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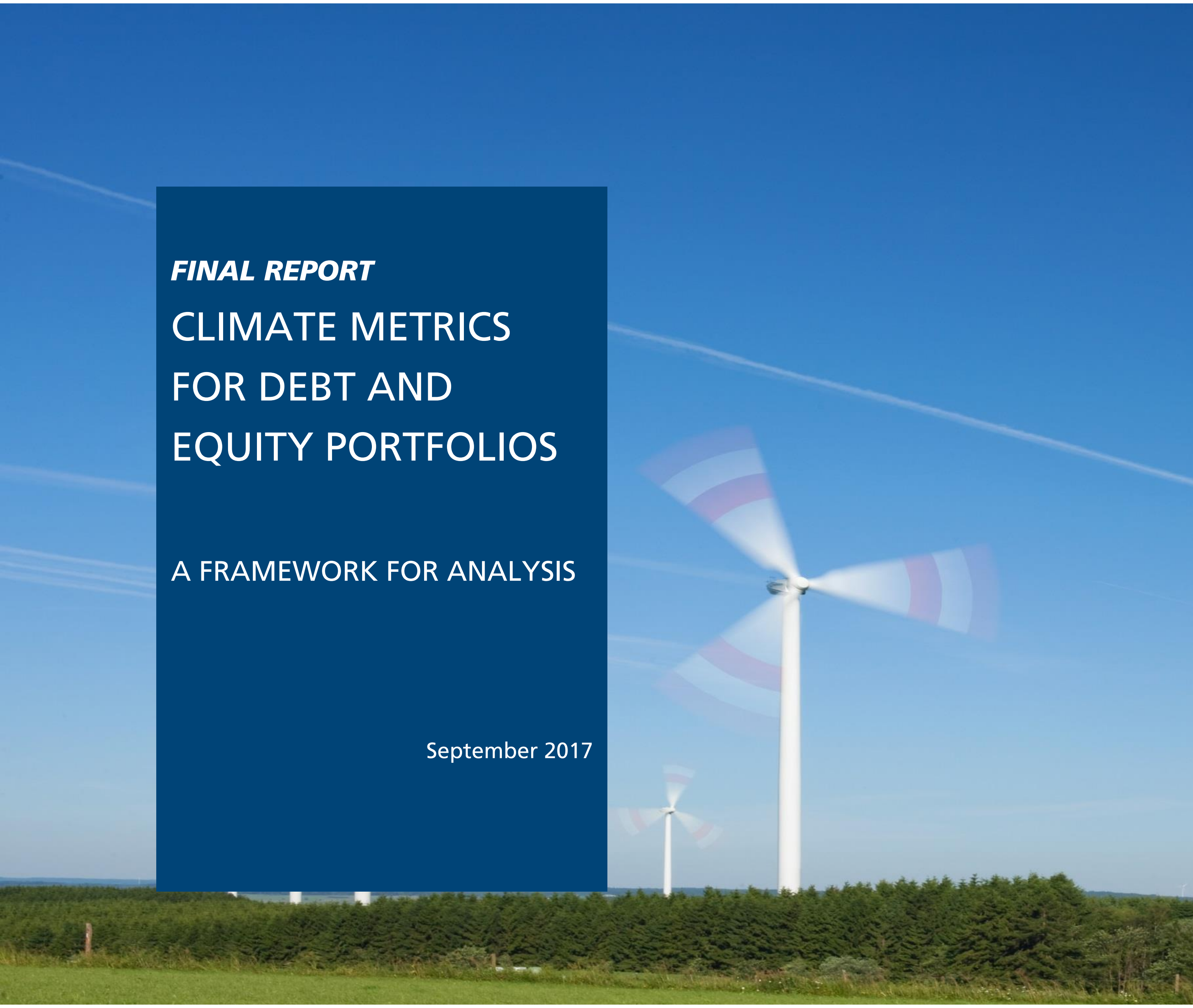

FINAL REPORT

CLIMATE METRICS FOR DEBT AND EQUITY PORTFOLIOS

A FRAMEWORK FOR ANALYSIS

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List of Abbreviations and Acronyms

AFR	Alternative Fuels and Raw Material
bbl	Barrel
BNEF	Bloomberg New Energy Finance
CAPEX	Capital Expenditure
CO_2	Carbon Dioxide
CSR	Corporate Social Responsibility
ESG	Environmental and Social Governance
FS	Frankfurt School of Finance & Management
FSB – TCFD	Financial Stability Board - Task Force on Climate-related Financial Disclosures
GDP	Gross Domestic Product
GHG	Greenhouse Gas
IEA	International Energy Agency
IPO	Initial Public Offering
MWh	Megawatt-hours
OECD	Organisation for Economic Co-operation and Development
R&D	Research & Development
SEI	Sustainable Energy Investment
S&P	Standard & Poor
tCO2eq	Tonnes of Carbon Dioxide Equivalent
UNEP	United Nations Environmental Programme (since March 2017 UNE)
US	United States
USD	United States Dollars
VaR	Value at Risk
VC	Venture Capital
WRI	World Resource Institute

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1. INTRODUCTION[1]

The Paris Agreement requires significantly increased efforts to reduce emissions in the short term and net zero emissions by the second half of the century. To meet the investment needs in green technologies and other emission reduction measures, both public and private financing is required at scale and needs to be applied in a mutually enhancing way. The transformation will include alternative sources of financing since long-term loans becomes scare after the financial crisis.[2] For the success of the transformation, it is therefore important that investments are compatible with long-term climate protection scenarios. This means, on the one hand, that financing of low-carbon initiatives has to become mainstream. The other side of the coin is to avoid long-term investments in carbon-intensive technologies, thus cementing a path dependency to a fossil economy, especially in carbon intensive sectors like energy and transport. Against this background, it is relevant to tackle the question: how to assess whether current financing flows and investments are consistent[3] with a two degree scenario?

Substantial progress has been made over the last decade in developing methods that assess the consistency of financing flows and investments needed for a two degree scenario. Financing refers to the process of raising funds for business activities and in a broader sense, consist of equity (publicly-traded equity, private equity), debt (bonds, private debt), or mixed forms thereof. Investments describe the activity of buying some kind of long-term asset. Financing is often required to enable investment activities. So far, assessment methods for two-degree consistency are quite heterogeneous regarding their approaches and objectives, but they have in common a focus on project finance and equity portfolios. Publicly-traded equity plays an important role in climate finance because equity owners are assumed to be in a direct position to influence companies' business operations. Within the project "Developing Sustainable Energy Investment (SEI)

[1] We thank Jakob Thomae, Chris Weber, and many others for valuable opinions and inputs into the report.
[2] OECD, 2013. *Policy Guidance for Investment in Clean Energy Infrastructure: Expanding Access to Clean Energy for Growth and Development*, s.l.: Report submitted to the G20 with inputs from the World Bank and UNDP. OECD, n.d. *Enabling Investment in Sustainable Energy Infrastructure*. [Online] Available at: https://www.oecd.org/dac/POST-2015%20sustainable%20energy.pdf [Accessed 20 June 2017]. And Corfee-Morlot, J., 2012. *Toward a green investment policy framework: The case of low-carbon, climate-resilient infrastructure* (Environment Directorate Working Papers), Paris: OECD Publishing.
[3] Note that in this report, "consistency" and "compatibleness", "consistent" and "compatible" is used interchangeably to refer to whether the investment portfolio would lead to a two degree scenario world.

Metrics, Benchmarks, and Assessment Tools for the Financial Sector"[4] initiated by the European Commission,[5] climate performance metrics are discussed and developed to benchmark publicly-traded equity and corporate bonds / credit portfolios with the two degree scenario by firstly looking at where a decision maker is today and where it is going in the future in terms of climate performance. The most important decision makers in the scope of the project are, of course, companies but also sovereigns and other organizations that take financing and investment decisions are analyzed, although in less detail.

In the following, Chapter 2 contributes by providing a conceptual framework of mapping climate metrics. This conceptual framework includes an inventory of existing metrics and classifies them according to two dimensions. As such, it helps to detect what kind of additional climate metrics are still required. Thus it is extending the notion about key design principles for climate metrics. The development of a climate metric from the debt investor's perspective just recently caught researchers' attention and only few approaches[6] have been developed until now.

The debt market is important due to its size (in terms of volume) and function (in terms of resource allocation) in the economy. Climate transition needs the capital market. The inter-temporal function of the financial market is crucial to the financing of large renewable energy projects that usually have a long asset life-time. There is an ongoing debate whether the influence of equity investors on ecological business strategy is bigger than the influence of debt investors, e.g. because their default rights are superior. This report contributes to that debate as it develops a framework to reflect the consequences of the different positions in Chapter 3. That chapter provides a numerical illustration of a number of the design characteristics that have been introduced and also includes a dynamic perspective in the light of the debate whether to account for debt and equity in a different way. The application of the framework to five hypothetical portfolios supports that equity and debt should not be treated fundamentally different. Doing so may, in fact, have adverse effects. It is also advisable to include a view on "brown" as well as "green" activities in a metric. The framework further offers

[4] In the following referred to as "SEI metrics project"
[5] Project website: http://cordis.europa.eu/project/rcn/194638_de.html
[6] For example Erlandsson, U., 2017. *Credit alpha and CO2 reduction: A portfolio manager approach*, s.l.: Fourth Swedish National Pension Fund (AP4). Retrieved from http://www.ap4.se/globalassets/formular/rapportarkiv/ovriga-rapporterdok/ecobar170419.pdf in June 2017

opportunities to consider dynamic aspects, e.g. through decomposing changes into effects caused by underlying assets on the one hand and so-called portfolio effects on the other.

2. INVESTORS' PERSPECTIVE ON CLIMATE METRICS

2.1. DEFINITION OF CLIMATE METRICS

Climate metrics can be described as an umbrella term for a bundle of different qualitative or quantitative indicators that evaluate the climate consequences of all kinds of economic actors, mainly companies. Conventional climate metrics predominantly rely on the assignment of numbers to observations of climate data from observations (ex-post) or projections (ex-ante) in a systematic manner.[7] Conventional climate metrics can be static or dynamic in nature: If they are applied only at a certain point of time, they are static as they provide merely a snapshot. In case conventional climate metrics are regularly assessed and a timeline of values is available, they can be also dynamic as it is possible to identify trends and anticipate future developments. As a consequence, conventional climate metrics reveal strong similarities to financial indicators in performance measurement systems known from the field of Management Accounting.

The increasing relevance of international climate targets, most prominently to limit global warming to a value below two degrees compared to preindustrial times, triggered the desire of several actors, among others researchers, policy makers, financial supervisory authorities, activists, companies as well as capital market participants etc., to develop metrics that measure how much emission reduction is enough to achieve the Paris Agreement target. Therefore, the previously prevailing notion of dynamic climate metrics has been extended. Dynamic does no longer only mean to assess past performance and anticipate future developments, but to set this development into the context of a specified target. Taking this new perspective into account, the mathematical definition of metric defined as "a binary function of topological space which gives, for any two points of the space, a value equal to the distance between them"[8] becomes relevant.

[7] Stenner, A. J., Smith III, M. & Burdick, D. S., 1983. *Toward A Theory of Construct Definition*. Journal of Educational Measurement, 20(4), p. 1–12.
[8] Retrieved from https://en.oxforddictionaries.com/definition/metric in May 2017

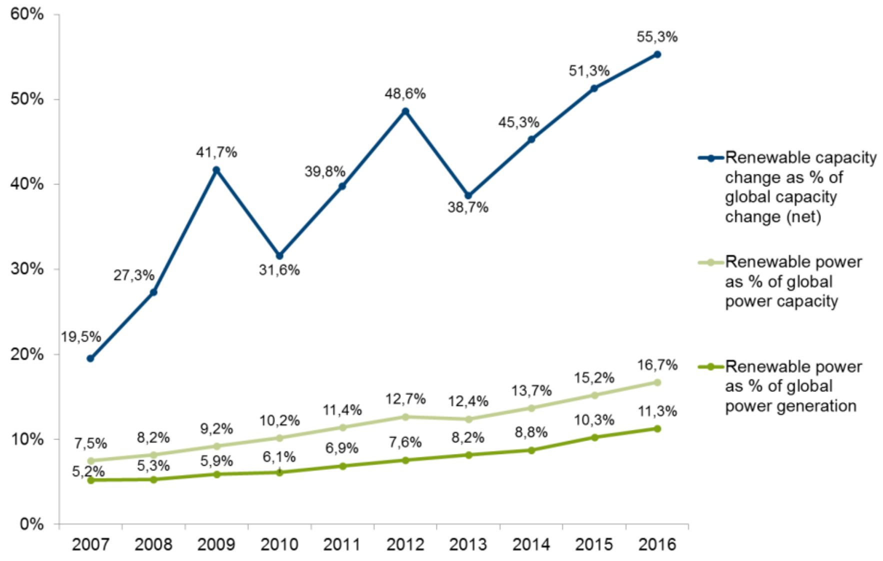
For the success of the structural change of the economy towards a low-carbon resilient economy it is important that only those investments are made that are compatible with the long-term climate goal. Substantial progress has been made in conceptualizing climate metrics in broader context of investments that assess the consistency of financing and investment needed for a two degree scenario to inform the financial decision makers on the climate aspect of their investments.

In the context of climate metrics for investors, the climate metrics will ideally provide information on where the investments they are funding stand today, as well as where the financing flows are going in terms of climate impacts, and how investors can improve their "green position". Using climate metrics as a facilitating tool, it is this type of information that informs policy decisions and provides a double check on whether climate actions are on the right track and right direction. This new and Paris Agreement target-oriented climate metrics type can complement the existing dynamic indicators to provide additional insights. It will ideally be used to analyze development/change and inform on the path of clean investments. As the extension of the dynamic perspective into climate impact measurement is far from simple, the SEI metrics project initiated by European Commission aims to significantly contribute in this endeavor. We illustrate the importance to extent the notion of dynamic climate metrics and develop new target-oriented approaches in Box 1.

Box 1: Dynamic Climate Metrics

As shown in the Figure below, the renewable capacity change as % of global capacity change (net) is illustrated for 2007-2016, which depicts an upward going trend on RE capacity generation. The graph is an indicator that measures dynamic changes in renewables investment developed in scope of the Global Trends in Renewable Energy Investment Report that is published yearly by the FS-UNEP Centre. The measurement looks at how many investments flow in and how much renewables generating capacity is added. Repeatedly disclosing the changes over time, this is a typical example for the application of dynamic climate metrics. However, any information about consistency with the two-degree target is not provided. Note, that the two lines below show a measurement over the corresponding time period: which fraction of the capacity installed / power produced in a given year is based on renewables.

Renewable Power Generation and Capacity as a Share of Global Power, 2007-2016; %



Source: Frankfurt School-UNEP Centre/BNEF, 2017. *Global Trends in Renewable Energy Investment 2017*, Frankfurt am Main: s.n.

In summary, this report uses the term climate investment metrics as a generic term for measurement approaches assessing the climate impact of financing and investments. Therefore, this holistic definition combines on purpose conventional climate metrics with the comparatively new approach of measuring two degree-consistency; in this report referred to as SEI metrics.

2.2. CONCEPTUAL FRAMEWORK TO MAP CLIMATE INVESTMENT METRICS

In recent years, there was a significant increase of financing activities and investments labelled under numerous different terms such as “green”, “ecological” or “socially responsible” which coincided with the creation of more and more climate investment metrics. Besides, a first approach in a paper by WRI, UNEP-FI and the 2-Degree Investing Initiative focusing on institutional investors only was published in 2015[9], these metrics have not yet been put into a more general conceptual framework. Therefore, this chapter is providing a conceptual

[9] Dupre, S. et al., 2015. *Climate Strategies and Metrics: Exploring Options for Institutional Investors*, s.l.: WRI / UNEP-FI / 2° Investing Initiative / Portfolio Carbon Initiative.

framework based on quality characteristics for the assessment and evaluation of climate metrics to support financial decision makers on the climate alignment of their investments.

The amount of academic literature in concern of climate investment metrics from an economic perspective is very limited.[10] Even though some first publications from the grey literature include some kind of categorization, they missed to conceptualize climate metrics in the broader context of green, ecological or socially responsible investments. Three previous studies significantly contributed to the climate metrics landscape developed in this report: Firstly, in 2014, UNEP[11]-FI and GHGP Financed Emissions Initiative have conducted a study analyzing which conventional climate metrics are used by financial institutions.[12] Secondly, there is a publication on the metrics options for institutional investors published by the WRI, UNEP[13]-FI, and the 2° Investing Initiative and the Portfolio Carbon Initiative in 2015.[14] And thirdly, we refer to a draft report *Climate Metrics: Exploring Options for Banks* from 2 degree Investing Initiative, a review of the application of climate metrics in 35 large banks.[15]

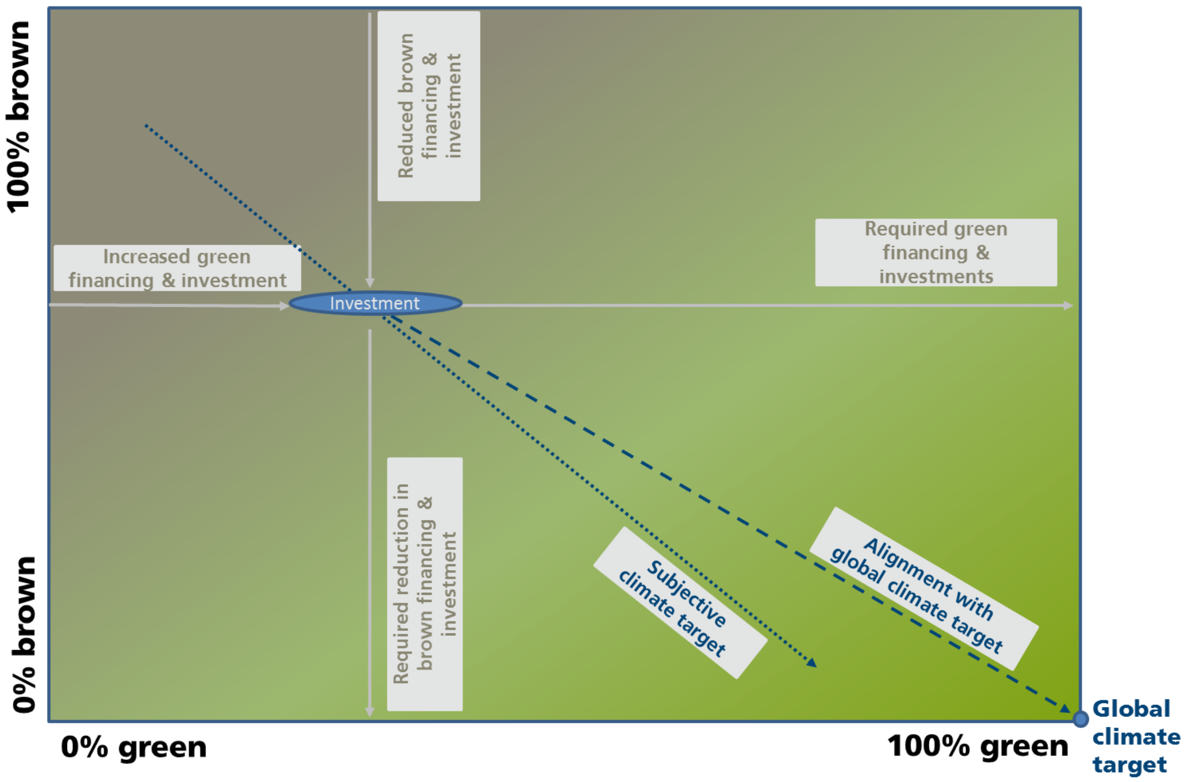
As depicted in **Figure 1**, the climate impacts of financing activities and investment opportunities can be assessed by measuring "reduced brown financing and investments" or "increased green financing and investments". Earlier, we defined a timeline of static snapshots of a financing flow or an investment as dynamic type of climate metrics. Dynamic climate metrics enable an evaluation of the climate impact of financing and investment regarding "progress-to-date" in terms of reduced brown or increased green investment. Based on the historical information a forward looking trend can be estimated by applying suitable extrapolation methods indicating a trend towards the achievement of a subjective climate target (blue dotted line in **Figure 1**). Thus, the financing flow or investment could also be assessed against the "forecast" of required green investments or to be reduced brown investments. However, this does not involve the reference to a global climate target such as the two-degree consistency. As discussed previously, it is

[10] This does not apply for the research fields of biology, chemistry, physics or other related areas.
[11] UNEP changed its name into United Nations Environment (UNE) in March 2017. As the paper was still published under the old acronym, we use this old name in this reference.
[12] UNEP FI / GHGP FINANCED EMISSIONS INITIATIVE, 2014. *Landscape Review of Alternate Climate Metrics*, s.l.: s.n.
[13] UNEP changed its name into United Nations Environment (UNE) in March 2017.
[14] Dupre, S. et al., 2015. *Climate Strategies and Metrics: Exploring Options for Institutional Investors*, s.l.: WRI / UNEP-FI / 2° Investing Initiative / Portfolio Carbon Initiative.
[15] 14 development banks and 21 private banks chosen according to a combination of global size rankings and process participation. Source: 2 Investing Initiative / UNEP FINANCE INITIATIVE / GREENHOUSE GAS PROTOCOL. "Climate Metrics: Exploring Options for Banks." DRAFT WORKING PAPER FOR CONSULTATION - DO NOT DISTRIBUTE, 2016.

important for a climate metric to assess also the direction of climate actions. This is reflected in ongoing discussions within the climate community highlighting the need for dynamic climate metrics assessing the consistency of investments with the long-term climate target (blue dashed line). While time series data of a static measure obviously introduce a dynamic element to this metric, a dynamic metric may carry substantially more information: it can also include information on companies policies, visions or other decision mechanisms related to what actually determines their actions & involvements, e.g. a low carbon strategy at the board level.

The debate has actually strong parallels to the transformation of the role of management accounting within companies; the function emerged from a merely history-based projector of figures and key performance indicators to an aggregator that is combining financials and corporate strategy and advising the executive management how to achieve set targets.[16] This is interesting because climate metrics can be, in a broader sense, considered as performance measurement system for green investments. As such, it is not a surprise that there is a demand for a climate metric that informs about strategic consistency

Figure 1: More Green vs less brown investments



[16] Nita, B., 2008. *Transformation of Management Accounting: From Management Control to Performance Management*. Business & Economics, 7(3), pp. 53-64.

The subsequent section provides an overview of existing climate metric types. Given the climate metrics literature, we are able to identify and map 14 types of metrics. Selection was based on two major selection criteria: (i) Measuring climate and environmental performance of companies; and (ii) designed for investors to inform on financing and investment decisions. The 14 climate metric types cover major climate metrics for investors without claiming completeness and will be localized in a two-dimensional matrix (see **Figure 2**).

Whereas the horizontal axis denotes the dimension "Emissions" ranging from "less brown" to "more green", the vertical axis "Time" ranges from "progress to date" to "forecast". In this context, "less brown" refers to measuring the avoidance of emission and destructive ecological impacts. "More green" represents the contrary conceptual approach of measuring achievements towards greener business operations. It is important not to mix the "green" and "brown" in Green / brown metrics which categorizes the underlying assets into "green" and "brown" and the concept we use here. "More green" and "less brown" categorizes the climate metrics into ones that measure avoidance of emission and achievement towards greenness. While the categorization of "green" and "brown" in Green / brown metrics is ambiguous for certain technologies (e.g. hydropower, nuclear) because the technologies are not seen as strict "green" or "brown",[17] categorizing metrics into measuring "less brown" or "more green" has less of this problem due to different contexts. Similarly, "progress-to-date" refers to the measurement of actual achievements (ex-post), whereas the term "forecast" relates to the forward projected perspective (ex-ante).

Figure 2 shows that there are climate metrics that inform financial decision makers (e.g. international public financial institutions, institutional investors, companies) on the environmental aspect of their investments. The metrics are diverse in terms of quality (quantitative vs. qualitative), unit of measurement, time nature of the measurement ("progress-to-date" vs "forecast") and specific characteristics (e.g. whether the metrics can aggregate positions at portfolio level).

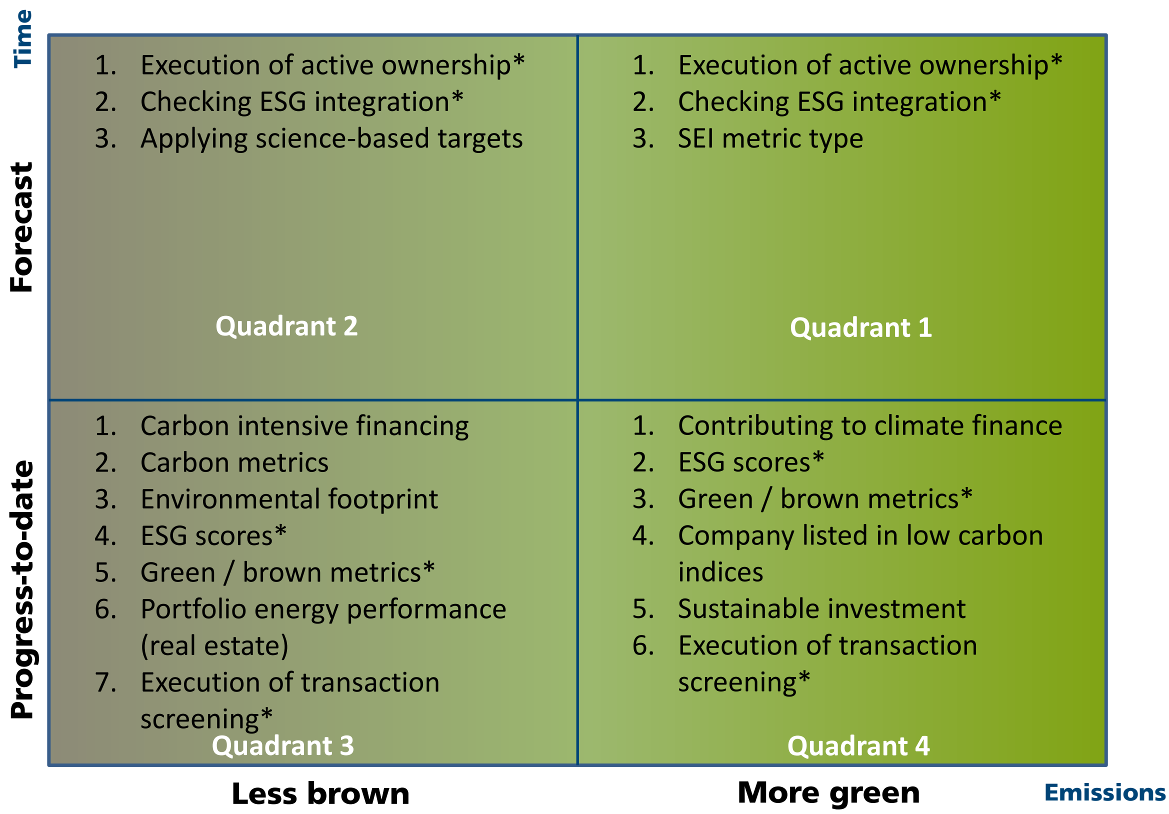
In general, we took the investor's perspective to categorize the climate investment metrics. This included a broader understanding of a metric. As such, some

[17] Dupre, S. et al., 2015. *Climate Strategies and Metrics: Exploring Options for Institutional Investors*, s.l.: WRI / UNEP-FI / 2° Investing Initiative / Portfolio Carbon Initiative.

categories may have overlaps depending on the viewpoint. Furthermore, some climate metrics are just binary indicators that investors can tick off during their decision-making process. For instance, the climate metric type ESG integration indicates if a company or project has implement ESG criteria into its code of conduct. As a consequence, the relevant information for the investor is if the investment object has or has not implemented ESG principles. At a first glance, such a climate metric may appear superficial; nonetheless it allows implementing some kind of qualitative assessment into the investment decision process.

Some climate metric types are listed under "less brown" as well as "more green" because their categorization depends on the way they are applied. We will outline the application context of the individual climate metric types that have a 'double-listing' when explaining the metric type the first time it is mentioned in the landscape.

Figure 2: Landscape of Climate Metrics



Note: * indicates the metrics that measures both "less brown" and "more green"
Source: Author's presentation

The explanation of the climate metrics classification will be done in a decreasing order; we will begin with explaining the climate metric types in quadrant 4 and finish with quadrant 1. Later on those metrics will be characterized with some more detail in **Table 1**. The table elaborates further the characteristics of the individual climate metric types. In the following we describe the metrics or classes of metrics which can be used by an investor if he wants to be more informed about if or to what extent a certain investment opportunity is consistent with the transition to a low carbon economy.

Quadrant (4) "green/progress-to date":

Contributing to climate finance

An investor may ask if the investment he/she is considering (or a large part of the company's investment that he considers to invest in) is counting towards what many institutions would call "climate finance". Climate finance is primarily related to financing approved for climate adaptation, resilience and mitigation activities. As such, it is accounted in monetary terms Climate finance also includes financing for green policies development and institutional building.[18] Climate finance has emerged as a very broad term referring to a financial aggregate. There is no clear common understanding on what exactly should be considered "climate finance".

ESG scores

Climate-related scores are embedded in the broader Environmental and Social Governance (ESG) scores. The climate scores consist of quantitative criteria (e.g. carbon footprint, quantitative emission reduction target) and qualitative criteria (e.g. qualitative emission reduction target, climate mitigation strategy).[19] ESG scores appear both in Quadrant 4 and Quadrat 3 because the objects it measures include both "more green" such as more renewable energy investments, and "less brown" aspect, e.g. energy efficiency investments.

Green / brown metrics

Green / brown metrics refers to metrics that calculate the share of the portfolio invested in "green" and "brown" sectors, companies, assets, products, activities or technologies. Green / brown metrics can reflect the current performance of a company (e.g. % of revenue of the company is from green investments in energy

[18] UNEP FI / GHGP FINANCED EMISSIONS INITIATIVE, 2014. *Landscape Review of Alternate Climate Metrics*, s.l.: s.n.
[19] This paragraph is based on Dupre, S. et al., 2015. *Climate Strategies and Metrics: Exploring Options for Institutional Investors*, s.l.: WRI / UNEP-FI / 2° Investing Initiative / Portfolio Carbon Initiative.

efficiency), but with forward-looking data it can also approximate the future performance of the company. The latter requires data disclosure on Research & Development (R&D) plans, fossil fuel reserves, capacity additions and retirement plans among others in "green" and "brown" investments.[20] The name of the metric already signals that it measure both "more green" and "less brown", thus this metric appears both in Quadrant 4 and Quadrat 3.

Company listed in low carbon indices

Low-carbon indices act as benchmark for equity portfolios. For example, the MSCI ACWI Low Carbon Target Index (which is a portfolio) represents a lower carbon exposure than the broader market by overweighing companies with low carbon emissions (to sales) and with potential low carbon emissions (market capitalization / dollar).[21] The listing in low carbon indices can act as a binary indicator for investors and enable investors to decarbonize their portfolio by limiting the portfolio exposure to climate-related risks.

Sustainable investment

An investor may ask if the investment for the investment of a company is compatible with his own criteria for a "sustainable investment". Sustainable investment refers to the financing and investments in sustainable products and projects. This includes a variety of activities (lending, underwriting, etc.) in clean energy sources and clean technologies. Most commonly sustainable investment is taking into account not only environmental (green) aspects but also social and economic considerations. A subcategory of sustainable investment is the concept of low-carbon financing, which also refers to the financing and investments in clean, environmentally friendly products and projects.[22] This metric type is accounted in monetary terms.

[20] This paragraph is based on Raynaud, J., Mary, S., Voisin, S. & Hazra, S., November 2015. *Investor Guide to Carbon Footprinting*, s.l.: Kepler Cheuvreux / IIGCC / 2° Investing Initiative / Deloitte.
[21] MSCI, 2017. *MSCI ACWI Low Carbon Target Index (GBP)*. [Online]
Available at: https://www.msci.com/documents/10199/a61f00d8-7f84-4125-ae11-db8776e981b6
[Accessed 3 February 2017].
[22] UNEP FI / GHGP FINANCED EMISSIONS INITIATIVE, 2014. *Landscape Review of Alternate Climate Metrics*, s.l.: s.n.

Execution of transaction screening

Transaction screening metrics measure the number or value of transactions screened by internal environmental and social risk mechanisms, or international standard such as the Equator Principles.[23]

Quadrant (3) "less brown/progress-to date"

Carbon intensive financing

Here, the investor is interested to measure financing of the carbon-intensive sector (e.g. fossil fuel power plant). A lower level of carbon intensive financing is an indicator of "less brown".

Carbon metrics

The climate metrics family includes carbon foot-printing and its sub-categories financed emissions, locked-in Greenhouse Gas (GHG) emissions and avoided emissions by firms. Carbon metrics measure emissions that are financed, locked-in or avoided by investors given certain arbitrary allocation rules. For example, in financed emission, tonnes of Carbon Dioxide (CO_2) equivalence financed by investors given a chosen allocation rule in an absolute value. The value can be normalized in terms of revenue, sales, market capitalization, products or employees to make them comparable across companies, sectors or portfolios. Allocation rules, which are the rules according to which CO_2 equivalent emissions are allocated to different financiers of a company / project have a big influence on the magnitude of the financed emissions value. For example, the ownership approach allocates all the emissions to shareholders while liability structure approach allocates emissions to shareholders and debtors according to the relative weight of equity and debt in the company / project.[24]

Environmental footprint

Environmental footprint is a metric type only suitable for asset owners. The metrics allocate a proportion of the environmental impact of companies relative to amount of stock held or as a proportion of, for example, enterprise value.[25]

[23] Ibid.
[24] Dupre, S. et al., 2015. *Climate Strategies and Metrics: Exploring Options for Institutional Investors*, s.l.: WRI / UNEP-FI / 2° Investing Initiative / Portfolio Carbon Initiative.
[25] UNEP FI / GHGP FINANCED EMISSIONS INITIATIVE, 2014. *Landscape Review of Alternate Climate Metrics*, s.l.: s.n.

ESG scores as well as **Green / brown metrics** have already been discussed in the section of Quadrant (4).

Portfolio energy performance (real estate)

Portfolio energy performance pertains to real estate investments. Measurements include energy consumption in real estate investments and counts of properties in the portfolios that have third party verified sustainable certification. [26] This metrics specifically pertains to the real estate sector and the measurement is unique to this sector. Given that there is no category with general measurement that can be applied to all, the overlapping of Portfolio energy performance with other metrics is minimum.

Quadrant (2) "less brown/forecast"

Execution of active ownership

Investors that have ownership rights in the companies may choose to actively take strategic decision to improve the ESG performance of their companies. Viewed as a metric, it measures whether the investors have exercised formal or informal influence on their companies to engage in ESG performance and disclosure. It can take binary values. The measurement takes both "more green" and "less brown" aspects into consideration, thus appears in both Quadrant 2 and Quadrant 1.

Checking ESG integration

ESG integration refers to the deed of screening investments for environmental and social impacts against positive lists and negative lists, as well as quantitative conditions.[27] Positive lists include a category of clean investment technologies, industries or sectors, e.g. solar and wind power investments. Negative lists, on the contrary, exclude certain technologies, industries or sectors from financing, e.g. financing restrictions for coal-fired plants.[28] Qualitative conditions are conditions under which projects / programs with potentially adverse effects on the climate get financed, e.g. best available technology, contribution to energy access or national climate strategy. Qualitative conditions are conditions usually expressed in numeric values / baselines that make projects / programs with potentially

[26] Ibid.
[27] Ibid.
[28] Höhne, N. et al., May 2015. *Developing Criteria to Align Investments with 2° C Compatible Pathways*, s.l.: NewClimate Institute / Germanwatch / 2° Investing Initiative.

adverse effects eligible for financing, e.g. carbon intensity baseline of 550 Tonnes of Carbon Dioxide Equivalent (tCO_2eq) / Megawatt-hours (MWh).[29] [30] As a consequence, climate metric type ESG integration often related to a binary indicator (yes/no).In particular, development finance institutions and climate funds have explicit or implicit mandate on environmental protection and play an important role in intermediating climate finance. These institutions have started to include climate-related criteria in their financial decision at general funding level, sector-specific level and technology-specific level. Given that ESG integration measures both "more green" and "less brown" aspects of the company and take these into consideration when making financing decision, ESG integration appears both in Quadrant 2 and Quadrant 1.

Applying science-based targets

Science-based target is designed for companies to adjust CO_2 intensity in line with the scenario that would limit global temperature to two degree above pre-industrial levels. The simplest approach is based on a linear trajectory ignoring the differences in company size, in sectors and in mitigation potentials. A more advanced approach takes the added value of companies into consideration and allocates carbon budget to companies based on their relative contribution to the economy. The science-based target which takes sectoral de-carbonisation paths into account is the most sophisticated approach of all, taking differences in sectoral potential growth, mitigation potentials, and availabilities of low-carbon technologies among others into consideration. Based on a number of assumptions, the science-based target can inform companies of their targeted CO_2 intensity in a target year that can make the company's production consistent with the two degree scenario.[31]

Quadrant (1) "green/forecast"

Execution of active ownership as well as **checking ESG integration** was already discussed in the section for Quadrant (2).

[29] Ibid.
[30] Besides this group of climate criteria mentioned, public financial institutions also use ESG scores in their decision making. The climate criteria mentioned above and ESG score are the only two climate metrics that public financial institutions use in our mapping sample.
[31] This paragraph is based on Pineda, A. C. et al., September 2014. *Methodology for Setting Corporate Emission Reduction Targets in Line with Climate Science: The Sectoral Decarbonization Approach (SDA)*, s.l.: CDP / WRI / WWF.

SEI metric type

The SEI metric type – to be developed within this project – is still in development and is based on similar principles of the science-based target setting. It provides companies a benchmark reflecting an ideal energy mix and technologies that are consistent with the two degree scenario. It aims at assessing the deviation between the current mix of energy and technologies with the benchmark. As it is scalable to the portfolio level, SEI metrics shall inform equity as well as debt investors about the two-degree consistency of their investment portfolio.[32]

2.3. ANALYSING THE CLIMATE METRICS LANDSCAPE

Next, we will provide an analysis of the characteristics of the 14 different climate metric types that aim to provide an overview of the characteristics of the climate metric types in the sample (see **Table 1**). Those characteristics include information about the reference point of the different metrics (progress up to now versus forecast) if it considers "green" or "brown" activities, whether it looks at compatibility with the 2 degree target or not and also which unit the metric actually uses.

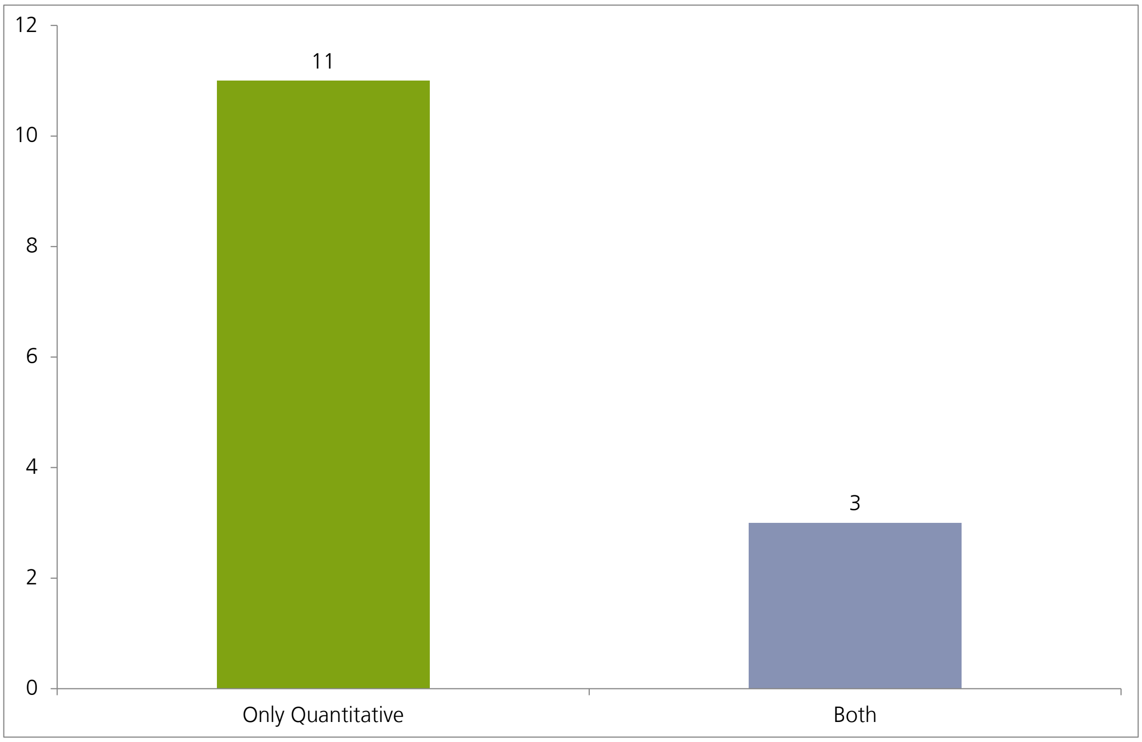
According to Chapter 2.2 there are significantly more climate metric types that measure "progress-to-date" in comparison to forecast-based metric types. "Progress to date" measurement is a back-looking method to indicate how much is achieved at a certain point in time. Only 4 metrics provide forward-looking measures into the future. This shows that the majority of existing climate metrics that are requested by stakeholders use back-ward looking data to evaluate the past performances.

Besides, it can be stated that there is no real preference in the climate metric design about the perspective, "less brown" or "more green", taken. However, it is important to mention that there are many climate metric types that can be used to analyze both perspectives.

As depicted in **Figure 3**, the majority of climate metric types have quantitative measurements. Some also include qualitative measurements, e.g. ESG integration including qualitative measurements by screening investments against positive / negative lists, besides measuring quantitative aspects.

[32] 2° Investing Initiative, 2015. *Assessing the Alignment of Portfolios with Climate Goals*, s.l.: 2° Investing Initiative.

Figure 3: Quantitative vs. qualitative climate metric types



Another difference between the individual climate metric types lies within the various units of measurement. In total, there are eight different units which explained in detail as follows:

CO2 intensity: In our sample, CO2 intensity is used as a benchmark in ESG integration and science-based target. In ESG integration, investments are screened against certain benchmark, for example, carbon intensity baseline of 550tCO2eq / unit sold, to evaluate the project's carbon intensity performance against the benchmark. CO2 intensity in another case is the target output of the science-based target for a company in a target year, e.g. a company's two degree compatible carbon intensity in 2019 may be 550tCO2eq / unit sold.

tCO2eq financed/ avoided/ locked-in/ allocated to company value: This unit measures tonnes of CO2 equivalent that can be attributed to investors based on some allocation rule. Taking financed emissions as an example, an investor's financed emissions in a given year is 400 tCO2eq under an equity allocation approach (which means the emissions are all allocated to shareholders). Tonnes of CO2 equivalent attributed to investors are a typical measurement in the carbon metrics family.

Percent of revenues based on "green" or "brown": This unit of measurement refers to % of revenue, earnings or profit from "green" and "brown" products or services. It is predominately used in Green / brown metrics.

Monetary terms: This unit of measurement counts the monetary value in the investment. It is used in carbon-intensive financing, sustainable investment (& Low-carbon financing), climate finance, all of which evaluate the value amount invested in projects with certain characteristics; usually these are energy efficient projects.

Order (ranking): This unit of measurement gives a certain order list. ESG score uses this unit of measurement by ranking companies according to the environmental and social performances.

Counts: Counts quantify the number of certain items. This unit of measurement is used in portfolio energy performance where counts of properties in the portfolio that have third party verified sustainable certification is counted, and in transaction screening where number of transactions screened for environmental performance is counted.

% deviation: % deviation from the benchmark shows how a given portfolio performs compared to a low-carbon indices are used in low-carbon indices and SEI metrics.[33]

0 or 1 (binary): Binary units take the values 0 or 1. Active ownership, for instance, is a binary measure since if the investors have exercised formal or informal influence on companies to engage in ESG performance, then it is "1" and if not, then it is "0".

Another important dimension is the asset class that the climate metric addresses in the landscape of climate metrics. While it is difficult to assign climate metrics to certain asset classes, in the literature most of the metrics are designed or already used in practice in project finance and equity portfolio. Climate metrics that assess debt side assets are rarely addressed.[34] We will discuss this implication in more detail in section 2.5.

[33] 2 degree benchmark and SEI metrics refer to the same metrics developed in this project. The report uses the two terms interchangeably.
[34] Note Sectoral Decarbonization Approach allocates carbon budget to sectors. 2 degree benchmark implicitly uses allocation of carbon budget to companies.

Table 1: Landscape of Climate Metrics

Metric type	Quantitative / Qualitative	Unit	"Progress to date" or "forecast"?	"Less brown" or "more green"?	Does it assess two degree compatibility?	Examples
Execution of active ownership	Quantitative and Qualitative	0 or 1	Forecast	Both	No	Engaging companies on ESG performance or ESG disclosure through formal rights and / or informal influence.
Carbon metrics	Quantitative	tCO2eq financed, avoided, locked-in	Progress to date	Less brown	No	Financed emissions, locked-in GHG emissions, avoided emissions.
Environmental footprint	Quantitative	tCO2eq allocated to company value	Progress to date	Less brown	No	Allocation of a proportion of the environmental impact of companies relative to amount of stock held or as a proportion of enterprise value.
Carbon intensive financing	Quantitative	Monetary terms	Progress to date	Less brown	No	Financing value or exposure to carbon-intensive sectors.
Sustainable investment	Quantitative	Monetary terms	Progress to date	More green	No	Financing and investments in low-carbon projects, e.g. clean energy, energy efficiency, green vehicles, renewables projects.
Contributing to climate finance	Quantitative	Monetary terms	Progress to date	More green	No	Financing for green policies, stronger institutions. Related to climate adaptation and resilience rather than climate mitigation.
Green / brown metrics	Quantitative	% of revenue, earnings or profit from "green" and "brown" products or services	Progress to date	Both	No	Certain company has x% of its revenue from "green" activities, e.g. energy efficiency businesses; and y% of its revenues from "brown" activities, e.g. selling electricity generated coal power plant, where x% + y% = 100%.
Checking ESG integration	Quantitative and Qualitative	CO2 intensity (tCO2eq/production unit)	Forecast	Both	No	Screening investments for environmental and social impacts against positive lists and negative lists, as well as quantitative conditions.

Execution of transaction screening	Quantitative	Number of transactions / Monetary terms	Progress to date	More green	No	Transaction number or transaction value screened by internal environmental and social risk mechanisms, or international standard such as Equator Principle.
ESG scores	Quantitative and Qualitative	Order (ranking)	Progress to date	Both	No	Each company receives a score which signals the level of carbon exposure risks, e.g. MSCI ESG Ratings, Bloomberg ESG Disclosure Scores.
Company listed in low-carbon indices	Quantitative	% deviation from the indices	Progress to date	More green	No	Company listed in a benchmark that overweighs companies with low carbon emissions, e.g. the MSCI ACWI Low Carbon Target Index and the STOXX Low Carbon indices.
Portfolio energy performance (real estate)	Quantitative	Counts / units of energy consumption	Progress to date	More green	No	Energy consumption in real estate investments; counts of properties in the portfolios that have third party verified sustainable certification.
SEI metric type	Quantitative	% deviation from the benchmark	Forecast	More green	Yes	Benchmark that assesses a portfolio's consistency with the two degree scenario, e.g. SEI metrics.
Applying science-based targets	Quantitative	tCO2e/tonne	Forecast	Less brown	Yes	A company in a given year Y should have CO2 intensity X tCO2e/tonne in order to be compatible with two degree scenario in 2050, where Y is between 2010 and 2050.

Source: Dupre and Chenet (2012); Dupre, et al (2013); UNEP FI / GHGP FINANCED EMISSIONS INITIATIVE (2014); Dupre, Thomä, et al. (2015); Höhne, Bals, et al. (May 2015); Raynaud, et al. (November 2015); 2° Investing Initiative (2015), Thomä, Weber and Dupre (2016), and MSCI (2017)

2.4. CHALLENGES OF CLIMATE METRICS

Climate metrics, like all other metrics are constraint by the challenges related to the act or process of measurement. This section aims to discuss the most relevant challenges within a certain focus on those challenges that arise during the development of an SEI-type metrics as discussed within this project / report.[35]

First, we look into general inherent challenges of climate metrics. One challenge is the **selection of the adequate climate metrics**. The assessment of "Landscape Review of Alternate Metrics" published by UNEP FI and the GHGP Financed Emission Initiative in 2014 demonstrates that banks and institutional investors use about different 70 indicators that can be assigned to the individual metric types and even more names and labels were used for the same metric. As a consequence, it seems difficult for investors to select the most useful climate metrics for their investment decisions. It is often unclear what is comparable and what not.

One of the key selection criteria for the climate metric type landscape was that climate metrics needed to be designed to inform investors' decisions. On an individual basis all of them comply with this requirement. However, investors might be interested in **aggregating climate metrics on a portfolio-level**. Even though many of the climate metric types are expressed by numeric values using quantitative units of measurement, an aggregation might not be useful or provide wrong information. A challenge in this context is the difficulty to control that all climate metrics for the individual portfolio components (e.g. companies) are calculated following the same (standardized) procedure and relate to the same data. For instance, it is possible to aggregate „Green / brown Metrics" if there is granular data for each company in observation, which means we can clearly say how much % of products and services in the company are green and how much is brown (where they should cover all the products and services in the company). However, we observe that full disclosure is not possible for the reason that it is difficult to classify certain sectors in strict "green" or "brown", e.g. hydro power. Frequently only % of green in certain products and services are reported. However, aggregating different categories of "green" may also not make sense. We will extend the discussion of potential challenges in the next section.

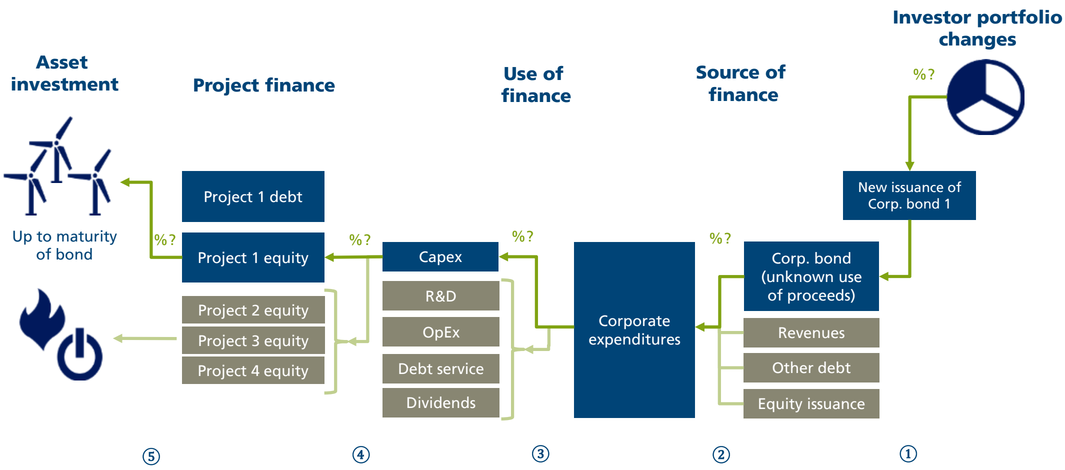
[35] As a consequence, there may well be additional challenges for the individual metric types discussed in the previous section which are not covered within this section.

Another problem is the **completeness and inconsistency of data** for the individual metric: This challenge involves on the one side unavailability of data for individual companies and on the other side the risk that the same metric might be not determined based on the same information. Even though financial institutions may define how to determine individual metrics, there remains a risk of incompleteness or inconsistency of data reported by companies.

Box 2: Operationalize climate metric concepts

One prototype that extends the perspective that most existing climate metrics offer has been proposed and discussed within the SEI metrics project. As illustrated in the Figure below, the approach links the changes in investor portfolio to the resulting changes of green assets. The approach calculates how much clean technology assets are resulting from US$ 1 change in investment from the investor. In doing so, such an approach would clearly provide additional and useful information and appears worth following. Nevertheless, we suggest that challenges in data collection, information disclosure and assumptions should not be under-estimated (see a more comprehensive treatment of data availability and assumptions needed as well as error calculation in Annex).

The biggest challenges in implementing the prototype relate to the path dependency and the economic efficiency of being a metric that can provide investors with a cost-efficient tool to inform investment decisions and policy makers a benchmark to assess direction.



Note: Prototype of a Proposed Dynamic Climate Metric

Source: Adapted from the idea of 2 degree Investing Initiative.

Next, climate metrics are confronted with the **reflection of uncertainties**: This challenge relates to the risk of different and inconsistent approaches to reflect uncertainties about data or future events. This challenge is especially valid for all qualitative metrics but also to metrics that include emission projections.

Furthermore the **scope of interpretation** may vary: This challenge can apply in two ways. First, the measurement of qualitative metrics leaves room for interpretation even though assessment guidelines might be in place. It is one thing to have a procedure foreseen and another thing to actually follow that procedure in everyday decisions. Second, the explanatory power of individual quantitative measures might be limited and always dependent on benchmark values.

An additional risk is that some climate metrics are **missing a link to strategy**: This kind of challenges is known from other performance measurement systems[36] but also applies to climate metrics. The interpretation of individual climate metrics, especially the mere assessment of quantitative ones risks supporting wrong decisions if they are analyzed without contextualizing the individual company's strategy. Any kind of carbon metric on a stand-alone basis, for instance, would not provide much information without further background information about company-specific targets, industry benchmarks or previous emission levels.

Now, we draw attention to the challenges in the operationalization of dynamic climate metrics that set the future development of investment objects into the context of a specified target. Their application remains difficult as a number of specific challenges arise. The understanding of these specific challenges is important as this paper seeks to extend the notion of how metrics as envisioned within this project can be developed and applied.

One major constraint and probably the most important one in the design of metrics which seek to inform about the consistency with a two-degree target is to define the **reference point** for the comparison. One option would be to assume a "fair share" rule and compare a portfolio with a benchmark that is calculated based on the current point in time as starting point and the increase / decrease of the exposure over a 5-year time horizon. The fair share rule maps economic impact

[36] Bourne, M. et al., 2000. *Designing, implementing and updating performance measurement systems.* International Journal of Operations & Production Management, 20(7), pp. 754-771.

to portfolio underlying companies based on the market share of the companies in the market. Then the method provides either an absolute 2°C alignment assessment or a relative 2°C alignment assessment depending on data availability in the sector.[37] Another constraint of mapping the two-degree consistency of company actions and potential improvements signifies the **path dependency**. Path-dependency acknowledges that there are multiple ways to achieve two-degree consistency like for example using different technological approaches or different implementation measures resulting into different speed and levels of improvement within or across individual sectors. Another limitation is the **lock-in effect**. This term refers to the tendency for certain carbon-intensive technological investment to persist over time, making it more difficult to move to lower-carbon pathways, and owing to a combination of linked technical, economic, and institutional factors. As a consequence, the tracking of improvement against an overarching climate goal is complex and difficult to evaluate. This aspect makes it also difficult to compare the development of two companies. Closely linked to the challenge of path dependency is the difficulty to reflect the dimension of **time** into the SEI metric. Different to most conventional climate metrics, accurate SEI metrics would need to constantly measure the company's evolution rather than measuring a value at a specific date.

Given these major challenges, it is necessary to conduct further research and tests to overcome the existing barriers in the development and application of SEI metrics for the evaluation of investment decision. The SEI metrics project has the potential to significantly contribute useful insights to this discussion.

In regard to the numerous challenges of climate metrics mentioned above, we would like to take a step back and have a look into general quality criteria of metrics, also relevant for climate metrics in **Box 3**.

[37] 2° Investing Initiative, 2016. *2°C Portfolio Assessment*, s.l.: s.n.

Box 3: Quality characteristics of metrics

The measuring procedure aims to receive information concerning a specified criterion. Therefore, measurement seeks to be precise and the relationship between the measured values should reflect the relationships in the real world. In order to evaluate the quality of existing climate metrics as well as for the development of new climate metrics, this section proposes a number of characteristics that may be considered (see Table below).[38]

Characteristic	**Description**
Valid and meaningful	A metric should adequately reflect the phenomenon it is intended to measure and should be appropriate to the needs of the user.
Sensitive and specific to the underlying phenomenon	Sensitivity relates to how significantly a metric varies according to changes in the underlying phenomenon.
Grounded in research affecting outcomes	Awareness of the key influences and factors on the metric.
Statistically sound	Metric measurement needs to be methodologically sound and fit for the purpose to which it is being applied.
Intelligible and easily interpreted	Indicators should be sufficiently simple to be interpreted in practice and intuitive in the sense that it is obvious what the metric is measuring.
Relate where appropriate to other metrics	A single metric often tends to show part of a phenomenon and is best interpreted alongside other similar indicators.
Allow international comparison	Metrics need to reflect specific goals, but where possible should also be consistent with those used in international metrics programs so that comparisons can be made.
Ability to be disaggregated over time	Metrics should be able to be broken down into areas of particular interest, such as regional areas.
Consistency over time	The usefulness of the metric is directly related to the ability to track trends over time, so as far as possible metrics should be consistent.

[38] The indicator characteristics are taken from Brown, D., 2009. *Good Practice Guidelines for Indicator Development and Reporting*, Busan, KOREA: A contributed paper, Third Wolrd Forum on 'Statistics, Knowledge and Policy', accessible at https://www.oecd.org/site/progresskorea/43586563.pdf; (the criteria are specific for New Zealand, take the parts where appropriate); The last two indicator characteristics are taken from Anon., n.d. *Characteristics of Good Indicators*. [Online] Available at:http://web1.sph.emory.edu/DTTAC/planningFundamentals/docs/Mod5-12.CharacteristicsofGoodIndicators.pdf

Timeliness	There should be minimal time lag between the collection and reporting of data to ensure that metrics are reporting current rather than historical information.
Linked to policy or emerging issues	Metrics should be selected to reflect important issues as closely as possible. Where there is an emerging issue, metrics should be developed to monitor it.
Compel interest and excite	The metric should resonate with the intended audience.
Meaningful	The metric should represent important information about the program for stakeholders.
Practical and feasible	The data for the metrics should not be too burdensome to collect. The indicator should be reasonable in terms of the data collection cost, frequency, and timeliness for inclusion in the decision-making process.

The reflection of these quality criteria in the design of climate metrics is important to ensure their informativeness, relevance as well as adequacy. Given the large number of climate metrics applied by investors (including asset owners, asset managers, bank, and international financial institutions) to evaluate investment decisions[39] the quality characteristics can also help to choose the right metric for the right purpose.

[39] The report "Landscape Review of Alternate Metrics" published by UNEP FI and the GHGP Financed Emission Initiative in 2014 conducted a large-scale empirical analysis on climate metrics applied by banks and institutional investors and found that a collection of approximately 70 metrics are included in the range of observed metric types. The report denotes 13 different metric types.

2.5. SEI METRICS IN THE LANDSCAPE

There are already a number of climate metrics that allow for integration of climate aspects into investment decisions. Current policies focus on setting a price on carbon which would create incentives for investors to shift investments into clean technologies; however no framework on international level has been reached.[40] As such, the application of climate metrics targeted at financing and investment decisions may reveal economic advantages. Furthermore, with the notable exception of the metric proposed for equity in the context of the current project, the metrics are typically not applied to inform on the consistency between the investment portfolio and the two degree limit.[41] Conventional climate metrics will always only allow observing and analyzing developments and changes in actions on company-level to some extent. As illustrated in **Figure 2**, most of them provide an exposed-based notion of development (progress-to-date) or an ex-ante notion of development (forecast-oriented) optionally with regard to an individually defined target (if applicable). They do not refer to international climate targets and inform about any environmental achievement in a higher context. Investments that involve climate benefits may still create barriers to reach the two degree scenario as it lacks a benchmark to inform about the required level of investment in context with asset-types and potential path dependencies. A climate metric that quantifies the investment gap that is needed to reach the two degree scenario, in this paper referred to as SEI metric, is required.

SEI metrics are quantitative metrics that measure the relative deviation of a given investment portfolio from 2°C decarbonisation pathways. As depicted in **Figure 1**, most of the metrics locate in Quadrant 3 and Quadrant 4 (progress-to-date metrics). There are comparatively few forecast-oriented metrics. In particular, the Quadrant 1 ("more green / forecast") that SEI metrics is in has also few candidates. This reveals that there is a gap where forecast oriented metrics that link climate goals with financing / investments are lacking. SEI metrics attempts to fill the gap that no metric to date serves as an indicator directly linked to an underlying climate goal. Currently, the climate community is faced with long life-time of assets (brown) and the urgency of decarbonization. Conventional climate metrics

[40] Dupre, S. & Chenet, H., 2012. *Connecting the Dots between Climate Goals Portfolio Allocation and Financial Regulation*, s.l.: 2° Investing Initiative.
[41] Höhne, N. et al., May 2015. *Developing Criteria to Align Investments with 2° C Compatible Pathways*, s.l.: NewClimate Institute / Germanwatch / 2° Investing Initiative.

inform financial institutions and investors on the climate benefits but it does not ensure that the investments are enough for the two degree limit.[42] SEI metrics on the other hand serve as an important step in translating and connecting investments with the global climate goal, informing not only on the status of progress, but also on "how much is enough".

2.6. THE ROLE OF DEBT VS EQUITY INVESTORS IN CLIMATE METRICS

As indicated in section 2.2, it is difficult to assign climate metrics directly to one or several asset classes. However, it can be observed that most of the climate metrics in our sample are mentioned in the context of equity investment and project finance. It has not yet been addressed to which extent they are useful or can be applied for decisions on debt investments. Closely related to this issue, there is an ongoing debate about the role and impact of debt investors on the sustainable or green development of companies compared to those of equity investors. It would be easy to say that debt investors carry less responsibility for the companies or projects which they finance based on their inferior default rights. However, there are a number of arguments that the role and influence of debt investors should not be neglected in terms of sustainability aspects as companies often require debt finance to realize economic growth.[43]

The financial sector itself as a provider of capital claims to contribute actively to making the world a better place.[44] Also many researchers and practitioners assume that green or socially responsible investing promotes companies' environmental and social performance. Bank loans globally signify the largest source of external financing.[45] Therefore, the financial sector is enabled to direct firm operations indirectly by their activities of screening, monitoring and contract enforcement because these determine the access to finance.[46] Arguments why debt investors

[42] Höhne, N. et al., May 2015. *Developing Criteria to Align Investments with 2° C Compatible Pathways*, s.l.: NewClimate Institute / Germanwatch / 2° Investing Initiative.
[43] Scholtens, B., 2006. Finance as a Driver of Corporate Social Responsibility. *Journal of Business Ethics*, 68, pp. 19-33.
[44] E.g. Deutsche Bank, 2017. *Responsible business*. [Online] Retrieved from https://www.db.com/cr/en/responsible-business/index.htm in May 2017; HSBC, 2017. Sustainability. Retrieved from http://www.hsbc.com/our-approach/sustainability in May 2017
[45] International Bank for Reconstruction and Development/ The World Bank, 2015. Long-Term Finance. Global Financial Development Report 2015/2016.
Retrieved from http://documents.worldbank.org/curated/en/955811467986333727/pdf/99100-PUB-REVISED-Box393195B-OUO-9-until-9-14-15.pdf in May 2017
[46] Scholten, B., 2006. Finance as a Driver of Corporate Social Responsibility. *Journal of Business Ethics, 68*, 19-33.

exert influence on the social and environmental performance of companies can be categorized into three broad areas:

First, debt investors have an interest that their clients are **financially viable** and able to **repay debt on time**. Indeed, companies that steadily comply with the key selection criteria of stakeholders (including debt investors) are considered to outperform competitors and enjoy competitive advantages.[47] There are a number of recent research studies that show that companies with better social and environmental performance can outperform the market over a long-term period[48] as well as during their initial public offering (IPO) process.[49] However, there is also skepticism in this field as the empirical evidence for a positive relationship between environmental performance and company profitability is mixed, applied methodologies may have weaknesses. Some studies even find a negative association.[50] Nonetheless, it seems reasonable to assume that debt investors trust in the concept of eco-efficiency, an "approach that seeks to simultaneously reduce costs and environmental impacts using tactics such as waste minimization or reuse, pollution prevention or technological improvement", to improve companies' repayment ability.[51] Further cost saving effects can be generated through the creation of corporate reputation.[52] Most green products are associated with better quality and fair business practices[53] that can convince consumers to pay a premium price for sustainable products.[54] The claim of corporate responsibility and sustainability has become a mass phenomenon.[55] Researchers have observed an

[47] Hall, R., 1993. A framework linking intangible resources and capabilities to sustainable competitive advantage. *Strategic Management Journal*, *14*(8), 607–618.
[48] Dam, L, & Scholtens, B., 2015. Toward a theory of responsible investing: On the economic foundations of corporate social responsibility. *Resource and Ernegy Economics, 41*, 103-121.
Guenster, N., Bauer, R., Derwall, J., & Koedijk, 2011. The Economic Value of Corporate Eco-Efficiency. *European Financial Management, 17*(4), 679-704.
[49] Chan, P. T., & Walter, T., 2014. Investment performance of ''environmentally-friendly'' firms and their initial public offers and seasoned equity offers. *Journal of Banking & Finance, 44*, 177-188.
[50] Al Abri, I., Xiang, B., & Hodges, A., 2016. Does it pay to be sustainable? Corporate sustainability and corporate financial performance: A study based on the Dow Jones Sustainability Index (DJSI). Paper presented at Paper presented at *Southern Agricultural Economics Association's Annual Meeting.* San Antonio, Texas, United States of America.
Renneboog, L., Horst, J. T., & Zhang, C., 2008. Socially responsible investments: Institutional aspects, performance, and investor behavior. *Journal of Banking & Finance, 32*, 1723-1742.
[51] Korhonen, J., & Seager, T. P., 2008. Beyond Eco-Efficiency: a Resilience Perspective. *Business Strategy and the Environment*, *17*(7), 411–419.
[52] Barney, J., 1991. Firm Resources and Sustained Competitive Advantage. *Journal of Management*, *17*(1), 99–120.
Sur, S., & Sirsly, C. A. T., 2013. What's in a name? Decomposing corporate reputation to assess the relative impact of temporal, firm and industry level factors. *Journal of Management and Governance*, *17*(4), 1047–1072.
[53] (McWilliams, A., & Siegel, D. S., 2001. Note Corporate Social Responsibility : a Theory of the Firm Perspective. *Academy of Management Journal*, *26*(1), 117–127.
[54] Laroche, M., Bergeron, J., & Barbaro-Forleo, G., 2001. Targeting consumers who are willing to pay more for environmentally friendly products. *Journal of Consumer Marketing*, *18*(6), 503–520.
[55] Pedersen, E. R., & Neergaard, P., 2008. From periphery to center: how CSR is integrated in mainstream performance management frameworks. *Measuring Business Excellence*, *12*(1), 4–12.

increased loyalty of consumers for products with a clean image and reputation.[56] Firms may be able to realize lower salaries, attract employees[57] and achieve improved negotiation margins with clients and suppliers.[58] Also, green washing remains a wide spread concern.[59]

The second argument for debt investors to take responsibility and insist on improvements of the environmental and social performance of their clients is related to **risk management** aspects. Empirical studies present comparable results. Sharfman & Fernando (2008) found that companies caring about their environmental performance signal their awareness of risks and are able to reduce their weighted average cost of capital.[60] The researchers also postulate that these companies improve their ability to carry debt over time. In accordance with this, social and environmental performance significantly lowers the idiosyncratic risk of a company.[61] It is assumed that companies that proactively engage in sustainability can reduce their future political cost that may arise as the interaction of a company with its societal and regulatory environment may cause additional costs.[62] Companies anticipate regulatory actions and adjust their business practices to avoid higher future costs.[63] In addition, there is empirical evidence that responsible bond funds significantly outperform conventional bond funds by mitigating ESG risk; in particular during economic crisis situations.[64]

Third, debt investors have a severe interest to improve their own green investment **reputation** as it may involve similar benefits for them as previously mentioned for their client companies.[65] Besides, the financial sector is considered as high-risk industry for sustainability issues. Since the financial crisis in 2009, especially banks

[56] Fombrun, C. J., Gardberg, N. A., & Barnett, M. L., 2000. Opportunity Platforms and Safety Nets: Corporate Citizenship and Reputational Risk. *Business and Society Review*, *105*(1), 85–106.
[57] Deephouse, D. L., 2000. Media Reputation as a Strategic Resource: An Integration of Mass Communication and Resource-Based Theories. *Journal of Management*, *26*(6), 1091–1112.
[58] Rose, C., & Thomsen, S., 2004. The impact of corporate reputation on performance: Some Danish evidence. *European Management Journal*, *22*(2), 201–210.
[59] Laufer, W. S., 2014. Corporate Social Accountability and Greenwashing. Jornal of Business Ethics, 43(3), 253–261.
[60] Sharfman, M. P., & Fernando, C. S., 2008. Environmental Risk Management and the Cost of Capital. *Strategic Management Journal*, *29*(6), 569–592.
[61] Mishra, S., & Modi, S. B., 2012. Positive and Negative Corporate Social Responsibility, Financial Leverage, and Idiosyncratic Risk. *Journal of Business Ethics*, *117*(2), 431–448.
[62] Watts, R. L., & Zimmerman, J. L., 1986. *Positive Accounting Theory*. Upper Saddle River: Prentice Hall.
[63] Gamerschlag, R., Möller, K., & Verbeeten, F., 2010. Determinants of voluntary CSR disclosure: empirical evidence from Germany. *Review of Managerial Science*, *5*(2–3), 233–262.
[64] Henke, H. M., 2016. The effect of social screening on bond mutual fund performance. *Journal of Banking and Finance, 67*, 69-84.
[65] Wu, M. W., & Shen,, C. H., 2013. Corporate social responsibility in the banking industry: Motives and financial performance. *Journal of Banking & Finance, 37*, 3529-3547.

have experienced a substantial decline in reputation[66] because they are perceived to be unethical and insincere actors.[67]

Comparing the arguments for debt investors taking over responsibility for their investments and subsequently influencing the social and environmental performance of their clients to those of equity investors, in particular institutional equity investors, it can be stated that there is not much difference between them. It might be necessary to consider the third argument less applicable for private equity investors; however, the first two most important arguments do not seem to be different from the equity investors' perspective.

Several climate metrics in our sample potentially require a rule to allocate responsibilities / achievements to various financiers. For example, carbon metrics may require such a rule to allocate tCO2eq financed, avoided or locked- in among equity holders and debt holders. The rule can play an important role in determining the relative responsibilities of equity holders versus debt holders. Given the arguments presented above, we consider the possibility that the requirements of debt investors and equity investors in metrics to be similar. That means, it can be questioned if an approach to measure the two-degree consistency of companies really requires reflecting debt and equity portions. To further unveil this implication, we develop a framework to test the impact of different levels of debt-equity-ratios on the environmental performance of companies in the next chapter. This framework will enable us to reflect consequences of the different positions. To further unveil this implication, we develop a framework to test the impact of different levels of debt-equity-ratios on the environmental performance of companies in the next chapter. This framework will enable us to reflect consequences of the different positions.

[66] Menassa, E., & Brodhäcker, M., 2015. The type and quantity of corporate social disclosures of German "Universal" banks. *Journal of Management and Governance*, 1–25.
[67] Pérez, A., & Rodríguez del Bosque, I., 2011. The Role of CSR in the Corporate Identity of Banking Service Providers. *Journal of Business Ethics*, *108*(2), 145–166.

3. DEBT-EQUITY PERSPECTIVES ON MAPPING GREEN INVESTMENTS

The coordinate system presented in the last chapter allows for a specific type of climate metric to be defined in the climate metric landscape. Most of the climate metrics that employ the static approach are backward looking (measuring progress-to-date). Several initiatives are exploring alternative metrics that inform about consistency with higher level climate targets (e.g. two degree consistency). Given that the financing assets can be generally divided in to debt and equity, the assessment for how much climate responsibility investor account in different assets classes need a guiding rule. The arbitrary allocation rule for the relative responsibility allocation among equity holders and debt holders becomes very relevant when discussing climate metrics for investors.

The role of debt investors on the sustainable or green development of companies compared to those of equity investors is an ongoing debate in the climate community (see Section 2.6). The Financial Stability Board - Task Force on Climate-related Financial Disclosures (FSB – TCFD) recommends quantitative disclosure analyses relating organisations in the economy to potential climate scenarios including the two degree scenario.[68] So far, there is no common ground on the attribution rule to equity and debt holders. Investors would need one solution on the actual attribution to emissions, and ideally provided with a tool to assess whether the underlying investments are aligned with the global climate target.

Given the importance of the topic, we have developed a general mapping of climate responsibilities (emissions, green assets needed, etc.) to investors with a flexible weighting factor in this chapter.

The method is robust in the sense that the total amount of green assets will stay an invariant variable. Thus, this framework contributes to the discussion of equity and debt issues in climate metrics. Notably, treating debt and equity alike provides consistency to the current SEI metrics equity approach in the SEI project.

We also apply the framework to a set of five stylized investment portfolios. Based on the results, we confirm that differentiating between debt and equity has a

[68] Financial Stability Board, 2016. *Recommendations of the Task Force on Climate-related Financial Disclosures*, s.l.: s.n.

strong influence on what the metric shows and it may also shift relative positions of the portfolios. We finally also extend our view to a dynamic view on the metric, thereby taking up the discussion about so-called flow-based metrics (see **Box 1**).

3.1. A FRAMEWORK TO DISCUSS ATTRIBUTION OF GREEN ASSETS OR EMISSIONS TO DEBT OR EQUITY

As discussed above, these metrics often face the challenge to attribute something, e.g. emissions or "green assets" to investment. One of the questions raised in this respect is asking to what extent debt and equity should be treated differently. In other words, if a company owns US$ 100m in green real assets (e.g. a wind farm), then how much should be attributed to an investor who owns 10 percent of that firm's equity? Or someone who provides US$ 5m worth of debt?

While the current debate has been outlined in section 2.6, this subsection suggests a simple framework to compare the quantitative consequences of attaching different weights to debt or equity within an investor's portfolio. We then illustrate the consequences of different weights for a small number of archetypal portfolios.

We assume that company $\mathrm{i}\ (1 \ldots \mathrm{n})$ has issued total debt $\mathrm{d_i}$ and equity $\mathrm{e_i}$. Each of those companies is responsible for some "green" ($\mathrm{g_i}$) or "brown" ($\mathrm{b_i}$) activity. This could be "owning green infrastructure" or "producing emissions", but also things such as "additional investment in green infrastructure. Further, we assume that there are investors $\mathrm{j}\ (1 \ldots \mathrm{m})$ who possess some of the debt $\mathrm{d_i^j}$ or equity $\mathrm{e_i^j}$ of firm i.

If we consider the simple "extreme cases" first; namely, either an attribution based on equity only or on debt only, then in the former case the attribution to investor j may be represented as

$\mathrm{g_i^j} = \mathrm{g_i} \frac{\mathrm{e_i^j}}{\mathrm{e_i}}$ ("Green activity of company i to investor j based on **equity** only") or

$\mathrm{g_i^j} = \mathrm{g_i} \frac{\mathrm{d_i^j}}{\mathrm{d_i}}$ ("Green activity of company i to investor j based on **debt** only").

"Brown" activities could be attributed accordingly.

As it is typically considered inappropriate to attribute the activities based exclusively on either debt or equity, we suggest a framework to leave this open and introduce a weighting that can continuously shift between exclusive equity contribution and pure debt contribution.

There are infinitely many ways to attach weight to debt or equity investments. One helpful property of any such mapping would be that the sum of, for instance, green investments or financed emissions or whatever is mapped to the investments (debt and equity) is invariant with respect to the weighting that is applied. In other words, if green power generation assets (owned by company $\mathrm{i}\,(1 \ldots \mathrm{n})$) are mapped to all their debt and equity holders, then the sum of all mapped assets should (i) be equal to the sum of the firm's actual possession of green power generation assets and (ii) this should be the case irrespective of the weight that is attached to equity and debt. For the case of financed emissions, this means that total emissions attributed to the total group of investors should be the same if we compare a case where all emissions are attributed based on equity to a case where debt is carrying some weight, too.

We therefore suggest a framework that attempts to parametrize the weight by choosing β between 0 and 1, where $\beta = 1$ represents the extreme case that all is attributed to equity and $\beta = 0$ refers to a situation where all is attributed to debt. Values in-between assign some weight to both with the "special" case of $\beta = \frac{1}{2}$ making no difference between a dollar of debt investment and a dollar of equity investment.

The "green activity" of company i attributed to an investor based on his debt *and* equity portfolio positions is suggested as:

$\mathbf{g}_{\mathbf{i}}^{\mathbf{j}} = \frac{\beta e_i^j + (1-\beta) d_i^j}{\beta e_i + (1-\beta) d_i}\, \boldsymbol{g}_i$ (for "brown" activities $\mathbf{b}_{\mathbf{i}}^{\mathbf{j}}$ accordingly). **(1)**

Note, that the "extreme cases" as introduced above naturally emerge for $\beta = 0$ and for $\beta = 1.$ Our suggested framework also fulfills the invariance condition as laid out above. The "green activity" to be attributed to the full portfolio of one investor j (denoted by g^j) can then be expressed as the simple sum over all his portfolio positions (e_i^j, d_i^j):

$$\boldsymbol{g^j} = \sum_{i=1}^{n} \frac{\beta e_i^j + (1-\beta) d_i^j}{\beta E_i + (1-\beta) D_i} \boldsymbol{g_i} \text{ , with } (\boldsymbol{0} < \boldsymbol{\beta} < \boldsymbol{1}) \text{ , and } \boldsymbol{b^j} \text{ accordingly.} \quad \textbf{(2)}$$

This represents a framework that is able to map any measure or indicator that can be quantified on the level of a company to an investor-portfolio consisting of debt and equity.

Numerical application of this framework to any portfolio requires (i) portfolio data, (ii) market data on the companies that are in the portfolio, such as total equity and total debt, (iii) any data on the "activities" to be mapped to the portfolio, such as "green assets" owned by the companies, carbon emissions, etc.

For the sake of easier reference, the following table (**Table 2**) summarizes the variables as they are used in the framework.

Table 2: Variables in the Framework

j: investors (1 … m)
i: companies (1 … n)
d_i^j : debt that investor j holds in company i
e_i^j : equity that investor j holds in company i
e_i : total equity of company i : $e_i = \sum_{j=1}^{m} e_i^j$
d_i : total debt of company i : $d_i = \sum_{j=1}^{m} d_i^j$
g_i : "green" assets of company i
b_i : "brown" assets of company i
g_i^j : "green" assets of company i attributed to investor j
b_i^j : "brown" assets of company i attributed to investor j
g^j : total "green" assets attributed to investor j
b^j : total "brown" assets attributed to investor j
β : weight, $\beta = 1$: only equity; $\beta = 0$: only debt

3.2. APPLICATION TO FIVE STYLIZED INVESTMENT PORTFOLIOS

We now apply the framework as developed in section 3.1 to five stereotype investment portfolios. This serves to illustrate how the framework can be applied and which aspects of a portfolio and of the metrics-design may drive the results shown by the metric.

We assume three representative companies of which the first (1) performs "green activities", the second (2) performs "brown activities" and the third (3) is neither "green" nor "brown". They all have issued debt and equity which can be part of an investor's portfolio. We assume a capital structure of 40% equity and 60% debt for all companies. Changing this assumption will change the number that the different metrics will yield, but it does not affect our qualitative results.

We assume five different portfolios and apply a "greenness" metrics as well as a "brownness" metrics to all the portfolios for different debt/equity weights. Then we examine what the different metrics would show as results for the corresponding portfolios.

The five portfolios are normalized to identical sizes. In other words, without loss of generality they all have an identical size of 100US$ (or 100%) in order to keep the results of the metrics comparable across portfolios. For larger portfolios the result of the metrics simply scales linearly with the size. The **five stylized portfolios** are:

Green Debt: A portfolio that contains debt only. 90% climate irrelevant debt (company 3) and 10% green debt (company 1).

Energy Mixed: A portfolio containing energy assets, but not restricted to low carbon. Equity and debt, "green" and "brown" (companies 1 and 2) in comparable sizes.

Green Equity & Mixed Debt: The portfolio has a comparatively strong equity engagement in "green" companies. The debt-part of the portfolio contains a small fraction of "brown" debt.

Decarbonized Debt & Mixed Equity: The portfolio is focused on debt which is "decarbonized" (non-brown) and contains some green bonds. A small fraction of brown equity is left in the remaining equity part of the portfolio.

Green Venture Capital (VC): Focus on equity, often "green". In the debt (e.g. liquidity) a tiny amount of "brown" bonds is left.

The table below (**Table 3**) provides an overview of the portfolio data for each of the stylized portfolios as they are described above and enter the analysis. Of course, one may argue that other stylized portfolios would be more relevant. They can be added and examined in this framework. The point of this illustrative application is to understand some of the drivers and to discuss the differences between the "greenness" and the "brownness" as metric as well as the choice of using debt, equity or both as a base for the metrics.

Table 3: Composition of the stylized portfolios. All add up to 100.

	"green" equity	*"green" debt*	*"brown" equity*	*"brown" debt*	*non-clim. e & d*
green debt	*0*	*10*	*0*	*0*	*90*
energy mixed	*5*	*5*	*10*	*10*	*70*
green equity & mixed debt	*10*	*0*	*0*	*10*	*80*
decarbonized debt & mixed equity	*3*	*7*	*5*	*0*	*85*
green VC	*7*	*3*	*0*	*5*	*85*

Note, that we choose the portfolios in a way such that they all contain 10% of their volume invested in the "green" sector. Their positions in "brown" assets vary. We further assume that the "green" sector as a whole owns 100 units of "greenness" $(g = 100)$ and the $(b = 100)$ accordingly.

Applying the metrics as laid out in (2) to the five portfolios for different beta, for "brownness" and "greenness" separately yields results as shown in **Figure 4**.

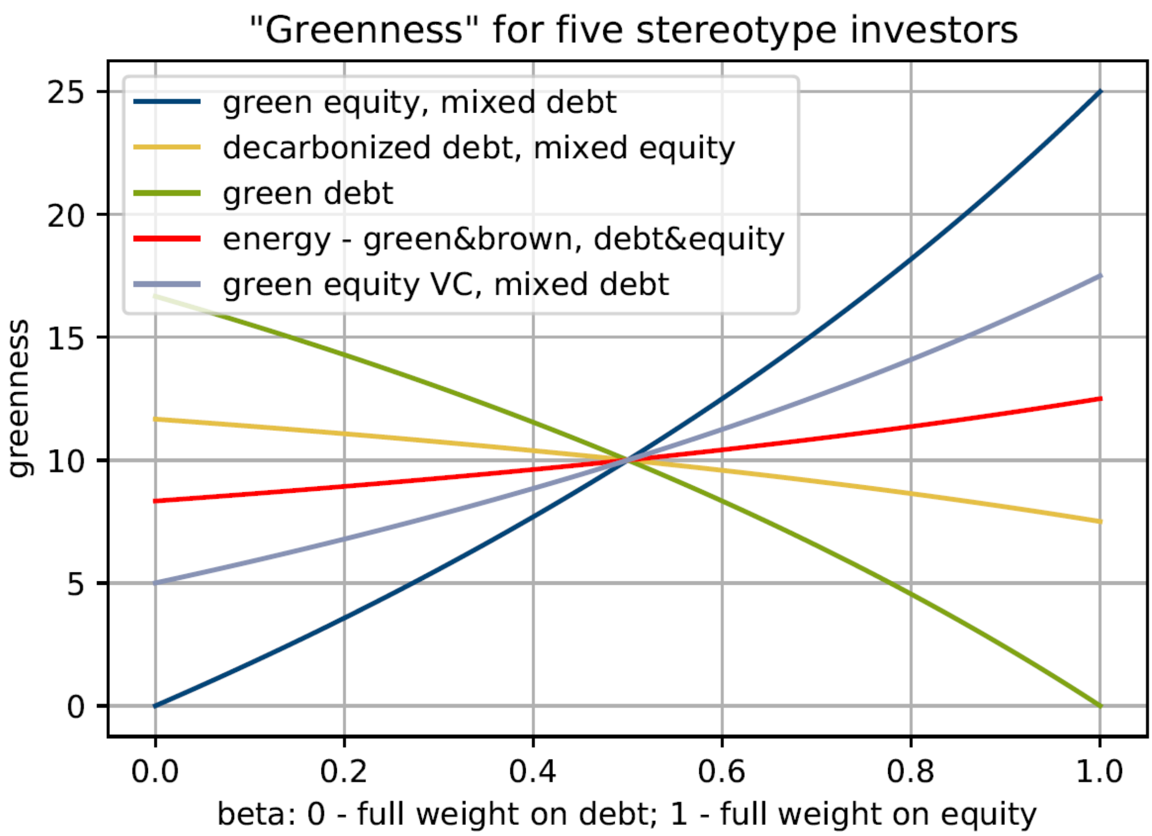
Figure 4 shows that the two metrics yield for different β ranging from all weight on debt to all weight on equity. The graphs show how many of the 100 units of brown or green activities will be attributed to the portfolio. Note that (i) only relative sizes of the indicator matter for us here[69] and (ii) we have shown the "brownness" with a negative sign here, for the simple reason that we wanted the higher curve to be the one more in line with the green transformation.

The graphs as shown in **Figure 4** suggest that:

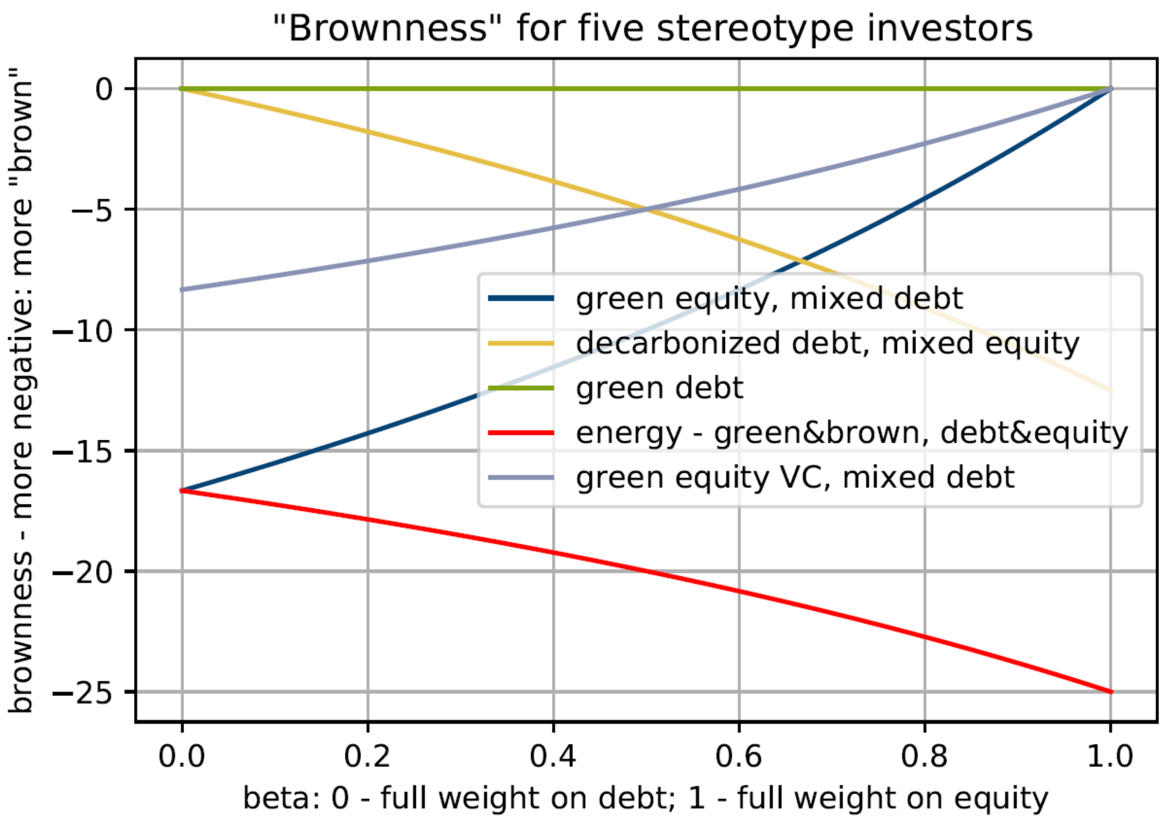
- The weight attributed to debt or equity (β) matters a lot for the value that the metrics reports for an individual portfolio. This holds for metrics along the "brown" as well as the "green" dimension.

- Not only does the value change, but we even see strong changes in the relative positions of the different portfolios. Again this holds for both measures ("green" and "brown"). As the green (debt and equity) positions in all five portfolios add up to the same volume, the corresponding green measure collapses into one value at $(\beta = 0.5)$. Around this point the relative positions of the different portfolios are completely reversed.

Figure 4: Metrics as Applied to the Stylized Portfolios



[69] The two main reasons for this are, that the assumption of 100 units or "green" or "brown" activities is rather arbitrary and that we have only assumed the capital structure for companies 1 and 2. Assuming a certain size is equally possible but would not provide us with more insight.



- Of course, the portfolio itself matters a lot in terms of driving the result produced by the metrics. And it is less surprising that measuring "brownness" in our illustration is independent of "greenness". This is partly due to the fact that we have chosen the two companies to be either "brown" or "green". Again, our framework in general allows not only for investors to be engaged in "brown" and "green" companies at the same time, but also companies to perform both types of activities at the same time.

Based on these findings, we therefore do not see a particular reason why a metric should make a difference between debt and equity. In fact, if we assume that at some point the result of applying the metric to a portfolio could be relevant to an investor, then making a difference between debt and equity may increase the risk of incentivizing an investor to shift between debt and equity positions in his portfolio for no other reason than optimizing what the indicator shows. This is unlikely to be economically beneficial.

3.3. A SIMPLE DYNAMIC VIEW

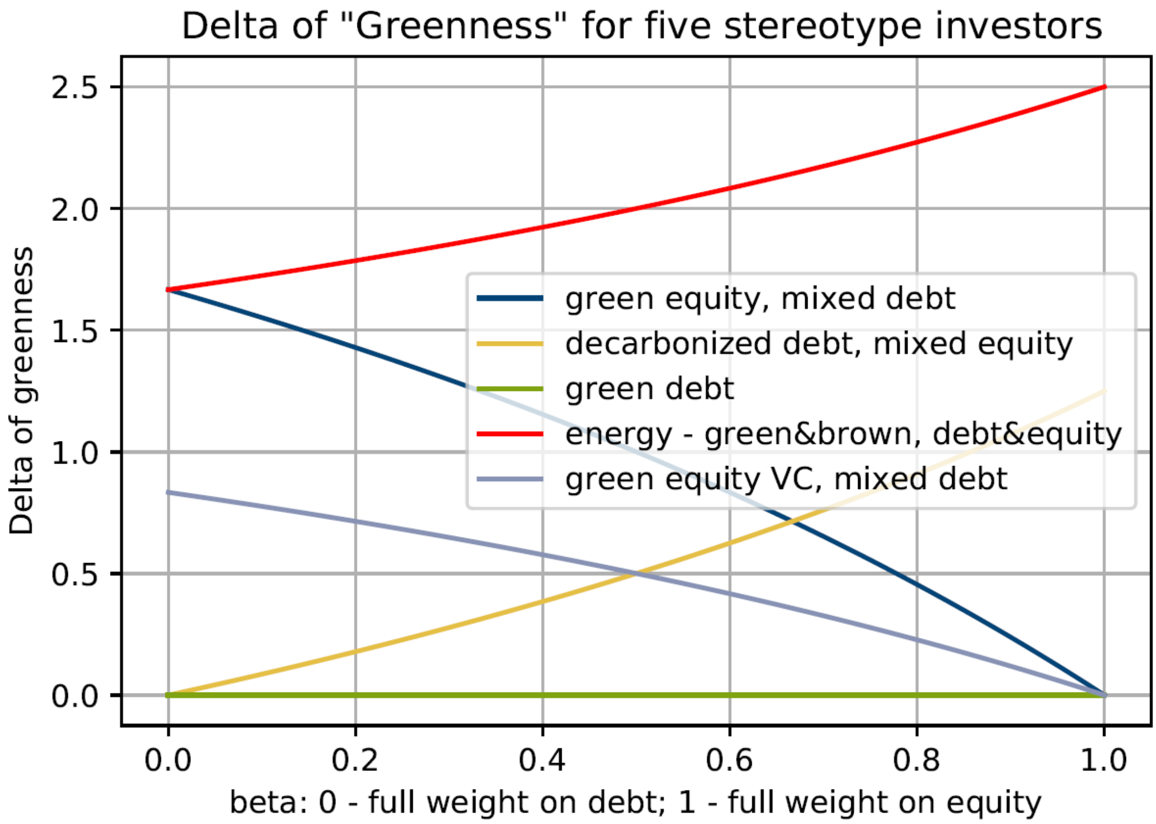
As discussed above, the current situation is not described by a static status quo alone, but it involves current and ongoing changes as well. Inter alia, this is referred to as forward-looking perspective, flow-based view or dynamic perspective.

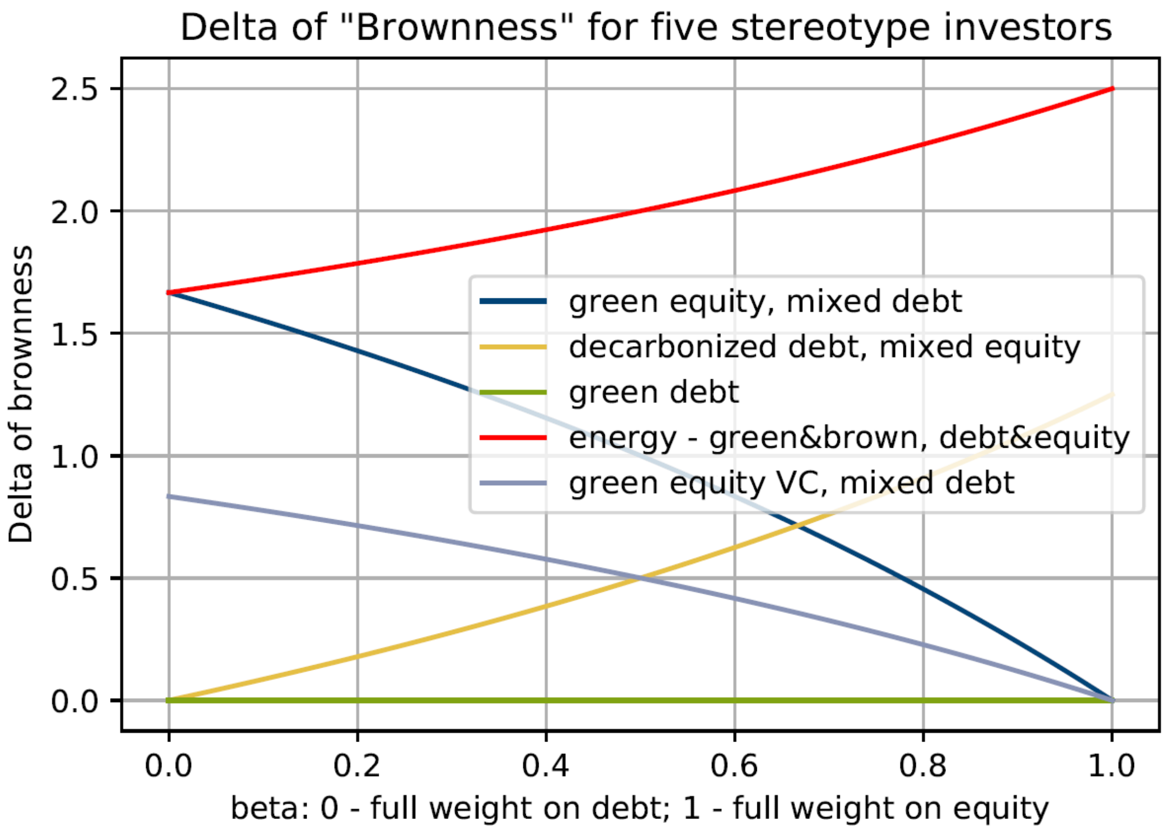
The suggested framework is flexible in the sense that it may attribute “value changes” (investment flows into green power assets) identified with the companies (instead of the values itself, such as green power assets owned) to the different portfolios. This paper now provides a numerical illustration of this simple dynamic perspective before the next subsection widens the discussion to a more comprehensive dynamic view which may even include qualitative elements.

Instead of looking at static portfolios we now move to portfolio changes. As will be seen, those indicators have different meanings and will have to be interpreted differently. **Figure 5** shows our indicators of “greenness” and “brownness” from above in this different way: The scenario is based on the portfolios as above and then assumes a particular decarbonization strategy of all portfolios that contain “brown” assets. Each investor substitutes 10 percent of his or her “brown” assets by the corresponding volume of “green” debt or equity assets. The figure illustrates those new indicators for the five stereotype portfolios and for different weights of equity and debt.

The graph shows that (i) the “greenness” resembles the appearance of the “brownness” indicator from the static case above – simply flipped up-side down. And (ii) within this simple dynamic perspective the “greenness” (change) of each portfolio is identical to its “brownness” (change). This is of course due to the construction of the de-carbonization scenario (where “brown” investments are simple substituted by “green” ones).

Figure 5: One Period Dynamic Metrics as Applied to the Stylized Portfolios





A look at the figure reinforces the obvious point that this representation does not contain significant information about the status quo, the level of "brownness" or "greenness" of the portfolios. The intersections – where the indicators change their relative ranking if the debt versus equity weight is changing – remain the same. Note further that when constructing such a de-carbonization scenario we only look at an effect at the portfolio level ("portfolio effect", see below), not an "underlying asset effect".

3.4. TOWARDS A MORE COMPREHENSIVE DYNAMIC VIEW – PORTFOLIO-DECOMPOSITION

The framework as suggested is in principle also able to capture elements of a more comprehensive dynamic view. If, e.g., a company has a low carbon strategy in place, this could be assumed to characterize the full company (debt and equity) as something like "acting based on a low carbon strategy". Depending on the weight of debt versus equity, our methodology could then provide a proxy of how much of the portfolio is governed by a low carbon strategy. This way a qualitative indicator may be transformed into something quantitative at the portfolio level. Note, however, that (i) aggregating different indicators (e.g. greenness, brownness, and qualitative indicators) is a different topic, and that (ii) our methodology allows for assuming different debt versus equity weights for different types of underlying company indicators.

In general, there are two ways how the quantitative indicator – generated by a portfolio-metric that is applied to a portfolio – changes over time: The first one we have just outlined above: the companies might change their behavior, their activities ("green" or "brown"). This means that the fraction of the activities as they are attributed to different investors will change accordingly. We suggest calling this the "**Underlying-Asset-Effect**".

Second, the investor might have changed the portfolio. He just decided to invest differently. It might not even matter if that difference is due to climate reasons, other regulatory reasons, risk-return considerations or simple value changes within the portfolio. We suggest calling this the **"Portfolio Effect"** on a given metric.

The suggested framework can also be used to perform a so-called "decomposition analysis" of a portfolio that has changed the composition of investments in companies that have also changed over time. Further work in this area could serve as a starting point to identify progress in the real economy in quantitative terms and compare that with potential progress on the portfolio-investment side.

4. SUMMARY REMARKS AND OUTLOOK

The positive association between the amount of debt / leverage of companies and capital expenditure is considered to be confirmed in financial academic literature. Besides, topics such as environmental responsibility and sustainability have found their way into mainstream business routines as they are considered to increase firms' attractiveness. As a consequence, firms could use corporate disclosure about capital expenditure decisions in regard to sustainability or environmental aspects to lower their cost of capital.[70] However, literature shows that this kind of information is rare.[71] Corporate reporting in this field is still broadly unregulated and many companies still do not link their so-called corporate social responsibility strategies to their financial accounting. Instead, they tend to limit their reports to vague statements in regard to financial commitments.[72]. As a consequence, companies are more likely to disclose such information when they plan to raise additional external finance.[73] Information on spending is perceived as useful. This type of information is of semi-public / private nature.[74] In credit risk modelling, the key parameters are financials, behavioral (e.g. variables derived from the client's account structure), and qualitative (e.g. variables derived from the client's credit standing as perceived by the account manager)[75], and Value at Risk (VaR) calculation for banks.[76] The main factors considered in assigning a rating are company size, characteristics, industry risk and financial indicators.[77] Standard & Poor (S&P) rating also looks at CSR-related activities (analyst driven rating model)

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[77] Brennan, D. & Brabazon, A., 2004. *Corporate Bond Rating Using Neural Networks*. IC-AI, pp. 161-167.

in firms; there is evidence that environmental issues positively affect firms' ratings.[78] However, it is important to understand better how investors make decisions concerning green financing and investments and how their consistency to global climate targets like the two degree goal can be tracked. To meet the ambition of the Paris Agreement, a substantial increase in green investments will be required. Companies will likely be more motivated to dedicate financial means to green investment if this is valued by capital markets. To provide an enabling environment for green financing and investment to market participants, adequate tools are required to not only measure investment portfolios' exposure to "greenness" or "brownness" but also define some measure of sufficiency, how much is enough to reach the overall two degree target.

This report aims to contribute to this area in two ways: Firstly, we provide a systematic overview of the landscape of climate investment metrics. We suggest dimensions along which different approaches can be characterized. Secondly, we suggest a mapping framework that is suitable to capture the main dimensions of the metrics landscape and can be applied to examine one question within the metrics-design debate; the potential difference in the role of debt versus equity investments. We then apply this framework to a set of example portfolios in order to derive some general conclusions that may help to design and discuss future types of climate investment metrics. In our numerical illustration, we include metrics of the status as well as metrics of how the status has changed. The results suggest that for a comprehensive picture it is worth considering both metrics separately. Further, we are not able to identify a comprehensive measuring why debt investment should be treated fundamentally different from equity.

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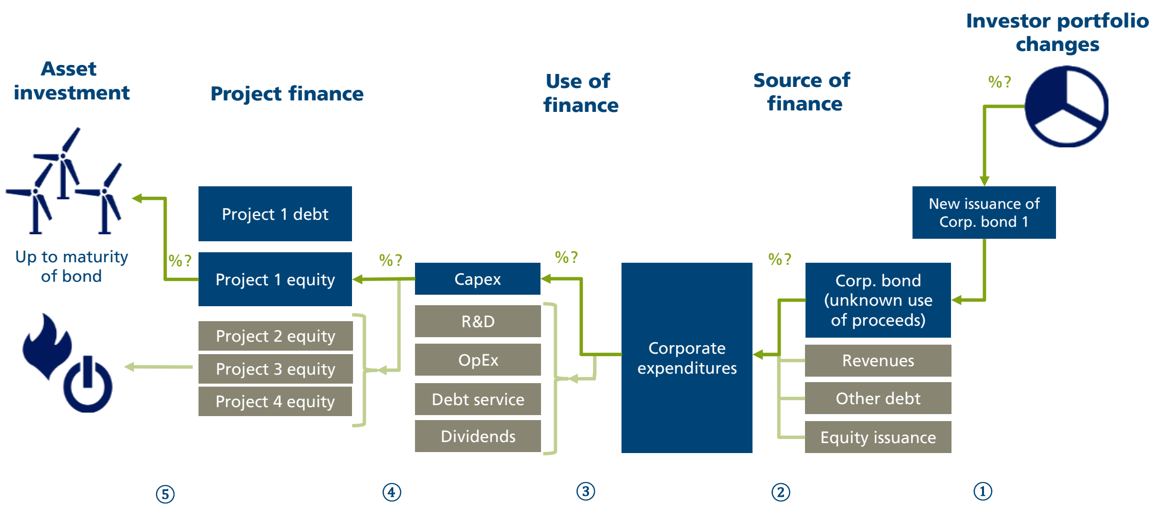
Annex: Data Availability and Assumptions for A Dynamic Climate Metric Prototype

One dynamic climate metric prototype as discussed within the SEI metrics project emphasizes the linkage between financing increase received by companies from investors and the new built assets in clean technology in the company. As discussed earlier in **Box 2**, the approach calculates how much increase in clean technology assets are resulted from US$ 1 investment increase from the investor.

Figure 6: A Dynamic Climate Metric Prototype



Source: based on the idea of 2 degree Investing Initiative.

Descriptions for arrows in **Figure 6**: ① The investor's increase in corporate bond investment that flows into the observed company. ② The increase in investment from the investor goes into the company's account and is to be spent as corporate expenditure. ③ The company uses certain amount of the investment from the account as Capital Expenditure (CAPEX). ④ The capex is used as project equity to finance certain clean technology projects. ⑤ The financing leads to certain amount of total clean technology asset value (project equity value + project debt value).

To compare investor investments with investments required to reach the two degree scenario, 3 steps are necessary (the Figure above represents the part that calculates the projected clean technology assets based on the current investment trend):

I. Investor's US$ 1 increase in corporate bond investment is translated into US$ x increase in project equity in clean technology projects

The flows ① to ④ describe the process of converting US$ 1 increase in investment to US$ x increase of project equity in clean technology projects. In particular, there is evidence that linkage between corporate expenditure and debt issuance exists.[79]

II. Investor portfolio and two degree Target portfolio[1]

Flow ⑤ converts increase in project equity into increase in clean technology asset investment value (project equity and project debt); the asset investment value is a proxy for the real new assets realized based on the current investment trend.

By repeatedly applying the methods above, a dynamic metric that measures the increase in green assets generated by increase in corporate bond investment from the investor is established.

DATA AVAILABILITY & ASSUMPTIONS

The approach requires reliable disclosure of company-performance data. The following table (**Table 4**) presents the results in data availability assessment on ① to ⑤. Information on ①: investor's corporate bond investment in the company can be obtained from the investor. ②: Investor's corporate bond as % in the company's corporate bond portfolio can be skipped in the calculation.[80] ③ and ⑤ are obtainable based on assumptions. ④ is not obtainable due to data unavailability. This requires detailed data source on the company's capex and company's project equity in a chosen period, the level of granularity is however not there in the current clean technology database.

[79] Galizia, F. & O' Brien, D., 2001. *Do Capital Expenditures Determine Debt Issues?*, s.l.: Economic and financial reports/European Investment Bank.

[80] (Corporate bond from investor / corporate bond in the company) * (corporate bond in the company / corporate expenditure) will give us % corporate bond from investor in corporate expenditure. This allows us to look at ③ directly.

Table 4: Exploring Data Availability for Establishing Links in the Dynamic Climate Metric Prototype

Description	Ratio	Data Source	Results	Major Challenges	Ratio Obtainable?
LINKING CORPORATE EXPENDITURES TO CAPEX ③	% capital expenditure in the total corporate spending for a given year	Bloomberg Terminal	Ratios on ③ can be calculated based on: Capex / Corporate expenditures (capex ratio) = Capax / (Capex + R&D Expense + Opex + Debt Service (Principle and Interest Repayment) + Dividend Payment) Corporate expenditure is the sum of capex, R&D expense, Opex, debt service and dividend payment	a. Mixing information from income statement and cash flow statement b. R&D expenses are frequently capitalized into capital expenditure	Yes, assumptions needed
LINKING CAPEX TO PROJECT EQUITY ④	% capex used as project equity to finance clean technology projects	Bloomberg New Energy Finance (BNEF)	Although BNEF has many projects in record, the number of projects that have both project equity & project debt value are scarce --- out of the 170 projects from utilities, 20 of them have this detailed information (and this is mainly because 16 of them are in China, note that in BNEF, projects in China seem to have surprisingly good disclosure). None of the 39 projects from oil & gas companies have this detailed information (both project equity & project debt info).	Based on data availability, it is not possible to establish the link between capital expenditure and project equity given the current data completeness of the database.	No, data not sufficient
LINKING PROJECT EQUITY TO ASSET INVESTMENT ⑤	% project equity in total project finance volume	BNEF	Ratios on ⑤ can be calculated based on: equity ratio = (project equity) / (project equity + project debt) The average equity ratio in developed countries is 25%, while in developing countries is 26% --- the difference is not very significant.	The concern is how representative the equity ratio is based on the available sample size and whether an aggregated average of equity ratio is biased towards specific countries, e.g. 93.43% and 86.19% observations respectively in solar and wind (in terms of technology) and 81.88% observations in term loan (in terms of financing instrument) are from China.	Yes, assumptions needed

Note: ① should be given by the investor and ② does not enter the calculation.

Table 5: Assumptions for the Dynamic Climate Metric Prototype

Description	Areas	Assumptions
CONVERTING INVESTOR'S US$ 1 Increase TO US$ X INCREASE in GREEN ASSETs	Assumptions in the Dynamic Climate Metric Prototype	Homogeneity of money: homogeneity of money is a concept that states each unit of money is exactly the same as every other unit. This assumption is needed to simplify the conversion of investor's US$1 to US$ X green. Data availability constraint means that we need the following assumptions: 1) The percentage of total corporate expenditure used as capex is the percentage that the company takes from each money source and use as capex. For example, if the total corporate expenditure is x and x is completely financed by three money sources A (this is the investor), B and C and there are five money uses: capex, R&D, opex, debt repayment and dividends (x = A + B + C). Assume that capex is 20% of x, based on Assumption 1 the company takes 20% out of source A, 20% out of source B and 20% out of source C and then put these together to use as capex (20% A + 20% B + 20% C = 20% (A + B + C) = 20%x). In reality, the company might have slightly different preferences in how to use different money sources for different purposes. If in reality the company uses more than 20% of investor's money in capex, then the conversion factor in our model is underestimated; and vice versa. 2) The percentage of capex in financing clean technology project is the amount of capex financed by the investor used in financing clean technology projects. Here is an example: assume capex is y and y is completely financed by source P, source Q and source R (y = P + Q + R) and there are currently three possible project finance decisions (clean tech project, non-clean tech project, and no new project). Assume 35% of capex is used to finance clean tech project, based on Assumption 2, 35% of source P, 35% of source Q and 35% of source R is attributed to financing clean tech projects (35%P + 35% Q + 35% R = 35% (P + Q + R) = 35% y). 3) The average of project equity ratio (project equity / (project equity + project debt)) for clean technology projects by technology and by country is representative for the companies in the country using the technology.
CONVERTING EMISSIONS INTO ASSET INVESTMENT NEEDS	Assumptions from International Energy Agency (IEA) Technology Roadmaps	IEA technology roadmap identifies least-cost mixes of energy technologies and fuels to meet energy demand using cost optimization covering 28 world regions and permitting technology choice analysis (about 1000 individual technologies).[81] The framework assumptions include the fundamental drivers of demand for energy services (economic activity: measured in real Gross Domestic Product (GDP) growth projections and population projection), and energy prices (fossil fuel prices by scenario).[82] IEA roadmap for different technologies has its own set of assumptions. We have found detailed assumption descriptions in the technology roadmap for the Indian Cement Industry, thus we will take it as an example to see what types of

[81] IEA, 2014. *Technology Roadmap Solar Thermal Electricity 2014 edition*, s.l.: OECD / IEA.More information on IEA Technology Roadmap can be found under https://www.iea.org/roadmaps/

[82] Detailed assumption tables can be found under https://www.iea.org/etp/etpmodel/assumptions/

		assumptions are needed in developing a roadmap. The roadmap in Indian Cement Industry takes an optimistic view on the development of technology and assumes that when the technology becomes cost-competitive, the new technologies will then be adopted. It also assumes no barriers to adopting new technologies from social, regulatory and information symmetry perspectives. In addition, assumptions are made are per capita demand of materials which again is based on GDP, income, expected capacity addition, consumption and production of materials. As for investment, the roadmap estimates that United States Dollars (USD) 200/t clinker capacity is required to build a new plant, and reaching target plant level requires 10% to 25% additional investment. It is also assumed that "investments between USD 27/tCO2 and USD 33/tCO2 will be required for clinker substitutes and between USD 15 and USD 20/t clinker capacity for Alternative Fuels and Raw Materials (AFR)."[83]
	Assumptions from SMASH / CIRED Technology Investment Roadmaps	The first set of scenarios includes the technical and sectorial assumptions from the IEA scenarios and takes into consideration the impact of different macroeconomic contexts on investment roadmaps. Uncertainties exist with regard to GDP growth and energy investment profiles in certain regions and with regard to carbon free technologies. The second set of scenarios is different from the IEA scenarios assumptions and takes into consideration the alternative macroeconomic assumptions, e.g. stagflation risk in Organisation for Economic Co-operation and Development (OECD) countries, changes in oil prices and more elaborated climate policies. Population growth, economic growth, total factor productivity growth, fossil fuel resources, technology costs and learning rates are important input assumptions. The projection on investment needs to realize the energy future depend on two assumptions: the savings rate (the hypotheses used in the model are a) "exogenous savings rates derived from the World Bank scenarios[84]; and b) endogenous savings rates by which the saving rates adapt to provide the funds necessary for the investments required to fulfill expected final demand" and the international flows of capital (in the model two rules are retained: "a balancing of external accounts in 2020 and a linear reduction of imbalances towards balanced accounts in 2100 which corresponds to a scenario with persisting imbalances up during the simulation period"). Last but not the least, two polar assumptions are made on the major trends in the oil market, namely "a continued market flooding strategy aiming at a price of 40 $/ Barrel (bbl) to discourage alternatives in the short run (including investments to export United States (US) shale oil and gas) and an immediate return to restrictions in investments and oil supply to reap the short term rents of oil markets through a price objective of 120$/bbl."[85]

[83] This paragraph is based completely on IEA, 2012. *Technology Roadmap Low-Carbon Technology for the Indian Cement Industry*, s.l.: World Business Council for Sustainable Development (WBCSD) / International Energy Agency (IEA).
[84] World Bank, 2013. *Capital for the Future: Saving and Investment in an Interdependent World*, s.l.: s.n.
[85] This paragraph is based completely on SMASH_Deliverable 1.1, date: 31.10. 2016.

CONSEQUENCES OF DATA MEASUREMENT ISSUES – ERROR PROPAGATION

Define $\Delta x_{i,j}$ as the increase in investment resulting from the portfolio change of investor j in company i, we would like to know how much green asset investment in company i is a result of investor j's portfolio change in company i.

Based on the graph on dynamic climate metric prototype, we see that $\Delta x_{i,j}$ goes through the following processes. The increase in investment firstly goes into corporate expenditure (money pool), then part of the money pool is used as capex (distribution 1), then part of the capex is used in green project equity (distribution 2), then the green project equity leverages certain amount of debt into the total green asset investment (leverage effect).

$\Delta x_{i,j}$ → Money Pool → Distribution 1 → Distribution 2 → Leverage effect

Let $\alpha, \beta, \text{and}\, \gamma \in (0, 1)$ be defined as $\alpha = \frac{\text{capex}}{\text{corporate expenditure}} * 100\%$, $\beta = \frac{\text{green project equity}}{\text{capex}} * 100\%$, and $\gamma = \frac{\text{green project equity}}{\text{green asset investment}} * 100\%$, we have $Q = \Delta x_{i,j} \times \alpha \times \beta \times \frac{1}{\gamma}$ as the amount of green asset investment in company i that can be seen as result of investor j's portfolio change in company i.

We now want to examine how a potentially wrong measurement of the data is expected to influence the quality of the result. In other words how an error propagates when determining the desired quantity Q.

Given the expression $Q = \Delta x_{i,j} \times \alpha \times \beta \times \frac{1}{\gamma}$, we would like to know the uncertainties of quantity Q when $\alpha, \beta, \text{and}\, \gamma$ have uncertainties $\Delta\alpha, \Delta\beta, \text{and}\, \Delta\gamma$. [86]

Applying the simple method of error propagation:[87]

$$W = \frac{ab \ldots c}{xy \ldots z}, \text{ then } \frac{\Delta W}{|W|} = \sqrt{\left(\frac{\Delta a}{a}\right)^2 + \left(\frac{\Delta b}{b}\right)^2 + \cdots + \left(\frac{\Delta c}{c}\right)^2 + \left(\frac{\Delta x}{x}\right)^2 + \left(\frac{\Delta y}{y}\right)^2 + \cdots + \left(\frac{\Delta z}{z}\right)^2}.$$

To $Q = \Delta x_{i,j} \times \alpha \times \beta \times \frac{1}{\gamma}$, where $\Delta x_{i,j}$ is a given constant yields:

[86] Assuming the quantities $\alpha, \beta, and\, \gamma$ have errors which are uncorrelated and random.
[87] See more reference at http://ipl.physics.harvard.edu/wp-uploads/2013/03/PS3_Error_Propagation_sp13.pdf, accessed on 27.06.2017

$$\frac{\Delta Q}{|Q|} = \sqrt{\left(\frac{\Delta\alpha}{\alpha}\right)^2 + \left(\frac{\Delta\beta}{\beta}\right)^2 + \left(\frac{\Delta\gamma}{\gamma}\right)^2}$$

In other words the square root of the sum of the square of all relative errors provides the relative error of the result.

Note, that some implicit assumptions made in this context include: (i) we measure/determine the data in relative terms, the propagation as determined above only holds for relative errors (although modification for absolute terms are straightforward). (ii) We assume that the errors in measuring the different ratios in the flow diagram are fully uncorrelated. Correlations among errors will change the total error. (iii) None of our measurements is subject to a so-called systematic error (but rather statistically symmetric and normally distributed).

Numerical examples for our cases would be:

1) $\frac{\Delta\alpha}{\alpha}$ =10%, $\frac{\Delta\beta}{\beta} = \frac{\Delta\gamma}{\gamma} = 0$, $\frac{\Delta Q}{|Q|}$ = 10%

2) $\frac{\Delta\alpha}{\alpha} = \frac{\Delta\beta}{\beta}$ =10%, $\frac{\Delta\gamma}{\gamma} = 0$, $\frac{\Delta Q}{|Q|}$ = 14%

3) $\frac{\Delta\alpha}{\alpha} = \frac{\Delta\beta}{\beta} = \frac{\Delta\gamma}{\gamma}$ =10%, $\frac{\Delta Q}{|Q|}$ = 17%

i.e., if the relative error to be made in measuring alpha, beta and gamma is 10% for each, then the total error is expected around 17%.

SUMMARY REMARKS ON THE PROTOTYPE

The proposed prototype involves many assumptions in the approach (see **Table 5**). Most assumptions raise concerns about the accuracy of data estimation. For example, the accuracy of using a sector-based project equity / (project equity + project debt) ratio to estimate clean technology asset value based on clean technology project equity value affects the accuracy of the results. Similarly, the reliability of using Bloomberg data to approximate for corporate expenditure (sum of various items) also affects the results. Another question arises as to how much an investor can affect a company's investment volume in clean technology projects. The "contribution to clean development" attributable to an investor strongly depends on the company's financing decisions, e.g. how many clean technology projects it invests in.

As a consequence, and assuming that data related challenges can be met, the prototype appears to be a promising stating point, which – in a next step – would benefit from enrichment by information on procedures and policies in place at a company regarding how investment and spending decisions are made.

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