Swiss Sustainable Finance

Focus

MEASURING CLIMATE-RELATED RISKS IN INVESTMENT PORTFOLIOS

1 INTRODUCTION

Issues surrounding climate change pose a myriad of challenges and opportunities for actors in the financial sector. With the 2015 Paris Agreement, the global community agreed to substantially reduce anthropogenic emissions within the next three decades to keep global warming below the defined 1.5° C [1] target (UNFCC, 2015). This will bring about major structural economic transitions around the world and require extensive mitigation and adaptation efforts by consumers, governments and businesses alike.

A diverse set of national policies [2] has already been implemented. More and more companies are also adopting so-called science-based targets (SBT), vowing to comply with specific targets [3] and establishing new business models to do so. Nonetheless, as recent reports have indicated (IPCC, 2018), a rapid intensification of these efforts is required to prevent temperature rises with potentially catastrophic effects. Increased awareness by civil society and changes in consumer behaviour in response to the urgency of climate change put further pressure on governments and corporations.

As a result, this transition can manifest itself in countless ways, such as new regulatory environments or paradigm shifts for the economy. Investors thus face considerable uncertainties when taking investment decisions. Moreover, since the Paris Agreement specifically demands that "financial flows [be made] consistent with a pathway

towards low greenhouse gas emissions and climate-resilient development"[4], investors also face a responsibility to include climate change concerns in their investment decisions.

It is therefore paramount that investors and asset managers have a clear understanding of the climate-related risks and opportunities linked to their portfolios. To assist with this, the Task Force on Climate-related Financial Disclosures (TCFD) was established in 2015. It provides key recommendations for investors to identify risks and opportunities from climate change and for organisations to improve the standard of climate-related financial disclosures. Currently, however, the measurement of climate-related risks for investors is still an emerging field.

This publication aims to shed light on existing practices to measure climate-related risks of investments in listed equity and corporate fixed income[5] and describe the landscape for providers of such measurement services. We introduce the different types of climate-related risks and opportunities that investors and their portfolios face (Section 2) and a range of available methodologies to assess any identified risks and opportunities (Section 3). The publication then establishes recommendations for investors seeking to implement climate-related risk measurement, based on available guidance and interviews that were conducted. It also provides an outlook on possible and desirable future developments (Section 4). Finally, a detailed overview of data providers that assist investors in applying risk assessment measures is given (Section 5).

2 CLIMATE-RELATED RISKS AND OPPORTUNITIES

The performance of an investment portfolio and its risk-return profile are closely linked to the value of its underlying assets. This value is increasingly affected by climate-related risks and opportunities resulting from the effects of climate change and the adaptation and mitigation measures that are taken to respond to these effects and to prevent their further intensification.

For investors, the assessment of climate-related risks and opportunities is therefore crucial, given their potential effect on a portfolio's valuation. These risks are not necessarily reflected in standard risk metrics, however, due to their long-term effects. In addition, climate-related risks are still not fully priced in by stock markets (Tan et al., 2018), which Mazzacurati et al. (2017) described as a "massive market failure".

2.1 OVERVIEW OF CLIMATE-RELATED RISKS

The TCFD (2017) defines two main categories of climate-related risks that may have financial implications for a company that need to be considered in investment decisions: physical and transition-related risks. Table 1 introduces these categories, along with the specific sub-categories, and illustrates how these risks could manifest for invested companies, and their possible financial implications.

TABLE 1:
Climate-related risks for companies

	CLIMATE-RELATED RISKS					
	Physical risks		Transition-related risks			
	Acute risks	Chronic risks	Policy and legal risks	Technology risks	Market risks	Reputation risks
Examples of potential risks	Increased risk of extreme weather events	Changes in climate and landscape, e.g. coastal areas or rain forests	Imposition of mitigation policies or regulation and exposure to litigation	Investment and transition costs to low-carbon technology Uncertainty of investment decisions	Uncertainty regarding consumer behaviour, market signals and supply chain	Stigmatisation of industry Changes in consumer preferences and stakeholder expectations
Examples of possible financial implications	Reduced revenue from negative impacts on production facilities, sales and workforce Increased operating, capital and insurance costs, as well as asset depreciation due to damages		Increase in operating and / or litigation costs Forced capital depreciation due to policies	Value loss of existing assets Reduced demand for products and services Costs of developing and procuring new technology	Reduced demand Increased costs from unexpected market changes in supply chains	Reduced revenue due to decrease in demand, production, capital availability and employee attractiveness

Source: Adapted and simplified from Taskforce on Climate-related Financial Disclosures (2017a)

[1] The initial text of the Paris Agreement sets the temperature goal at staying "well below 2°C" and "pursue [...] 1.5°C" (UNFCCC, 2015, p. 3).

[2] E.g. the Energy Strategy 2050 and the CO_2 law for Switzerland (Swiss Confederation, 2013)

[3] An example of such an SBT is the commitment of Procter & Gamble "to reduce emissions from operations 30 % by 2020 from a 2010 base-year" (Science Based Targets, 2017).

[4] The Paris Agreement: UNFCCC, 2015, p. 3

[5] Other asset classes, such as real estate or sovereign bonds, are not considered due to their different methodological characteristics and to keep this paper compact. However, their climate-related risks can be substantial and merit separate treatment.

Companies that fail to account for these climate-related risks pose further risks for investors, specifically. As described earlier, the main types of risk for investors are changes in the valuation of shares and corporate bonds held in portfolios, and default risks for bond holders. Further risks are of a reputational nature, due to the public's growing awareness of carbon-intensive industries and their detrimental climate impacts. This has led to a call for divestments from fossil fuel companies, with some insurance companies (Unfriend Coal, 2017), public institutions and pension funds (Ansar et al., 2013) already having responded to this public pressure by implementing exclusions for fossil fuel related investments.

On a systemic level, future climate policies or technological developments influence the relative prices of assets and could even create stranded assets[6], in particular in the fossil fuel sector. Due to the very large amounts of capital tied up in such investments, this could lead to potentially dangerous systemic financial imbalances (Schoenmaker and van Tilburg, 2016). The market and reputational risks from stranded assets in the fossil fuel sectors are expected to be further exacerbated, as it is estimated that "less than half the proven economically recoverable oil, gas and coal reserves can still be emitted up to 2050" to achieve the necessary emission reductions[7].

2.2 OVERVIEW OF CLIMATE-RELATED OPPORTUNITIES

Climate change also unlocks opportunities which companies and industries will be able to realise due to the transition to a low-carbon economy. This can lead to a higher valuation of investment portfolios containing shares or bonds of companies profiting from climate-related opportunities (see Table 2). Forward-looking companies that choose to increase the resource efficiency of production processes and reduce dependence on fossil energy sources can strengthen their competitiveness, for instance by lowering their comparative cost structure. Furthermore, investing in new low-carbon products and services allows companies to establish themselves as market leaders, access new customer segments and improve their economic and physical resilience concerning climate change.

TABLE 2:
Climate-related opportunities for companies

	CLIMATE-RELATED OPPORTUNITIES				
	Resource efficiency	Energy source	Products and services	Markets	Resilience
Examples of potential opportunities	Improved production processes and operating efficiency	Access to new technologies and energy sources Access to incentive schemes and carbon markets	Development of new products, low-emission goods and services and climate adaptation measures	Access to new markets, assets and public sector incentives	Reduced energy and resource dependency
Possible financial implications	Increased production capacity and reduced operating costs Value gains of fixed assets	Increased capital availability and positive returns from low-carbon technology investments Reduced operational costs and exposure to future carbon policies	Increased revenue and better competitive position through new products and new solutions to adaptation needs	Increased revenue through access to new markets Better diversification of financial assets	Increased resilience leads to higher market valuation Increased reliability of production processes

Source: Adapted and simplified from Taskforce on Climate-related Financial Disclosures (2017)

[6] Stranded assets are "fossil fuel supply and generation resources which, at some time prior to the end of their economic life [...], are no longer able to earn an economic return, as a result of changes associated with the transition to a low-carbon economy" (Carbon Tracker, 2017).

[7] Meinshausen et al., 2009, p.1158.

3 COMMON MEASURES OF CLIMATE-RELATED RISKS AND OPPORTUNITIES

Investors may have different objectives when looking at climate risks related to their investments. In broad terms, these goals can be described as follows[8]:

1) Reduce exposure to climate-related risks (financial risk)
2) Reduce the climate impact of assets under management (reputational risk)
3) Contribute to the transition to a low-carbon economy (financial and reputational opportunities)

The currently available methods for looking at climate-related risks in investment portfolios mainly address objectives 1) and 2) directly, as they often aim at divestments from greenhouse gas (GHG) intensive sectors and/or investments in "green" technologies[9]. By doing so, they affect relative share prices on secondary markets and in this way also indirectly address objective 3)[10].

Depending on the intended outcome, different methods can be applied. When incorporating climate-related risks in a portfolio it may make sense to implement one or a combination of the following three strategies[11]:

— Reduce GHG emissions of investee companies, e.g. by excluding or underweighting companies from utility or energy sectors from the portfolio
— Reduce exposure to climate-related changes in regulation, e.g. by excluding companies with fossil fuel reserves which may become stranded due to tighter regulation on emissions
— Focus on substitution, e.g. with higher investments in renewable energies and other promising new technologies which may profit from a transition to a low carbon economy

The following metrics and approaches can support investors and asset managers in integrating climate risks and opportunities into their investment decisions, as well as monitoring and reporting on them.

3.1 IMPACT METRICS: CARBON FOOTPRINT AND CARBON INTENSITY

Carbon footprint and carbon intensity measure the carbon impact of a portfolio through its investee companies and are by far the most common methods used by investors to quantify the environmental implications of their portfolio. The **carbon footprint** – also called "financed emissions" – is calculated in tons of CO_2 equivalents per million USD invested ($tCO_2e/mUSD$)[12]. It expresses the amount of annual GHG emissions which can be allocated to the investor per million USD invested in a portfolio and is therefore probably the most intuitive carbon metric available at the portfolio level. The **carbon intensity** puts the total GHG emissions that can be attributed to an investor in relation to the total share of revenue attributed to an investor. It is expressed in tons of CO_2 equivalents per million USD revenue ($tCO_2e/mUSD$). By introducing revenue, the metric is adjusted for company size and is therefore a measure of how carbon-efficient the portfolio is in producing revenue through its investee companies.

While the two indicators do not measure climate-related risk per se, they are proxies that provide valuable information for investors by identifying assets that potentially pose climate-related risks in the future[13]. So they should complement a climate risk analysis, in particular for sectors where no green/brown shares (see Section 3.3) can be calculated. They are usually calculated based on historical data and allow for benchmark comparison, attribution analysis and portfolio decomposition. They also rely on an equity ownership approach, which means that all GHG emissions of a company are attributed to its market capitalisation only (debt and own capital are not included). They are therefore sensitive to changes in the portfolio company's share price and its form of capitalisation.

[8] Natixis (2016): p. 48

[9] Tan et al. (2018): p. 4

[10] Research on the impact of sustainable investments on the economy shows that capital allocation has an indirect impact, especially if investors engaging in capital allocation "hold a large market share, deviate strongly from the market portfolio, and focus on assets that are hard to substitute. The capital allocation impact is also more likely when companies depend on external financing for growth, and when the cost of conforming with the expectations of SI [Sustainable Investment] investors is low" (Kölbel et al., 2018). In contrast to capital allocation, active engagement as well as investments in private markets can have a more direct influence on company activities than secondary market investments. Even so, this publication focuses on investor activities to address the first two goals described in section 3.

[11] Blackrock (2016): p. 9

[12] All formulas can be found in Appendix 2 on page 10.

[13] A high carbon intensity potentially constitutes a reputation risk. It may also present a financial risk, if the carbon intensity is financially relevant (high carbon exposure) and cannot easily be reduced in the near future (high carbon dependency) (Hoffmann et al., 2008).

3.2 MEASURING THE EXPOSURE TO CARBON-INTENSIVE COMPANIES

For calculating a portfolio's exposure to carbon-intensive companies, TCFD (2017b) suggests calculating the **weighted average carbon intensity** in tons of CO_2 equivalents per million USD revenue (tCO_2e/mUSD). Unlike the carbon intensity described above, which estimates how carbon-efficient the portfolio revenues are overall, the weighted average carbon intensity calculates the carbon intensity of each portfolio company and scales it based on its weight in the portfolio. This metric can be used for the comparison with a benchmark, for the definition of reduction targets and potential ways to decarbonise a portfolio, as well as for reporting purposes[14].

Compared to the impact metrics, the weighted average carbon intensity does not rely on the equity ownership approach. This means that it can be better applied across equities and bonds. Similar to the carbon intensity indicator, it allows for portfolio decomposition and attribution analysis. This metric is more sensitive to outliers, and it favours companies with higher pricing levels than their peers. It can be used as a proxy for transition-related risk, but as stated by Raynaud et al. (2015), it only provides a snapshot, and no outlook into the future.

This is a disadvantage which is shared by both impact and exposure metrics: they are static and inform about the exposure or impact of a portfolio at a specific point in time, usually based on the last reporting period's emissions and sales, albeit without including forward-looking data.

3.3 GREEN/BROWN SHARE APPROACH

Green/brown share approaches aim at identifying both low-carbon activities that contribute to the transition to the low-carbon economy (green share) and activities with a negative effect on climate change (brown share). Green/brown shares can either be calculated at a technological level, where different industry-specific metrics are relevant (e.g. average gCO_2e/km of the fleet in the logistics sector), or by using industry classification data, such as GICS[15], ICB[16] or ISIC[17]. According to UNEP FI et al. (2015), these classifications can be useful when considering the high-carbon sector. However, they offer less detail regarding new "green" activities, such as energy efficiency measures or low-carbon technology.

3.3.1 Green Share

So far, there is no globally agreed-upon definition of which activities are classified as "low carbon"[18]. The taxonomies used today[19] broadly include

- renewable energy;
- energy efficiency (e.g. energy-efficient buildings);
- low emission public transport;
- vehicles with alternative powertrains (e.g. electric cars);
- water (e.g. water treatment and recycling);
- waste management and
- sustainable use of natural resources.

Data providers exist which can report green (and brown) activities on a company level as a percentage of annual sales in various levels of granularity (see overview in Table 3 and with more detail in UNEP FI et al. (2015)). A green share calculated for an investment portfolio therefore shows the portfolio's exposure to "climate-friendly" activities or technologies. However, it does not quantify the green share's contribution in terms of tons of GHG reduced.

To measure the contribution of a green share of a portfolio to reduce GHG emissions, the **"avoided emissions"** would need to be calculated. Today, calculating avoided emissions compared to a business-as-usual scenario is standard practice at a project level, especially for projects which are dedicated to carbon offsetting. However, no standard exists so far on how to account for avoided emissions at the company level, which would in turn also enable an aggregation at the portfolio level. The TCFD (2017b) asks that "avoided GHG emissions through the entire product life cycle" should be disclosed by companies but does not specify any guidance on how exactly this should be reported. Measuring avoided emissions at a portfolio level therefore needs profound knowledge of ongoing and future energy efficiency and emission reduction projects within the investee companies, as well as an understanding of the relevant business-as-usual scenarios, which, in theory, could be different for every company. An estimation of avoided emissions for specific portfolios is offered by various data providers (see Table 3).

3.3.2 Brown Share

The exposure to "carbon-related assets" (TCFD, 2017b) is a simple metric which can provide an initial idea of how big the brown share in a portfolio could potentially be. It represents the percentage of carbon-related assets, based on the current portfolio value. In this case, the term "carbon-related assets" refers to the industries that are considered the most carbon intensive. Consequently, this metric can be calculated without knowing the specific GHG emissions of the portfolio holdings. Also, it can be applied across asset classes, as it does not require any additional GHG data. It is therefore easy to calculate, but it does not provide as much insight, since it does not go beyond the sector classification used to establish the exposure.

[14] Natixis (2016): p.127

[15] Global Industry Classification Standard

[16] Industry Classification Benchmark

[17] UN International Standard Industrial Classification of All Economic Activities

[18] In its "Proposal for a Regulation of the European Parliament and of the Council on the establishment of a framework to facilitate sustainable investment" (COM/2018/353 final), the European Commission proposes establishing a so-called "EU taxonomy for climate change and environmentally and socially sustainable activities". This proposal is still in consultation.

[19] See Natixis (2016) or UNEP FI (2015)

3.3.3 **Stranded Assets**

To better understand the brown share of a portfolio, this metric should be complemented by an evaluation of possible stranded assets. According to the Carbon Tracker Initiative (2011), 80 % of the world's fossil fuel reserves can no longer be extracted if the global average temperature rise were limited to 2° C. Furthermore, high-value equipment and infrastructure with long time horizons which are used for extraction and transportation of fossil fuels, such as mining equipment and pipelines, could become stranded in the process as well.

So far, no simple metric has been proposed to evaluate the stranded asset risk within a portfolio. One possible explanation for this could be that a variety of additional data is needed to assess this risk, such as the type and amount of proven fossil fuel reserves and the involvement in fossil-fuel-related infrastructure projects. Moreover, it is still the subject of ongoing debate whether – and under which scenario – assets could get stranded (see e.g. Koehler et al., 2016). However, there are data providers which can provide a stranded asset risk metric on a company level (see Table 3).

3.4 **CLIMATE SCENARIO COMPATIBILITY ANALYSIS**

Climate scenario compatibility analysis is based on the idea that a "carbon budget" (i.e. the amount of emissions which can be safely emitted until 2050 to stay below a certain threshold of global warming), can be allocated to sectors and companies. Based on these assumptions and other reported company-specific data, it is then calculated whether a portfolio's future emission path is in line with the emission reduction path of the respective scenario [20]. This method takes data on future developments (i.e. investment plans) into account and thus has a forward-looking character. Interpreting the results in cases where a portfolio "overperforms" in certain sectors can be complex.

3.5 **CLIMATE-RELATED VALUE AT RISK**

There are also data providers which adapt the common risk measurement concept "value-at-risk" (VaR) to climate-related risk. These approaches aim at expressing the effect of climate-related risks on the value of a portfolio in a single figure. They include physical risks as well as transition risks and can be modelled for several different alternative climate scenarios. Similar to the climate scenario compatibility analysis, such metrics are based on both historical and forward-looking data. Forward-looking data includes, for example, forecasts of revenues based on patents related to low-carbon technology (on a company level), policy scenarios (on a market level) or climate change scenarios (on a global level).

3.6 **ESG DATA**

Traditional ESG indicators can further complement the analysis of a portfolio's transition-related risks. Indicators that collect data on companies'

- climate change policies,
- GHG reduction strategies,
- specific GHG reduction measures,
- scope 1, 2 and 3 GHG emission reporting or
- target setting

can help to estimate their preparedness for dealing with these risks. Among the companies that report GHG emissions, the level of detail of their scope 3 GHG emission reporting can be an indicator of how serious the company considers carbon management. Most traditional ESG data providers offer carbon management related ESG indicators and/or so-called "climate scorings" (Raynaud et al., 2015), i.e. company ratings which focus specifically on climate change management practices. Some data providers also combine metrics from several data sources in a carbon portfolio analysis to provide a detailed view on the topic from different angles.

[20] The most frequently used scenario for such analyses is the 2 degree scenario based on the International Energy Agency (IEA), while other scenarios (e.g. 1.5 degree scenario) could also be used.

4 CONDUCTING CLIMATE-RELATED RISKS SCREENING

Many different authors and institutions have published instructions on how climate-related risks should be analysed in the context of an investment portfolio [21]. A generic process for conducting a screening of climate-related risks could include the following steps.

4.1 SHORT GUIDANCE

- **Define the main objective you aim to achieve:** As mentioned at the beginning of section 3, the choice of metrics depends on the individual goals of investors. While the objectives can be divided into risk mitigation, impact mitigation and contribution to the transition, the metrics available cannot be allocated strictly to the individual objectives. Selecting a set of metrics that fits your goals is therefore key. Climate change is often addressed in sustainable investment policies as well. It should therefore be verified whether the goal is in line with this policy [22].
- **Select a research provider:** As Table 3 displays, there are many research providers offering different types of services. It makes sense to compare research providers based on services, coverage and costs, and select the one(s) which best suit your objective.
- **Apply screening to the portfolio:** The next step is to calculate the relevant metrics for a defined portfolio. If the respective resources are available, this can be carried out in-house, or else a research provider can provide this service.
- **Monitor climate-related risks:** You then compare your portfolio(s) to the relevant benchmark(s) and aim to understand which investments are responsible for deviations from the benchmark. Since most reporting companies update their GHG emission data once a year, annual monitoring should be sufficient.
- **Define subsequent action:** Based on what you have learned from the previous steps, you can then define which findings of your carbon risk screening should be considered in future investment decisions.
- **Report on climate-related risks:** In the light of increasing demand for transparency from different stakeholders, you should then define which items of your internal monitoring should be communicated to investors and/or the public.

Asset owners can also delegate some of the steps mentioned above to their asset managers.

4.2 COMBINING METRICS FOR BEST RESULTS

As concentrating on single metrics may not provide a full picture, it may make sense to combine different measures for better effects. For example, the **weighted average carbon intensity** indicates the level of exposure and can be used as a proxy, but it needs to be complemented by other metrics to better understand what drives the result. For instance, an investor can analyse the influence of sector allocation and stock selection effects on transition-related risks in an investment portfolio. Alternatively, more data, such as **green/brown shares** as a percentage of annual sales can be added. However, they do not exist for every sector and most of the metrics available rely on historical data and inform impact or exposure at a given point instead of over time.

Including **fossil fuel reserves** (possible **stranded assets**) adds a forward-looking element to the risk analysis, which can be transformed into potential future GHG emissions by multiplying with the respective emission factor. Carbon management related ESG indicators, although based on historical data, can give a sense of a company's ability to face future transition-related risks.

All further predictive analysis such as **avoided emissions** or **scenario analysis,** require, in addition to the GHG data, very detailed information at the company level on research and development activities in "green" products as well as capex data for "green" or "brown" projects, which is not easily available or may be unreliable.

4.3 OUTLOOK

In its Status Report, the TCFD (2018) acknowledges that today "the majority" of a sample of 1750 large cap companies "disclose some climate-related information". Yet very few companies report on the financial implications of climate change on their business model. With regards to the assessment of climate-related risks and opportunities at a portfolio level, further improvement in the quality and scope of the data reported is needed, especially to meet the requirements set by the TCFD (TCFD, 2017b): "Asset managers should describe metrics used to assess climate-related risks and opportunities in each product or investment strategy. Where relevant, asset managers should also describe how these metrics have changed over time. Where appropriate, asset managers should provide metrics considered in investment decisions and monitoring".

To fulfil these requirements entirely, investors need more standardised and consistent company-level data on ongoing and planned investments in "green/brown" research and development and products to be available for investment universes. Also, the availability, scope, consistency and reliability of reported GHG emissions data should be further improved. Investors must be aware as well that climate-related risks also include several physical risks (such as extreme weather events or rising sea levels) that companies and investors face. Their relevance is only expected to grow in the future.

While the debate on whether and when transition-related risks will become material goes on, France has already acted. Since January 2016, French asset owners and investment managers are obliged by Article 173 of the "Law on Energy Transition for Green Growth" to either report on GHG emissions and climate-related risks or to explain why reporting is not necessary [23].

5 DATA PROVIDERS

The following Table 3 gives a short overview of providers which offer data for measuring and/or services for assessing climate-related risks in investment portfolios. The information on the providers has been compiled based on the authors' own research and based on similar compilations published elsewhere (see below for sources).

[21] Hörter (2017), Blackrock (2016), Natixis (2016), Mercer et al. (2015), UNEP FI (2015) or Raynaud et al. (2015)

[22] For further information on how to establish a sustainable investment policy: Handbook on Sustainable Investments, Swiss Sustainable Finance, 2017.

[23] See Annex, Chapter "Reporting: Examples"

TABLE 3:
Data providers [24]

Name (including hyperlink)	Organisation Type	GHG Data Type [25]	GHG Scopes covered	GHG Data History	GHG Company coverage	Other Climate-related Risk Data	Climate-related Risk related Services
2DegreeInvesting	NGO	—	—	—	—	Publicly available reports tackling a wide range of issues around climate-related risks	Portfolio scenario alignment analysis [26]
Beyond Ratings	Company	reported and estimated	CO_2e Scopes 1–2 CO_2e Scope 3 supply chain for all sectors and product use for car manufacturers	since 2009	~10,000	—	Portfolio scenario alignment analysis Carbon portfolio analysis
Bloomberg	Company	reported and estimated	CO_2e Scopes 1–3 (Scope 3 only if reported)	since 2010	~10,000	Green/Brown Metrics Carbon management ESG indicators	Carbon portfolio analysis
Carbon Delta	Company	estimated	CO_2e Scopes 1–3	since 2013	~22,000	Climate-related risk rating Warming potential scenarios Green/Brown Metrics	Portfolio climate risk assessment Portfolio scenario alignment analysis
Carbon Market Data	Company	reported	CO_2e Scopes 1–3 (Scope 3 only if reported)	since 2005	~9,000	GHG data on ~18,000 installations	—
Carbon Tracker	NGO	—	—	—	—	Publicly available reports tackling a wide range of issues around climate-related risks	—
Carbon4 Finance	Company	reported and estimated	CO_2e Scopes 1–2 CO_2e Scope 3 supply chain and product use	since 2007	~10,000	Alignment with 2°C scenario Avoided emissions Climate Strategy indicator Green/Brown Metrics Physical risk data	Carbon portfolio analysis Portfolio climate risk assessment Portfolio 2°C scenario analysis Climate indices
CDP	NGO	reported and estimated	CO_2e Scopes 1–2 CO_2e Scope 3 supply chain and product use	since 2003	~3,600	Carbon management ESG indicators	Carbon portfolio analysis
Engaged Tracking	Company	reported and estimated	CO_2e Scopes 1–2 CO_2e Scope 3 supply chain and product use	since 2009	~30,000	Avoided emissions Fossil fuel reserves	Carbon portfolio analysis Low carbon indices Portfolio scenario alignment analysis
Fossil Free Indexes	Company	—	—	since 2013	~300	Fossil fuel reserves	Low carbon indices
Inrate	Company	reported and estimated	CO_2e Scopes 1–2 CO_2e Scopes 3 supply chain and product use	since 2009	~3,000	Carbon management ESG indicators Fossil fuel reserves Green/Brown Metrics	Carbon portfolio analysis
ISS ESG	Company	reported and estimated	CO_2e Scopes 1–2 CO_2e Scopes 3 supply chain and product use	since 2005	~25,000	Avoided emissions Carbon management ESG indicators Carbon risk rating Climate-related risk rating Fossil fuel reserves Green/Brown Metrics Physical risk data	Portfolio scenario alignment analysis Carbon portfolio analysis Portfolio climate risk assessment
MSCI	Company	reported and estimated	CO_2e Scopes 1–2 CO_2e Scopes 3 supply chain and product use only when reported	since 2008	~8,900	Carbon management ESG indicators Fossil fuel reserves Green/Brown Metrics	Carbon portfolio analysis Portfolio climate risk assessment Low carbon indices
Refinitiv	Company	reported and estimated	CO_2e Scopes 1–3 (Scope 3 only if reported)	since 2002	~7,000	—	—
South Pole	Company	reported and estimated	CO_2e Scopes 1–2 CO_2e Scopes 3 supply chain	only forward-looking data available	~20,000	Alignment with 2°C scenario Adaptive capacities Physical risk data	Portfolio scenario alignment analysis Portfolio climate risk assessment Avoided emissions portfolio analysis Portfolio 2° scenario analysis
Sustainalytics	Company	reported and estimated	CO_2e Scopes 1–2	since 2012	~13,000	Carbon risk rating Carbon management ESG indicators Fossil fuel reserves Green/Brown Metrics	Carbon portfolio analysis Portfolio carbon risk assessment
Trucost (S&P Global)	Company	reported and estimated	CO_2e Scopes 1–2 CO_2e Scope 3 supply chain and product use for some industries	since 2005	~14,000	Alignment with 2°C scenario Avoided emissions Carbon management ESG indicators Climate-related risk rating Fossil fuel reserves Green/Brown Metrics	Carbon portfolio analysis Portfolio scenario alignment analysis Low carbon indices
Vigeo Eiris	Company	reported and estimated	CO_2e Scopes 1–2 (Scope 3 only if reported)	since 2013	~4,500	Carbon management ESG indicators Climate-related controversies Fossil fuel reserves Green/Brown Metrics Physical risk performance	Carbon portfolio analysis Portfolio carbon risk assessment

Source: Own research, Providers, Natixis (2016), Raynaud et al. (2015), UNEP FI (2015)

[24] Table 3 has been validated by the providers themselves. Regarding the selection of providers, no guarantee for exhaustiveness can be given. For more detailed information, please check with the publicly available sources mentioned above.

[25] see Chapter 5.2 for further explanations

[26] The 2° Investing Initiative and its partners currently offer such analysis to investors online for free: http://www.transitionmonitor.com

APPENDIX

A.1 COMMENTS ON DATA QUALITY

A.1.1 GHG Data Types

Reported Data

When using company-level GHG emission data, investors should bear in mind that it is either reported by companies and/or based on estimations by specialised data providers if companies do not report carbon emissions. Reporting has steadily increased in the past years, covering around 1,900 companies[27] worldwide in 2017, which at least report scope 1 or scope 2 to CDP. Reporting on scope 3 emissions is increasing as well, but at a much lower level. This development is encouraging, but it needs to continue, as current figures show that less than 5% of over 40,000 listed companies worldwide reported at least scope 1 and 2 in 2017[28].

Although data is provided by companies directly, reported data contains errors and biases, as there is no global mandatory framework which defines how GHG emissions should be accounted for, or mandatory third-party verification. Companies decide which GHG emissions are within their system boundaries, and therefore reported, and which are not. This means that an investor can never be quite sure if a company really reports all GHG emissions that it should. A bias is also introduced by the fact that reporting companies are not evenly distributed between markets. Lastly, it is important to understand that reported data as well often contains estimations made by the reporting companies. A full set of scope 3 data always contains estimations, since it is impossible to measure, for example, the emissions of products sold during their use.

Estimated Data

GHG data can be estimated with different methodologies, which can roughly be grouped as follows:

- bottom-up extrapolation based on reported data (regressions and/or sector averages)
- bottom-up calculation based on reported energy data (e.g. energy consumption)
- top-down modelling via Economic Input-Output – Life Cycle Assessment (EIO-LCA)

Data providers often use a combination of these methodologies to estimate data. Each group of methods has its advantages and disadvantages, whose discussion is beyond the scope of this publication[29]. In general, it can be said that all three types of approaches can be used for estimating scope 1 and 2 GHG emissions. For the estimation of scope 3 emissions, EIO-LCA approaches offer advantages through their top-down and holistic view based on economic input-output and life cycle data which are independent of the potentially limited quality and coverage of company-reported data.

A.1.2 Scope 3 Data

Several data providers have methodologies in place for estimating scope 3 data at company level. From a theoretical point of view, it is essential to incorporate the upstream and downstream scope 3 emissions in a transition-related risk assessment, as it covers emissions which arise from a company's suppliers and from the use of its products and services. However, from a practitioner's point of view, the benefit of scope 3 data is under discussion. Some argue that data quality does not allow conclusions to be made. Others argue that for industries with significant upstream or downstream emissions, having a proxy for scope 3 GHG emissions is beneficial given the potential size of those emissions compared to scope 1 and 2. It is therefore important that data providers disclose their methods and data sources to investors for evaluation.

A.1.3 Double Counting

Aggregating GHG emissions at portfolio level also raises the question of how to deal with double counting. If a portfolio holds equities from an airplane manufacturing company as well as from an airline, chances are that some emissions are counted twice: the airline's scope 1 emissions, which arise from burning fuel by operating airplanes, are also accounted for in the manufacturer's scope 3 downstream emissions, if the airline operates an airplane from that manufacturer. However, Raynaud et al. (2015) argue that GHG data should not be adjusted for double counting when screening for climate-related risks. According to them, investing in a company and its supplier in fact doubles climate-related risks, which is then also reflected in the double-counted GHG emissions.

[27] https://www.greenbiz.com/article/cdp-data-reveals-shortfall-carbon-disclosure-north-american-companies

[28] https://data.worldbank.org/indicator/cm.mkt.ldom.no

[29] See Raynaud et al. (2015) or Natixis (2016) for further details.

A.2 FORMULAS FOR COMMON CLIMATE-RELATED RISK METRICS

METRIC	FORMULA
Weighted Average Carbon Intensity	$\sum_n^i \left(\frac{\text{current value of investment}_i}{\text{current portfolio value}} \times \frac{\text{company's GHG emissions}_i}{\text{company's mUSD revenue}_i} \right)$
Carbon Footprint	$\frac{\sum_n^i \left(\frac{\text{current value of investment}_i}{\text{company's market capitalisation}_i} \times \text{company's GHG emissions}_i \right)}{\text{current portfolio value in mUSD}}$
Carbon Intensity	$\frac{\sum_n^i \left(\frac{\text{current value of investment}_i}{\text{company's market capitalisation}_i} \times \text{company's GHG emissions}_i \right)}{\sum_n^i \left(\frac{\text{current value of investment}_i}{\text{company's market capitalisation}_i} \times \text{company's mUSD revenue}_i \right)}$

DEFINITIONS:
Current value of investment$_i$: Market value of an amount of equity of a company i held in an investment portfolio
Current portfolio value: Market value of all the equities (or other financial instruments) held in an investment portfolio

Sources: TCFD (2017b), Natixis (2016), Raynaud et al. (2015), UNEP FI (2015)

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