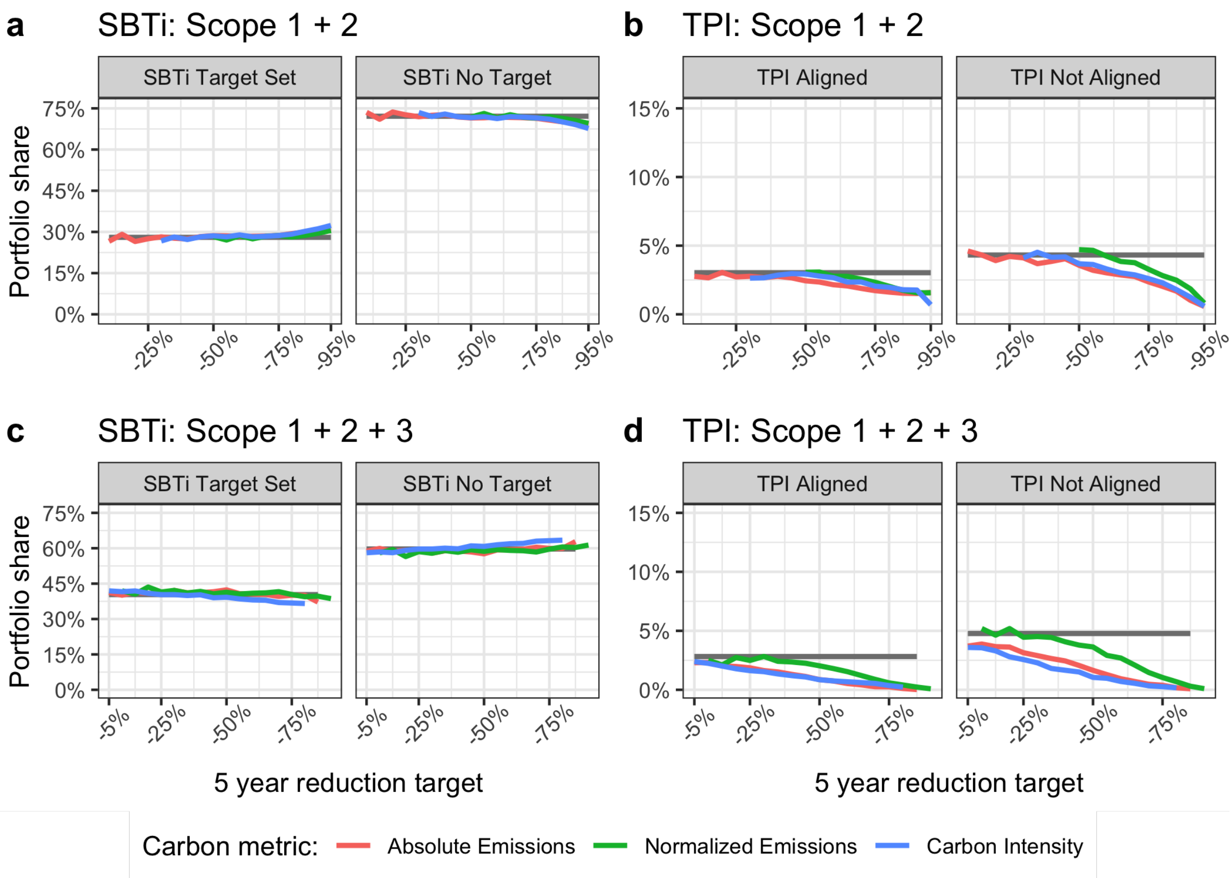

Figure 9: Changes in individually climate-rated assets under management
Panels a) and c) show the share of the portfolio invested in companies disclosing a 2°C or better target according to the Science Based Targets initiative criteria. Panels b) and d) show the share of the portfolio invested in companies rated by the Transition Pathways Initiative (TPI) as being Aligned (or Not Aligned) with a 2°C or better sectoral decarbonization budget. Companies not rated by TPI are not shown.

a 2° or better decarbonization pathway decrease in panels b and d. Declines in both portfolio shares occurs because TPI rates only the most highly emitting companies and reducing a portfolio's financed emissions shifts investments out of highly emitting companies regardless of their individual climate-alignment. These results highlight that portfolios constructed to increase the share of companies that have SBTi Paris-aligned targets or are rated Paris aligned by TPI can differ substantially from those with low portfolio emissions; investors should be aware that a portfolio considered net-zero aligned according to one method may be considered substantially mis-aligned according to alternative methods.

5. Conclusion

With an estimated US $275 trillion (Krishnan et al., 2022) in capital required to enable a net-zero transition by 2050, industry, policy makers, and the public increasingly require ways to measure the alignment of financial portfolios with climate goals. Measuring the emissions financed by investments is common in practice and it is critical that reductions in financed emissions—and their associated net-zero targets—credibly map to reductions in actual atmospheric emissions to support climate mitigation efforts. In this paper we analyze the use of financed emissions by simulating a wide range of investment portfolios that achieve a range of emission reductions using different carbon metrics and emission scopes, and we make three primary contributions.

First, investors can achieve large–over 95%–reductions in their financed emissions even while the physical emissions of the companies they invest in are increasing. That investors can claim net-zero aligned emission reductions despite increasing physical emissions demonstrates that financed emissions, even when measured using AE and including Scope 3 emissions, cannot be used to quantify progress towards net-zero targets or Paris alignment goals. The disconnect between financed and physical emissions occurs because changes in an investment portfolio's financed emissions combine changes in physical emissions within companies, (and for some carbon metrics, changes in company value and sales) with changes in the attribution of emissions across investors as portfolio holdings change. While declines in physical emissions can cause reductions in financed emissions, the converse is not true: reductions in a portfolio's financed emissions do not mean physical emissions are declining. Financed emissions do however remain a useful tool for investors seeking to reduce transition risks and proactively invest to support climate-mitigation objectives; we show how lowering a portfolio's financed emissions can shift investments out of high-emission industries and companies to lower emission alternatives.

Second, we systematically examine the variety of carbon metrics and emission scopes used to measure financed emissions. We show that changes in financed emissions depend critically on how they are measured: investors reporting 5-year increases in their financed emissions using one carbon metric could report a 50% reduction for the same portfolio if they use an alternative metric. Relatedly, we show that measuring emission reductions against a past emissions baseline is substantially different from measuring reductions from an industry benchmark portfolio. This work shows the importance of developing a standardized approach of a particular carbon metric, emission scope, and choice of benchmark in defining targets like the Net Zero Alliances' 65% reduction by 2030.

Third, we show how reducing a portfolio's financed emissions affects the share of assets that have set Paris Aligned targets or are rated as aligned with the Paris Agreement. We find that there is almost no relationship between a portfolio's financed emissions and the share of assets that have set Paris-Aligned targets of the Science-Based Targets Initiative. In contrast, reducing a portfolio's financed emissions also lowers the share of assets that are rated as both aligned and not-aligned with a 2°C trajectory as evaluated by the Transition Pathways Initiative. These differing results highlight an important distinction between approaches; reducing financed emissions reduces investments in all high emission companies, regardless of whether or not they are individually aligned with a low-carbon transition. Two further comments on this paper's findings are pertinent. Some approaches advise setting sector-level, rather than portfolio-level, financed emission reduction targets. While sector-level targets have their advantages, using sector-level financed emission reduction targets does not change this paper's results. Sector-level targets restrict the sets of companies within which investment shifts must be made, but do not prevent the core limitation of achieving financed emission reductions from changes in investments instead of reductions in physical emissions. A further issue is that if a large enough share of investors use financed emission metrics to direct their investments this would affect company valuations, and likely investment decisions and eventually real physical emissions. While important, such potential future general equilibrium effects of using financed emissions are beyond the scope of our analysis.

The conflation of changes in portfolio-level financed emissions due to changes in carbon metrics (including changes in physical emissions) with changes in portfolio holdings suggest that the decarbonization and net-zero progress of investments should be performed at an individual company, not portfolio, level. However, the concentration of emissions in a few highly-emitting companies shown in this paper implies that portfolios can have a substantial share of their investments be individually net-zero aligned even when their aggregate emissions are still increasing. One potential solution is to assess a company's emission reductions against forward-looking and science-based sector, or firm specific, trajectories. Companies' over- and under-shoot of their company-specific carbon budget can then be summed across companies to produce an emissions over- or under-shoot for an entire portfolio. While data intensive, these approaches may offer a way to ensure that stated reductions in financed emissions are matched by reductions in physical emissions.

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