Title
The Sixth Carbon Metric: A New Methodology for Climate Change Impact Investing

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Publication Date
2020-06-01

THE SIXTH CARBON METRIC

A New Methodology for Climate Change Impact Investing

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Abstract

The purpose of this study is to evaluate the efficacy of a novel greenhouse gas (GHG) emission metric within the context of recommendations made by the *Task Force on Climate-related Financial Disclosures* (TCFD) (TCFD 2017) for how asset owners and managers should account for the impacts of emissions associated with their investments and holdings. The goal of the metric is to incorporate requirements outlined by Paul Brest and Kelly Born in the seminal paper "*Unpacking the Impact in Impact Investing*"[1] into carbon metrics already recommended by the TCFD, including footprint analysis that adds and compares portfolios based on their associated Scope 1 and Scope 2 emissions[2] profiles. The new metric is designed to evaluate alternatively the directionality (slope) and velocity (rate) of carbon emissions reductions so critical to a market-based solution for addressing climate change. This study utilizes historical emissions and public equity security data to complete a cost-benefit analysis (CBA) on separate climate focused investment strategies and a common benchmark. The objective of the CBA is to determine which of the potential decisions for investments would lead to the best outcome, in terms of emissions reduction. This study assumes an initial investment of a hypothetical $1 billion ($1b) on behalf of a global pension scheme concerned about the long-term climate-related ramifications of their investments. This study finds that the use of a Smart Climate® approach leads to greater insight into the attribution of return performance and a total net benefit of carbon reductions (or impact) over alternative market approaches to investing for a low carbon future. In conclusion, this study finds that this new metric can be useful in assisting asset owners and managers in evaluating the total climate-related impacts of their investment decisions. In addition, this study also suggests that investors can achieve greater total impact by overweighting companies that score highly for how they are managing their climate change transition risk with regards to a business as usual benchmark.

[1] (Brest and Born, Unpacking the Impact in Impact Investing 2013)

[2] "The GHG Protocol Corporate Standard classifies a company's GHG emissions into three 'scopes.' Scope 1 emissions are direct emissions from owned or controlled sources. Scope 2 emissions are indirect emissions from the generation of purchased energy. Scope 3 emissions are all indirect emissions (not included in scope 2) that occur in the value chain of the reporting company, including both upstream and downstream emissions." (GHG Protocal n.d.)

Section 1: Acknowledgments and Introduction

Acknowledgements

This report has been completed in partial fulfilment of a Masters in Advanced Studies (MAS) in Climate Science and Policy from the Scripps Institution of Oceanography at UC San Diego and for the Sustainable Finance Foundation Course at the Smith School of Enterprise and the Environment at the University of Oxford. Research for this study included extensive course work on the Scripps and Oxford campuses. The objective of this report is to transform traditional carbon footprint analysis into a time series analysis so it could be used for a cost-benefit analysis for comparing competing equity portfolios for their financial and environmental impact.

The original concept for this study was conceived and drafted as a final project for the Cost-Benefit-Analysis class with Dr. Dale Squires at the School of Global Policy and Strategy (GPS) at UC San Diego in the spring of 2019. The methodology for this study was further solidified during the Sustainable Finance Foundation course at University of Oxford. The balance of this study was completed on behalf of and in partnership with staff at Entelligent®, a Boulder Colorado based climate risk analytics firm whose mission is to align asset owners and managers with a carbon constrained future. Results from this study are articulated in this paper and elements of this work performed have now been built into practical applications onto the Entelligent Smart Climate® platform. Overseeing this effort in the form of an academic committee is:

Dr. Pooja Khosla, *Chairwomen* ____*PoojaKhosla (June 12, 2020)*______________________

Dr. Corey Gabriel, *Member* __________________________

Mr. Jake Hawkesworth, *Member* ___*Jake Hawkesworth(June 12, 2020)*____________________

In addition to their invaluable guidance and advise, several other individuals made vital contributions to this effort. Their wisdom, intelligence, and support on completing this study was invaluable. They greatly assisted in overseeing that the mathematics were correct and could be stress-tested and integrated into the python code behind the Entelligent platform. These individuals are; Dr. Mark Labovitz, Dr. Elliot Cohen, Mr. Doster Esh, Mr. Filippo Radice and Mr. Nathan James. The concept, research design and methodology of various assessment tools including the transforming of the traditional CO_2 analysis into a format where a CBA could be performed are the original contribution of the author.

Introduction and Overview

The following study is an analysis utilizing the Smart Climate platform developed by Entelligent, a data provider, based in Boulder, Colorado and an application of a novel metric for the calculation of social welfare impact of investment decisions in climate focused public equity asset portfolios. This study employs a cost-benefit analysis (CBA) methodology to determine the utility of this metric for computing in dollars the total social welfare impact of a hypothetical $1 billion ($1b) investment made by a hypothetical global pension system. The study considers three separate strategies across six different portfolios.

The first is a business as usual strategy based on market capitalization weights which deploys no climate risk screen of any kind. The second is a climate focused strategy using the same market capitalization weights, but which aims to reduce the total carbon footprint of the portfolio by over-weighting companies with low scope 1 and 2 emissions and under-weighting companies with high scope 1 and 2 emissions. These low carbon approaches are based in the traditional ethos behind Socially Responsible Investing (SRI), i.e. screening funds to leave out securities deemed “bad” based on a single metric or small selection of specific metrics. In this case, low carbon funds utilize carbon foot-printing, or the act of counting the tons of total carbon emissions for a portfolio normalized by the market value of the portfolio, expressed in tons CO2e / $M invested. For this case, scope 1 and scope 2 GHG emissions are allocated to investors based on an equity ownership approach and leaving out securities that have absolute carbon footprint above certain thresholds.

The third strategy is one developed by Entelligent. This strategy aims to reduce the climate *transition risk* associated with a given portfolio using their proprietary Smart Climate® E-Scores®[3] data suite reliant upon the application of climate scenarios and the calculation of risk through measuring the sensitivity of a holding to multiple climate change scenarios. The platform and data to complete this analysis has been provided to the author by Entelligent. A brief description on how Entelligent’s E-Scores are computed can be found in a section below.

Both carbon minimization strategies and the transition risk strategy developed by Entelligent are part of an evolving movement within the financial services industry to assert the value of *doing good while doing well*. Firms or individuals who seek to achieve financial return while producing some extra social

[3] Entelligen’s Smart Climate patent can be found here: https://patents.justia.com/patent/20190066217

benefit are known as *impact investors.* An overarching question within this growing space centers on how to measure/assess the desired impact especially within equity holdings of publicly traded securities. If one holds that capital markets are efficient, then prices contain all available or public information. However, impact is possible if investors are investing based on in a different criterion with new or different information sets. Impact investing is best defined in the 2013 paper by Paul Brest and Kelly Born "*Unpacking the Impact in Impact Investing"* in the following way:

> "the investment must increase the quantity or quality of the social or environmental outcome beyond what would otherwise have occurred. The counterfactual is that ordinary, social neutral investors would have provided the same capital in any event." (Brest and Born, Unpacking the Impact in Impact Investing 2013)

Brest and Born outline a set of parameters or criterion that an investment needs to meet to be considered *additional*. This study looks to Brest and Born to design the methodology for determining whether or not a portfolio of public equities either does or does not fit the criteria for additionality. Prior to completing the steps of the CBA, this report will give necessary background on climate change focused investing and some of the market developments that are aimed at guiding investors to include the substantial but difficult to quantify risks of climate change.

Section 2: Definitions & Literature Review

Climate Change Risk & Financial Markets

The addition of greenhouse gases (GHGs) by humans to the atmosphere has already substantially and measurably shifted the Earth's climate system from pre-industrial times. The greenhouse effect is a natural phenomenon without which life on Earth as we know it could not exist. In fact, without the presence of atmospheric greenhouse gases such as Carbon Dioxide (CO_2), Methane (CH_4) and Nitrous Oxide (N_2O) the average temperature on Earth would be approximately -18°C. Conversely, increasing atmospheric concentration of these gases from human activity enhances the greenhouse effect, tilting the Earth's energy balance, bringing the world into a warming phase at a rate that has not been experienced in millions of years. Global average temperature increases are irrefutable in the instrumental record and are already leading to an increase in frequency and intensity of extreme weather events such as wildfires, droughts, hurricanes and floods. This change in rate and magnitude of disasters require new measurements and instrumentation to estimate seasonality essential to human industry and commerce. Climate Change is now a constant in our conventional wisdom and will not go away on its own.

Using the eleven decades between 1880 and 1990 to establish a mean of global temperatures (called a climatology in climate science parlance), the Earth has experienced an increase of ~1°C of total surface warming. Since 1880, the global annual temperature has increased on average at a rate of +0.07°C per decade. Since 1981, it has increased at twice that rate for a change of +0.18°C per decade on average. Given the fact that more than 70% of the Earth's surface is covered by water and the ocean has about 1000x more heat capacity than the atmosphere, these changes in temperature are extremely significant. This change is having substantial effects on nearly all-natural systems. Scientists have observed new seasonal temperature extremes, changes in precipitation patterns, reduced snow cover and summer sea ice extent, and shifts in habitat ranges for animals and plants. (Lindsey and Dahlman 2020) These shifts in the climate system represent serous risks to human-made systems which have been built upon a relatively stable climate. In the 4th Assessment Report (AR4) by the Intergovernmental Panel on Climate Change (IPCC), the authors state "taken as a whole, the range of published evidence indicates that the net damage costs of climate change are likely to be significant and to increase over time." (IPCC 2007 n.d.) Recognition of these facts is extremely pertinent to anyone concerned about the future.

In September of 2018 at a high-profile event in San Francisco, 392 institutional investors with $32 trillion in collective assets under managements (AUM) highlighted their commitment to climate action across their investments, corporate engagement, investor disclosure, and policy advocacy (Carbon Disclosure Project 2018). At face value, this is an astonishing number given the fact that it represents more than 35% of the roughly $88.5 trillion of global AUM reported at of the end of 2017 (Baghai, Erzan and Kwek 2018). Yet, the degree to which these investors are objectively and actively performing against these commitments is likely opaque and/or potentially misleading. A fact that was not missed by Chris Ailman; the chief investment officer (CIO) for the California State Teachers' Retirement System, the second-largest pension fund in the U.S., with $228 billions of AUM, in his statements at the Milken Institute Global Conference in May of 2019. During a panel event, Ailman stated:

> "I don't think the markets are pricing in the risk of climate change, because we're too short-term oriented… As we get longer in time and more variable weather, I think it confirms that the markets are potentially materially mispricing that future risk… This is such a global landscape change that I don't think markets are properly measuring and comprehending it… The realization for what the future may hold could be very stark and dramatic." (Ailman, 2019)

Ailman also stressed that while many investors are including environmental concerns into investment strategies, they are largely doing so from a non-financial risk perspective. At a minimum, Ailman argued that financial markets should begin to react to the likely case that natural catastrophes are to increase as time goes on i.e. "pricing in the risks of climate change." (Ciolli 2019) While environmental sustainability has been a topic within the socially responsible investment (SRI) community for several decades, this now appears to be going mainstream.

Task Force on Climate-Related Financial Disclosures (TCFD)

In December of 2015 the Financial Stability Board (FSB) announced it was to establish the Task Force on Climate-related Financial Disclosures (TCFD). This new organization would be chaired by Michael R. Bloomberg and its mission was to "develop voluntary, consistent climate-related financial risk disclosures for use by companies in providing information to lenders, insurers, investors and other stakeholders" (FSB 2015). The press release went on to state that the "Task Force will consider the physical, liability and transition risks associated with climate change and what constitutes effective financial disclosures in this area" (FSB 2015). Since its founding, TCFD has worked with numerous organizations and individuals to establish these recommendations to try and create a common framework from which the risks climate change could be understood.

In June of 2017, TCFD released "Final Report: Recommendations of the Task Force on Climate-related Financial Disclosures." As part of the recommendations across sectors for which disclosure frameworks should be used to help stakeholders understand and incorporate climate change risks into their decision-making processes, TCFD included the "Supplemental Guidance for Asset Managers." Within this the TCFD recommended five separate metrics for asset managers and owners to use to evaluate the carbon intensity or footprint of their investment. The intention for these metrics is to encourage asset owners and managers to provide information "they believe are useful for decision making along with a description of the methodology used." TCFD also recognized the "challenges and limitations of current carbon foot printing metrics" due to data quality concerns because of the self-reported nature of emissions data. (TCFD 2017)

Common Carbon Footprint & Exposure Metrics

As part of the final recommendations made by the TCFD was supplemental guidance for the financial sector was to approach the development of climate related disclosures that would better enable asset owners and managers to understand the concentration of carbon-related assets in the financial sector. In alignment with the FSBs initial proposal, these disclosures would aim to also "foster an early assessment of [climate-related] risks", "facilitate market discipline" and "provide a source of data that can be analyzed at a systemic level, to facilitate authorities' assessments of the materiality of any risks posed by climate change to the financial sector, and the channels through which this is most likely to be transmitted." (TCFD 2017) To meet these objectives, the TCFD proposed five separate metrics. These metrices are focused on absolute carbon footprints. A brief description of these metrics are below, while a more in-depth review is contained in the appendix section of this paper in the form of a table pulled from the final TCFD recommendations.

1) Weighted Average Carbon Intensity – This first metric is the primary metric recommended by TCFD to asset owners and managers. It seeks to reveal the exposure a given portfolio has to companies that are carbon intensive. This metric is different than the following TCFD metrics in that its associated emissions are allocated based on portfolio weights (the current value of the investment relative to the current portfolio value), rather than an equity ownership approach. Emissions for the portfolio are quantified as scope 1 and scope 2 per dollars of revenue. (TCFD 2017)
2) Total Carbon Emissions – Unlike the weighted average carbon intensity metric, this metric uses an equity ownership approach. This means that if an investor owns 5% of all outstanding shares of a given company, then the investor is responsible for 5% of the company's emissions. This metric is expressed in tons of CO_2e (of scope 1 and 2) in terms of absolute greenhouse gas emissions associated with a portfolio. This metric can be used for public equities as well as other asset classes by allocating emissions amounts across the total capital structure of the investee. (TCFD 2017)
3) Carbon Footprint – Like the total carbon emissions metric, this metric uses an equity ownership approach. The difference being that rather than expressing the absolute greenhouse gas emissions

associated with a portfolio, it is normalized by the market value of the portfolio, expressed in tons of CO_2e (of scope 1 and 2) per dollars invested. (TCFD 2017)

4) Carbon Intensity – This metric again uses the equity ownership approach. This metric seeks to reveal the carbon efficiency of a portfolio by evaluating the volume of carbon emissions per million dollars of revenue. The revenue of the companies in the portfolio is used to adjust for company size to provide a measurement of the efficiency of output. (TCFD 2017)
5) Exposure to Carbon-related Assets – The TCFDs fifth metric is aimed at revealing the amount or percentage of assets in the portfolio under question that are sectors and industries that are emissions intensive. This metric is expressed in either dollars or percentage of the portfolios total value. (TCFD 2017)

The TCFDs report states that these metrics should be used by asset owners and managers to report to their beneficiaries and clients as part of the potential exposure that their investments have to climate risk while recognizing limitations of these metrics (TCFD 2017). A more detailed description, along with the mathematics to calculate them, are contained within the appendix.

Gaps within Common Carbon Footprint & Exposure Metrics

The above reviewed five metrics as published by the TCFD are popular formulas used by asset owners and managers to guide their activities to meet such initiatives as The Portfolio Decarbonization Coalition (PCD n.d.) and the Montreal Pledge. Hundreds of asset owners and managers with trillions of dollars of AUM have signed onto these initiatives (Rust 2017). TCFDs metrics are used as a communication tool and an attempt to evaluate risks associated to climate change. These assessment metrices are good for structuring low carbon thematic funds and guiding investors about the emission associated with the current investing strategies. Yet some limitations remain. TCFD recognizes me of these and the limitation they have for being used as full risk metrics. (TCFD 2017)

One of the core issues is that there are quality concerns around the scope 1, 2, and 3 data due to variations in how firms estimate their own emissions. Companies also do not report every year and could potentially change how they are reporting their information year to year. In addition, research firms that compile and distribute this data also have varying ways in which they estimate missing companies or years. The metrics themselves also pose several problems in that they generally exclude scope 3, arguably the largest source of emissions. This can have the impact of skewing evaluations as it can unfairly reward companies whose emissions exist within their supply chains. Another issue is that these metrics are snap shots in time and historical, with reporting years lagging by not unsubstantial amounts of time. (Rust 2017) These facts make it difficult for investors to utilize these metrics within investment strategies. Yet investors still use these metrics to construct investible products, lacking alternatives to meeting market demand for climate-oriented portfolios. Three other areas where these metrics fall short are that they do not do a time series analysis, do not_take into account the future trajectory of the investmnets, and do not translate tons of CO2 into any meaningful impact metric to allow investors to determine the economic damages of one investment decision over the other. To globally achieve net zero goals there is a strong need of dynamic assessment metrices that are focused on measuring direction and magnitude of carbon abatements and reductions. Asset owners and managers need metrices that are robust to track the time series changes in carbon. The investing strategies that allow acceleration of carbon reductions are the strategies that are more aligned with net zero goals. This paper provides description of such strategies and assessment standards that are focused on measuring current and forecasted changes in carbon emissions standards associated with multiple investing strategies.

The Social Cost of Carbon

As discussed above, the impacts of changing the gas concentrations of the Earth's atmosphere are already being felt within human and non-human systems. These changes and the resulting shifts are on course to cause billions if not trillions of dollars' worth of damages. (Miller and Swann 2020) Climate change itself is a classic example of a market failure in so much that the global society must pay the price for the benefits obtained by those few who emit the majority of GHGs. This externality must be corrected for by some measure if there is any chance for a market response to be effective. While several ideas or solutions have been posited, this paper utilizes the Social Cost of Carbon (SCC), which at the most basic level is an attempt to put a dollar value on the harm that a ton of CO_2e emitted today will have on society in the future, discounted into todays dollars. (Evans, et al. 2017)

Estimates range greatly for this number, starting in the single digits going up to the thousands per ton. This number is extremely uncertain largely due to the fact that CO2 emitted today will persists in the atmosphere for thousands of years, thus continuing to increase the radiative forcing that is the trigger for climate change. This relationship to time creates a great deal of uncertainty within the assumptions made for the cost of damages. Under perfect economic conditions, the social cost of carbon would be valued at the pareto optimum where "the additional costs of cutting further emissions are balanced by the benefits of limiting further warming" (Evans, et al. 2017). This number is obviously difficult to come to as the real world does not always adhere strictly to economic theory. In addition, using a single value for the SCC (as typically done within the literature) "obscures the heterogeneous geography of climate damage and vast differences in country-level contributions to the global SCC, as well as climate and socio-economic uncertainties, which are larger at the regional level" (Ricke, Drouet, et al., Country-level social cost of carbon 2018). Yet, this tool remains vital in helping national agencies and private sector actors make decisions that take into account current and future generations by attempting to properly accounting for damaged caused by decisions made today. (EDF n.d.)

A wide range of literature exists on different methodologies for pricing the SCC, but generally two alternative approaches are used. The first is the marginal cost (MC) approach. This methodology attempts to directly calculate the difference in damages caused by slight changes in current emissions. The second is a cost-benefit analysis (CBA). This approach attempts to calculate the level at which the marginal cost of reducing emissions is equal to the marginal damage they cause. Values from these different approaches range greatly as the decision on what “marginal” means or what the value of some future cost is highly subjective. (Clarkson and Deyes n.d.) For the sake of simplicity, this study utilized the SCC value of $50 as published by the Environmental Defense Fund. (EDF n.d.) Expansion of this study could include a Monte Carlo analysis on a range of SCC values, but that is currently beyond the scope of this work.

Public Goods

For this analysis, public goods across the separate portfolios will be calculated using 1) financial returns and 2) greenhouse gas emissions. A description of these two factors are listed below. How these factors are used to calculate the net social welfare will be explained in the following section.

Financial Returns – The first factor that is analyzed is the economic benefits of the financial performance of the different climate focused investment strategies, over the counterfactual. This is accomplished using traditional portfolio performance analysis that looks at the aggregate behavior of the individual constituents (securities or companies) of the portfolios compared against the benchmark. This is accomplished by looking at the percentage gain or loss of each security over the individual time steps and multiplying that against the original investment amount in the original time step.

The investible universe that the portfolios are built from is the *All Country World Index* (ACWI) published by MSCI. The weights (or percentage) of the individual constituents (or companies) for ACWI are market cap weighted, meaning that an individual companies' weight within the portfolio is proportional to the percentage of its market capitalization value compared against the total market capitalization value of the entire portfolio. For every portfolio, the total returns are subtracted against the benchmark. If they are positive, it is a benefit. If they are negative, it is an opportunity cost.

The formula for computing cumulative returns outperformance is as follows:

$$CRO = \langle \left\{ \left[\frac{(Current\ Price\ of\ Portfolio) - (Original\ Price\ of\ Portfolio)}{Original\ Price\ of\ Portfolio} \right] - \left[\frac{(Current\ Price\ of\ Benchmark) - (Original\ Price\ of\ Benchmark)}{Original\ Price\ of\ Benchmark} \right] \right\} * I$$

*CRO= cumulative returns outperformance

As stated above, cumulative returns outperformance of the portfolio over the benchmark will be counted as a benefit and cumulative returns underperformance of the portfolio over the benchmark will be counted as an opportunity cost.

Greenhouse Gas Emissions – The atmosphere is a layer of gases that protects the surface of the earth from harmful radiation. These gases sustain such important biological functions as cellular respiration required by aerobic creatures. These gases also trap and reradiate longwave radiation that originated from the sun, a process that regulates the Earth's climate system and maintains a suitable temperature for life. By volume, dry air contains 78.09% nitrogen, 20.95% oxygen, 0.93% argon, 0.039% carbon dioxide and smaller amounts of various other gases as well as varying amounts of water vapor. (NOAA 2016) Since at least the Industrial Revolution, human activity has been changing the composition of the atmosphere via the burning of fossil fuels and changes in land use which have emitted large quantities of carbon dioxide (CO_2) and methane (CH_4), among smaller amounts of other GHGs. Due to their molecular properties of being infrared radiation (IR) reactive, these molecules bring more heat into the climate system. Gases that react in this way are known as greenhouse gases due to their role in contributing to the Greenhouse Gas Effect. This process is known as Global Warming. In response to the rising level of awareness around the risks of Global Warming, companies have increasingly come under pressure from public advocacy and shareholder groups to account and disclose the amount of emissions associated with their operations.

Corporate emissions have been broken down into three categories. Scope 1 are considered to be direct emissions from owned or controlled sources, such as on-site electricity generation, heating, and cooling. Scope 2 are indirect emissions from the generation of purchased energy such as imported electricity, steam, or chilled water. Scope 3 are all other indirect emissions from a company's supply chain such as purchased goods and services, employee commuting, upstream fuel extraction, and waste management. (Keoleian 2019) Scope 1, 2, and 3 emissions are reported as tons of CO_2.

A growing number of private and public organizations have become focused on collecting, verifying, and improving this data, though serious data quality and coverage problems exist. Scope 3 is currently not used in this analysis due to the complexity of appropriate accounting for it due to the opaqueness of supply chains. The used data has varying degrees of coverage going back to 2015 Q1. The data set used reports emissions at annually time steps. For this analysis these have been interpolated to quarterly time steps. Available company level GHG information will be matched to the portfolios and be aggregated to the total portfolio level. To transform this environmental financial accounting metric to an economic factor, this analysis will multiply the tons of CO_2 contained in the Scope 1 and Scope 2 emissions dataset (carbon footprint) against a Social Cost of Carbon (SCC). The Social Cost of Carbon is a measure of economic harm from the projected impacts of climate change, such as extreme weather events (e.g. hurricanes, flooding, drought, etc.), spread of disease, sea level rise, and increased food insecurity. The SCC is expressed as a dollar value for the total damages from climate change from emitting one ton of CO_2. A value of $50 per ton will be used as the SCC, the value of which has been published by the Environmental Defense Fund (EDF). (EDF n.d.)

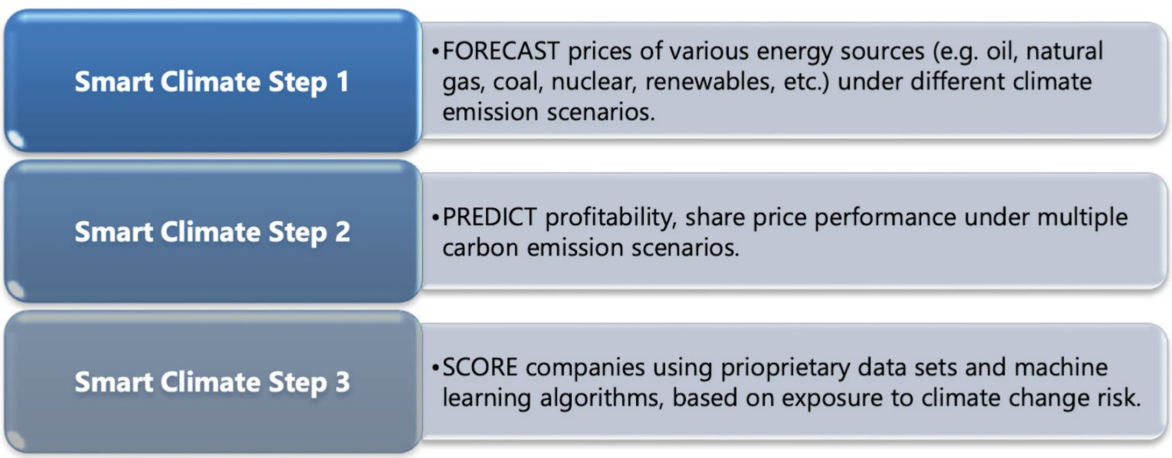
A time series analysis of the SCC is compared for all portfolios against their relevant benchmarks. Tons of CO_2 multiplied against the SCC of $50 avoided will be considered a benefit. Tons of CO_2 multiplied against the SCC of $50 gained will be considered a cost. The costs/benefits of emissions gained or avoided will then be added to the economic benefits/costs of the financial performance of the individual portfolios. The public good is CO_2 avoided while public cost is CO_2 gained.

Section 3: Data and Methodology

Smart Climate Platform

Entelligent's Smart Climate Platform is a solution for asset owners and managers that provides predictive analysis to help investors make better-informed decisions. Smart Climate models and simulations are based on a proprietary algorithm of over 140,000 differential equations and various data metrics. The platform utilizes a variety of external and internal data sets to provide analysis on public equities for the benefit of their clients. Using the platform, Entelligent can provide portfolio and manager evaluations, attribution studies, environmental impact studies, and generate new investment methodologies and strategies given clients preferences. Currently the Entelligent platform is being used by asset owners and managers such as Société Générale and the UNJSPF. At the core of the Smart Climate Platform is a patented algorithm, which generated the Smart Climate E-Score data suite. The Platform generates these scores using the following steps. (Entelligent 2018)

THE SMART CLIMATE 3 STEP PROCESS



Smart Climate scenario analysis tools assess potential implications of climate change risk exposures and related opportunities for investments. This method is designed to develop versatile strategies for a range of plausible climate futures. Smart Climate views climate risk exposure with a top down approach. The methodology downward deploys climate scenario signals from a global climate model to security level climate risk exposures. This approach is complementary to current ESG methodologies that collect and aggregate micro-level data in an attempt to gauge risks and opportunities. (Entelligent 2018)

Smart Climate E-Score Data

Tests have shown that Entelligent's Smart Climate E-Score gives positive grades to companies focused on making the fastest transition to a low carbon economy. Smart Climate seeks to identify companies with a large carbon footprint making the most progress to reduce emissions, as these firms have the greatest potential for environmental and valuation impact. Entelligent's patented algorithm generates Smart Climate E-Scores that guide investors through market risks associated with climate, energy, and policy transitions. E-Scores apply forward-looking scenarios to predict the most likely financial outcomes related to these risks. (Entelligent 2018)

Entelligent's E-Score computation starts by evaluating information on a global scale, consuming output from En-ROADS (Energy Rapid Overview and Decision Support) – an integrated assessment model which simulates energy mix and energy transitions arising from a range of potential climate change scenarios. The computation applies standard scenarios based on expert assessments. It also supports scenario customization. Entelligent modeling has over 150,000 configurable parameters like GDP, energy efficiency, technology improvements, carbon prices, fuel mixes, social factors, and policy goals, yielding a broad range of climate outcomes including changes to carbon emissions, energy access, and temperatures. Entelligent's simulations produce global climate and energy futures (scenarios) to estimate the impact of these futures on specific securities. The E-Score computations, detailed here, translate them from a global perspective into insights regarding a company's ability to address climate risk. (Entelligent 2018)

To calculate the Smart Climate E-Scores, Entelligent:

1. Translate energy and climate information into profitability indicators for each source of energy
2. Combine the profitability indicators with sector and security returns through a series of correlation steps to identify primary energy sources per security
3. Use the correlated energy source profitability indicators to generate predicted returns at the security level
4. Convert predicted security returns into E-Scores

Entelligent's scenario simulations yield climate and energy futures estimates. Entelligent's scenario settings are in agreement with the global scientific community including the United Nations (UN) and the Intergovernmental Panel on Climate Change (IPCC). These simulations produce futures estimates expressed in terms of global temperatures and carbon emission levels. (Entelligent 2018)

To translate this information into profitability indicators, for each energy source, we construct hypothetical global energy suppliers for each source by creating a time series of shifting energy demands, prices and costs. Calculated profitability indicators include net present value (NPV), internal rate of return (IRR), return on investment (ROI) and debt coverage ratio (DCR). (Entelligent 2018)

Our computation combines output from the following climate scenarios:

1. Carbon minimum (MIN) impact scenario: less GDP growth and lower carbon emissions
2. Carbon maximum (MAX) impact scenario: more GDP growth and higher carbon emissions
3. Business as usual (BAU) carbon impact scenario: current GDP growth and carbon emissions

Entelligent created these scenarios with the assistance of an advisory group of reputed scientists and organizations (e.g., the UN and the IPCC).

Component Portfolio Data

As stated above, this study is comparing a benchmark (the counterfactual or business as usual case) verses two climate focused investment strategies. The benchmark used for this study is MSCI All Country World Index (ACWI). The first climate focused investment strategy is based on traditional *socially responsible investing* methodology of not investing in or removing investments from companies which the investor believes to be engaged in lines of businesses that they morally disagree with. In this case, the exchange-traded-funds (ETFs) of iShares MSCI ACWI Low Carbon Target ETF (CRBN) and SP DR® MSCI ACWI Low Carbon Target ETF (LOWC). The second climate focused investment strategy is one developed by Entelligent. This study ran ACWI, CRBN, and LOWC through its scoring mechanism and reweighted the portfolios to generate Smart Climate derivatives of these portfolios. These are SCACWI, SCLOWC, and SCCRBN. They use Entelligent's proprietary company scoring methodology, the *E-Score*™, to determine individual constituent weights within the portfolio. The E-Score is based on Entelligent's *Smart Climate*™ methodology. The E-Score seeks to identify which companies are actively spending money on adapting to future climate change risks. It is Entelligent's hypothesis that companies that score well under this view have higher returns for less risk and over all show a decrease in emissions intensity per dollar of return. Preliminary analysis on this subject seems to confirm these hypotheses. The goal of this paper is to determine which decision leads to the most socially economic beneficial result and whether or not an investor can achieve additionality.

To transform the financial performance analysis into economic terms, this analysis uses cumulative returns outperformance with any outperformance of a portfolio over the benchmark. A cumulative return on an investment is the aggregate amount that the investment has gained or lost over time, independent of the period of time involved. A net cost is considered if the portfolio has any underperformance over its relevant benchmark. A net benefit is considered if the portfolio has any out-performance over its relevant benchmark.

ACWI is a widely used global equity index which is constructed and published by MSCI one of the leading investment research firms in the world. ACWI is one of their most used indices and has been designed to represent large and medium sized corporations across 23 developed and 26 emerging markets. The index includes 85% of the free float-adjusted market capitalization of the 49 markets with more than 3,000 companies across 11 different sectors. The index is built using MSCI's proprietary GIMI methodology which is designed to provides wide geographic and sectoral exposure. (MSCI 2020)

CRBN is an exchange traded fund (ETF) launched and managed by BlackRock, the largest asset manager in the world. CRBN seeks to maintain wide global exposure to equities while reducing the total carbon footprint of the portfolio. CRBN markets itself as a socially responsible fund as it seeks to overweight companies that have lower total emissions and underweight or divest from companies which have high total emissions. CRBN is benchmarked to the MSCI ACWI Low Carbon Target index. (iShares 2020) This index aims to give the same level of exposure across geographies and sectors while minimizing carbon exposure by overweighting companies with low carbon emissions (relative to sales) and those with low potential carbon emissions (per dollar of market capitalization). (MSCI 2020)

LOWC is an exchange traded fund (ETF) launched and managed by State Street Global Advisors. Like CRBN, LOWC has been designed to be a socially responsible fund that provides broad exposure while minimizing the carbon emissions of its portfolio. LOWC is also is benchmarked to the MSCI ACWI Low Carbon Target index. (State Street Global Advsiors 2020)

Emissions Data

In partnership with Entelligent, this study utilizes the Refinitiv ESG Carbon data. This was provided to Entelligent by Société Générale, a leading global bank, as part of their Global Markets Incubator. It is well known within the climate finance space that corporate emissions data faces several issues of reporting quality. In the "Refinitiv ESG Carbon Data & Estimate Models" report by Refinitiv, the company states that "only half of all companies in the Refinitiv ESG coverage report on CO2 emissions data" (Refinitiv n.d.). To fill this gap, Refinitiv has developed Carbon Data & Estimate models. If the company has not reported for the given year, Refinitiv utilizes their CO2, Energy, and Median Models to estimate to scope emissions data for non-reporting companies. The exact methodology for Refinitiv's approach is beyond the scope of this paper thou described in their report.

In general, corporate emissions are broken into three separate categories; Scope 1, Scope 2, and Scope 3. These are all reported in tons of CO_2e (Carbon dioxide equivalent). There is wide consensus as to what these general categories are.

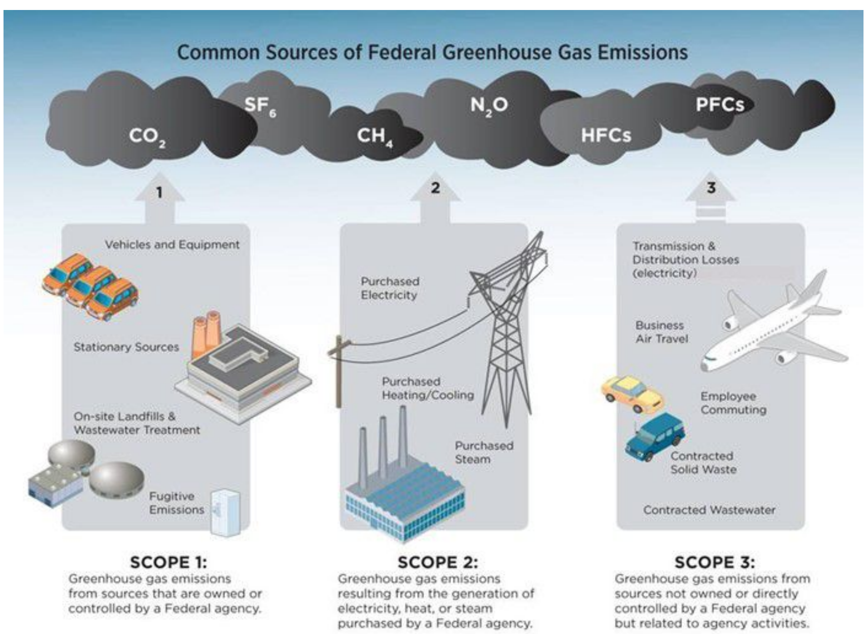


Table #: This graphic shows the sources for scope 1, 2, and 3 emissions

Source: (EPA 2018)

Scope 1 emissions are considered to be direct emissions emitted form sources that are controlled or owned by the company itself. This would include such things as on-site fuel combustion or the combustion of fossil fuels by fleets operated by the company. Scope 2 emissions are the indirect emissions, such as the generation of steam, heat, or electricity purchased by the company from a utility. Scope 3 emissions are form sources not owned by the company by related to the company's activities such as its supply chain. (EPA 2018) In general, portfolio evaluations utilizes Scope 1 and 2 as there is greater certainty and wider coverage for these values due to the opacity of supply chains.

Methodology

To meet the parameters outlined in *"Unpacking the Impact in Impact Investing"*, this study sets out the steps for completing a *cost benefit analysis* (CBA) from traditional social welfare economics onto a comparison of competing portfolios using the same universe and benchmark. In the section "A Framework for Quantifying Enterprise Impact" Brest and Born state that to complete an analysis of the magnitude of impact that individual investment decisions will have, one needs a policy framework to assess costs and social benefits. To accomplish this, a CBA will be used.

Social Welfare = Social Benefits – Social Costs

A CBA is based on traditional social welfare economics, which is based on maximizing the social welfare of members of a specific group to the point where one more unit increase of benefit will decrease the welfare of another (*pareto optimum*). To achieve this one needs to establish a *with and without* case (rather than a before and after) via the use of some counterfactual or business as usual benchmark. This runs directly in tandem with Brest and Born's requirement that "having impact implies *but-for* causation, and therefore depends on the idea of the *counterfactual"* (Brest and Born, Unpacking the Impact in Impact Investing 2013).

This CBA outlines how to compute the net costs and benefits of a hypothetical multinational pension fund looking at alternative climate focused investment strategies against a business as usual portfolio using a market cap weighted strategy as a benchmark. Such an approach is consistent with traditional benchmarks used to measure the investment performance of managers.

To compute the net benefits, two categories of potential benefits or costs are contemplated. The first calculating the cumulative returns difference between a portfolio and its relevant benchmark. If the portfolio outperformance the benchmark, this is viewed as a benefit. If it under performance its benchmark, this is viewed as an opportunity cost. The second is taking the tons of CO_2 either gained or avoided (using reported scope 1 and scope 2 emissions data) over the specified time period (2015-2030) and then multiplying it against the social cost of carbon of $50 then subtracting this value for the alternative climate focused investment strategies over the benchmark.

These results are then added up to establish the net benefits between the alternative climate focused investment strategies and business as usual portfolio benchmarks to determine what the net social welfare would have been had the pension fund made the investment in either of the different portfolios.

This time period has been established by the availability of scope 1 and scope 2 emissions data (first available time step is Q1 2015).

With a total of six portfolios, LOWC, CRBN, ACWI, and their Smart Climate (SC) derivatives (dubbed SCLOWC, SCCRBN, and SCACWI), these are run through a historical financial and carbon emissions performance review. The Carbon emissions data covered the MSCI ACWI universe from Q1 2015 through Q4 2018 (last available) and was reported annually and in tons of CO2e for the entire company.

Portfolio		**Benchmark**
SCACWI	vs.	ACWI
CRBN	vs.	ACWI
LOWC	vs.	ACWI
SCCRBN	vs.	CRBN
SCLOWC	vs.	LOWC

Table #: The above table shows which portfolio will be compared to what benchmark.

*SCACWI, CRBN, and LOWC are compared to ACWI because ACWI is a non-impact focused index that takes a sector and thematic neutral view. The Smart Climate derivatives of CRBN and LOWC (SCCRBN and SCLOWC) are compared to the non-Smart Climate version of themselves to demonstrate the impact of applying the E-Score to a divested portfolio.

This annual data is interpolated to quarterly time steps. The total shares owned of the individual securities within the portfolios is then computed supposing a million-dollar investment and given the particular weights for each company within the portfolio. The growth rate for a given time period of total carbon emissions for a portfolio normalized by the market value of the portfolio, expressed in tons CO_{2e} / $MM invested is then computed using the following formula.

$$\frac{\left\lceil \dfrac{\sum_{i=t}^{T}\left(Unit\ Time_i - Avg\ Unit\ Time\right)\left(Carbon\ Footprint_i - Avg\ Carbon\ Footprint\right)}{\sum_{i=t}^{T}\left(Unit\ Time_i - Avg\ Unit\ Time\right)^2} \right\rceil}{Avg\ Carbon\ Footprint}$$

This formula allows one to determine the rate of change of emissions of a given portfolio. This represents the slope of a linear regression normalized by the mean of emissions to make it a rate. Using the above formula, the Entelligent platform carries the values forward to 2030 to determine the pathway and whether or not the portfolio is going to meet emissions reduction targets using standard compounding methods.

$$Carbon\ Footprint_{t=0} * (1 + \ Carbon\ Footprint\ Growth\ Rate)^{t}$$

After these steps are complete, one can then take the difference of total carbon emissions for a portfolio normalized by the market value of the portfolio, expressed in tons CO_{2e} / $MM invested between the benchmark and the portfolio and multiplies by a *Social Cost of Carbon* (SCC) dollar value. This metric determines the impact of an investment decision on society, based on the belief that investors need to do more than just count tons of carbon. Applying the peer-reviewed literature on the *Social Cost of Carbon*[4], this metric allows investors to calculate how much positive or negative social impact in economic terms their investment will have relative to the benchmark. These steps were applied to each of the six generated portfolios to determine their social impact.

To meet these requirements and the above stated objective of this paper, this study computed the costs and benefits of a hypothetical $1 billion investment in a climate change focused public equity portfolio between alternatives and a counterfactual (or benchmark) for the purpose of establishing social, economic and financial impact. LOWC, CRBN and SCACWI are benchmarked to ACWI while SCLOWC is benchmarked to LOWC and SCCRBN is benchmarked to CRBN.

To measure the economic impact of the financial gains, these sample portfolios are back tested from 2015 Q1 up to 2018 Q4. The period being determined by the availability of the reported emissions data. To determine the economic impact of the emissions changes, the sample portfolios will be analyzed for the time period between 2015 Q1 and 2030 Q4. The reason for this time difference is because of the need to include forward looking carbon data as investors are interested in the impact of future carbon emissions rather than just strictly historical emissions.

The public sector rationale for this paper is the fact that investing is the main means at which commercial activity accesses capital to support its activities, which in turn are greatly responsible for the rapid increase in greenhouse gases that has been observed in the climate over the past ~300 years. Investors have increasingly begun to recognize this problems and associated risks from a changing climate and have sought strategies for reducing the impact of their activities. This growing

[4] https://www.carbonbrief.org/qa-social-cost-carbon

consciousness around the problems and risks posed by climate change have come in tandem with a rising movement within financial services space of socially responsible investing, which seeks to attain some social benefit while also achieving market like returns. Wide variety of names have been given to this movement.

This paper in particular is focused on attempting to identify strategies that materially reduce the amount of GHGs being emitted for activities associated to a particular investment. This would be considered climate focused impact investing. Due to the fact that pension funds are some of the largest asset owners in the world and that their individual members are generally made up of everyday people, like public sector workers such as teachers and firefighters, this paper takes the approach of considering a hypothetical investment decision on the part of the global pension system. By turning a financial analysis into a CBA using a social cost of carbon, the author of this paper believes that a methodology can be developed for evaluating the additionality of climate focused public equity investment decisions.

The study is focused on a hypothetical investment decision by a hypothetical global pension system on behalf of the pension system's membership. Nevertheless, the universe is defined by the underlying benchmark and in this case is the MSCI All Country World Index which applies to both the LOWC and CRBN investment strategies as they share the same benchmark and universe of public equity securities. The area for this study is global and the costs and benefits will be counted globally.

This study covers the period of 2015 Q1 through the end of 2018 Q4 for financial gains and 2015 Q1 through the end of 2030 Q4 for emissions changes and seeks to uncover the incremental cash flow using the net present value of costs and benefits for the returns of the fund and the social cost of carbon. The task requirements to be analyzed are the hypothetical mutually exclusive investments of $1 billion across six independent portfolios (thus a with and without). As stated above, LOWC, CRBN and SCACWI are benchmarked to ACWI while SCLOWC is benchmarked to LOWC and SCCRBN is benchmarked to CRBN.

To determine the costs and benefits, this project will analyze the return on investment for the public equity strategies, which include the two different climate focused strategies and a business as usual (BAU) strategy for the counterfactual based upon a market cap weighted strategy employed by MSCI for the calculation of its index. Economic costs and benefits will only be calculated for the period of investment as the intention of the task requirements is to determine what the social welfare impact would have been of a given investment decision had the pension system made it in Q1 of 2015 up until the closing of the last available quarter (Q4 of 2018). Thus, this is an *ex post* analysis for financial gains. The impact on public goods would of course have both positive and negative externalities beyond the financial boundary of the task requirements but are not relevant for this study at this time as the assumption is that the hypothetical party is only concerned about the impact of their investments over the investment time horizon. The costs and benefits of CO_2 either gained or avoided as multiplied against a social cost of carbon take into account future damages of CO_2 emitted. This is due to the design of the social cost of carbon price and its intention of capturing future economic harm from climate change.

As stated above, the task requirements will cover the period of Q1 2015 until Q4 2018 for financial gains while 2015-2030 for carbon changes. While economic externalities both positive and negative would likely extend prior to the time period of the analysis from a given investment decision, the study will focus exclusively on this period as it is attempting to answer what the net social welfare impacts would have been of a hypothetical $1 billion public equity investment across the mutually exclusive portfolios for investment. Due to data quality issues around CO_2 emissions that relate to quality of reporting and recover as well as number of reporting companies, more recent years will have a more complete picture as opposed to years further in the past. The time periods for investment are limited by the availability of scope 1 and scope 2 emissions. Typical portfolio analysis standards attempt to de-weight the power of compound interest and the potential for it to obscure other contributing factors to performance by using 10 to 15-year time horizons. The theory is that this captures multiple market cycles. The analysis was completed for $1 million so these results where multiplied against 1000 to achieve a billion-dollar equivalent.

Section 4: Results and Key Findings

Results & Key Findings

The following section outlines the results of the above described CBA steps and use of the novel metric for evaluating the impact of carbon emissions within equity portfolios. A stated above, the analysis was completed on $1 million so these results are then multiplied against 1000 to take it up to a billion. To calculate the costs and benefits of each portfolio, cumulative returns outperformance for each portfolio will be added to the tons of CO2e abated multiplied against the Social Cost of Carbon.

$$\text{Social Welfare} = \text{Social Benefits} - \text{Social Costs}$$

$$\text{Social Welfare} = \text{Cumulative Returns Outperformance} + (\text{CO2e abated} * \text{SCC})$$

Financial returns for each company within each portfolio are aggregated to the total portfolio level using the Smart Climate platform. The returns of each portfolio are then compared against the returns of the relevant benchmark. The results from this analysis are as follows:

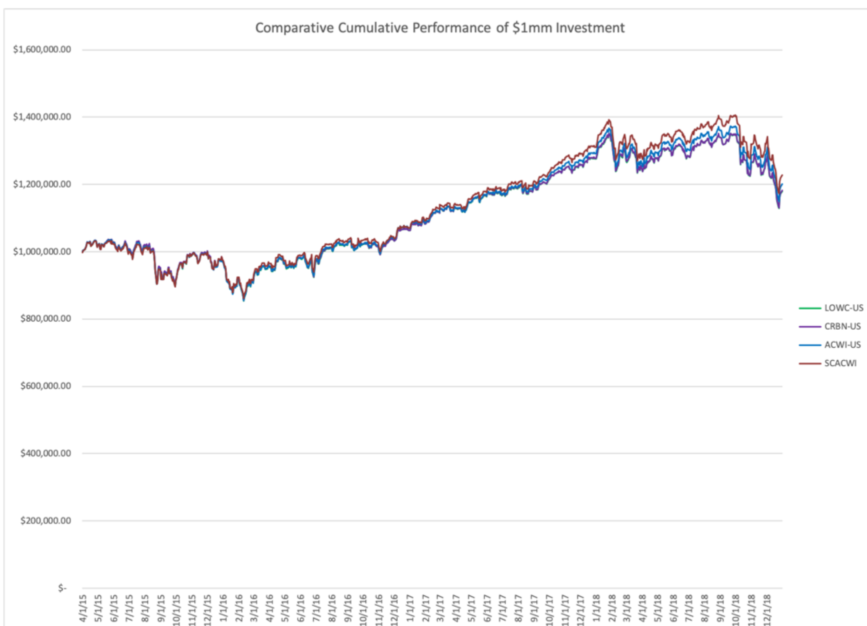


Table #: The above table showcases the total cumulative returns for ACWI, SCACWI, CRBN, LOWC, SCCRBN, and SCLOWC from the end of 2015 Q1 until the end of 2018 Q4

	ACWI		**SC-ACWI**		**CRBN**		**SC-CRBN**		**LOWC**		**SC-LOWC**	
	2015 Q1	2018 Q4	2015 Q1	2018 Q4	2015 Q1	2018 Q4	2015 Q1	2018 Q4	2015 Q1	2018 Q4	2015 Q1	2018 Q4
Amount Invested	$1mm		$1mm		$1mm		$1mm		$1mm		$1mm	

ROI*						

Table #: This table shows the financial impact by comparing the different portfolios vs. their relevant benchmarks for a hypothetical investment of $1b

*This found by subtracting the cumulative returns of the benchmark from that of the relevant portfolio. If the benchmark where to have greater returns, this would be viewed as an opportunity cost. If the Portfolio has greater returns, this is viewed as a benefit.

Carbon emissions changes for each company within each portfolio is aggregated to the total portfolio level using the Smart Climate platform. The carbon footprint growth rate of each portfolio is then compared against the returns of the relevant benchmark. These changes in tons of CO2e are then be multiplied against the Social Cost of Carbon. The robustness of this analysis could be improved with a Monte Carlo analysis of multiple global averages but for simplicities sake, a value of $50 per ton of CO_2 is used as a fair proxy and as defined by the Environmental Defense Fund at this time. Future studies could potentially expand on this methodology. An alternative methodology would be to look at other studies such as Ricke et. al. 2018 for their determination of the regional impacts of CO_2 and normalize those to the available geographic, sector and portfolio segments. But this methodology will not be used at this time and is reserved for future studies.

Table #: Historical and projected performance of carbon emissions for three portfolios and their Smart Climate® comparisons.

	ACWI		SC-ACWI		CRBN		SC-CRBN		LOWC		SC-LOWC	
	2015 Q4	2030 Q4	2015 Q4	2030 Q4	2015 Q4	2030 Q4	2015 Q4	2030 Q4	2015 Q4	2030 Q4	2015 Q4	2030 Q4
Total Emissions *	41.1	25.1	42.2	18	9.5	10.4	9.1	2.9	11.3	5.8	11.2	1.8
Emissions Reduced *	16		24.2		-0.9		6.2		5.6		9.4	
Emissions Reduction (%)	38.9%		**57.3%**		-0.09%		**67.7%**		49.2%		**83.5%**	
Social Impact **	$800		**$1210**		-$45		**$310**		$280		**$470**	

Table 4: Total emissions, emissions reduced, and emission reductions percentage for the *All Country World Index, iShares MSCI ACWI Low Carbon Target ETF* (CRBN), *SPDR® MSCI ACWI Low Carbon Target ETF*, and their Smart Climate® comparisons.
*Total emissions and emissions reduced are given in metric tons CO_{2e}.
**Assuming a $50 SCC per ton per $1mm investment

As stated above:

Social Welfare = Cumulative Returns Outperformance + (CO2e abated * SCC)

Thus, the total Social Value of each portfolio for the given time period is as follows after being multiplied against 1000 to take it up to a $1 billon investment:

Total Social Value Results			
Portfolio	**Environmental Impact (CO2 Abatement * SCC)**	**Financial Impact (ROI)**	**Total Impact ($)**
ACWI*	NA	NA	NA
SCACWI	$410,000		
CRBN	-$845,000		
LOWC	-$520,000		
SCCRBN	$355,000		
SCLOWC	$30,000		

Table #: These are the final results for the CBA given a fair accounting of the impact of comparing SCACWI, LOWC, CRBN, SCLOWC, and SCCRBN to their appropriate benchmarks to determine their financial and environmental impact given a hypothetical investment of $1b in 2015 Q1.
*ACWI has null results because it is solely used as a benchmark and thus has a neutral impact as it is the BAU investment case.

Summary of results

Section 5: Conclusion and Call to Action

Conclusion

In recent years, impact focused investing has shifted from a small movement on the sidelines to becoming a major trend within large pension funds, asset management firms, banks, and family offices. Yet getting a clean definition on *what impact is* and *how one achieves it* is very complicated. There is no silver bullet. But in order to move the needle on issues such as climate change, an agreed upon definition and unified approach is needed if finance is to play a role in addressing such issues as climate change.

Figuring out whether an investment has *impact* is extremely difficult, as outlined by Paul Brest and Kelly Born. Measuring or quantifying the resulting "improvement" and pinning it to the investment (establishing causality) can be near impossible. In order to meet the definition of impact, it must be shown that the quantity or quality increase of some social or environmental benefit would not have occurred on its own or without the specific intervention of that investor. This is difficult because if something is likely to make money, it's probably fair to say some other investor would likely do it.

With these two hurdles to overcome, how do investors seeking to make an impact, direct capital to asset classes? It is clear that impact investors should want more than to simply shift the world at the margins. So, how can investors expand impact into such assets like public equities?

As discussed, for the last few decades, the answer has been through *divestment*, or completely removing companies in specific lines of business (e.g. guns, porn, and gambling) or companies otherwise classified as unacceptable by management for other reasons (e.g. doing business with an apartheid government).

With regard to climate change, divestment strategies include large organizations selling all of their holdings within the oil and gas sector. Another strategy has been to assess the carbon footprint of a particular index and remove the companies that are above a certain threshold, thus creating a low carbon portfolio.

A fair a question to ask though is, do these approaches really cause the change that investors are seeking to make, i.e. *do they create impact*? This question is particularly pertinent to investors that want to contribute meaningfully to meeting international objectives such as limiting global warming to 1.5°C by cutting the amount of GHG emissions placed into the atmosphere via the burning of fossil fuels.

While such actions as the Rockefeller Foundation declaring they will no longer be invested in ExxonMobil (Neate 2016)or the city of Seattle saying they will avoid doing business with any bank involved in the Keystone XL pipeline (Beekman 2017) send a powerful political message that clearly has the potential to be a part of causing seismic shifts. Recall the release of Nelson Mandela from prison and the fall of the South African apartheid government after a global divestment campaign occurred (Counts 2013).

Yet, the question remains: by selling a set of holdings in a specific line of business , such as oil and gas exploration and production, or under-weighting or completely removing companies with higher carbon footprints as compared to their peers, are the total GHGs emitted into the atmosphere lowered materially and of a magnitude which is in-line with the objective?

One can look to economic theory in combination with probability to create a model which suggests that <u>this is not the case</u>. At the core of economics is the concept of demand and supply. By selling (or divesting of) a security, what impact does an investor have on the demand and supply function the market has for the share of that particular company? They are increasing supply while not changing the actual underlying value of the company in question whatsoever. The result is that this transaction actually increases the desirability of that particular stock and leads to price re-adjustment back to a similar equilibrium prior to the actions of the firm that divested. Without getting too heady with behavioral economics, this creates the classic prisoners dilemma as now other investors are going to be incentivized to operate under traditional paradigms and see the selling of the security as an opportunity to buy something of good value for a reduced cost, thus cancelling out any potential market message that could be sent to management in the form of a stock dip that would have resulted from the selling of it. It is true that profits are huge incentives for some investors to undo actions of divestments and this dynamic is unlikely to change.

Now there are certainly other reasons to sell energy holdings, as proven by the recent collapse of the coal industry (Frazer 2020), and it's a fair argument that at some future point a large percent of oil and gas assets will become stranded (Caldecott, Tilbury and Carey 2014) and there will be a massive market valuation correction . There is plenty of research on how new technologies or strong climate policies could help make this correction (P. Bolton, M. Despres and L. Pereira Da Silva , et al. 2020) , but in reality the time is not likely here now. Companies like Patagonia still make polyester sweaters

(Patagonia 2020), Ford still makes gas burning cars (Climate Disclosure Project n.d.), Lulu Lemon still makes nylon yoga pants (LuLu Lemon n.d.), and American Airlines still flies airplanes that burn jet fuel (Overton, 2019). One also need not mention the less than compelling international cooperation for meeting established targets via policy action (Harvey 2019). So, if that's the case, how should investors with large amounts of capital balance having well diversified portfolios with their (extremely) valid concerns about the impact of their investment decisions on the health of our global climate?

The author believes that this paper outlines an approach that can actually be used to evaluate real impact, limiting and reducing GHG emissions and thus direct investors towards how to create a viable market-based solution for climate change for investors with exposure to public equities.

In Summary, this approach looks at different strategies and uses a new set of carbon metrics built upon the recommendations of the Task Force on Climate-related Financial Disclosures (TCFD) that evaluates the emissions reductions of a portfolio over time compared to its benchmark forecasted out to 2030. It then translates these findings into a measure of the social cost of carbon of the portfolio given the amount invested.

This study has also found that using the Entelligent Smart Climate E-Score seems to identify those companies taking the necessary steps to address the risks of climate change within their own operations and *leading the pathway of carbon reductions*. In order for the world to "bend the curve" of climate change to a level that stabilizes our climate, focusing on carbon reductions can be a pathway to a virtuous cycle of change. The investors chasing carbon reductions become critical to having impact. This approach views CO_2 as an asset with a negative potential return rather than as a pollutant to be avoided. The author believe that this has the potential to cause major shifts by creating an avenue for the deployment of trillions of dollars (World Bank 2020) toward companies leading the pathway of carbon reduction.

This approach fits the above described requirements for impact as it allows one to 1) measure the change and establish causality to the investment by assigning a carbon emissions amount per dollar of investment and 2) determine the quantity or quality increase of some social or environmental benefit that would not otherwise have occurred without the specific intervention of the Smart Climate E-Score. It is this pathway that the authors see as leading to the greatest impact for a better future.

Section 6: Appendices

Appendix 1: TCFD Carbon Footprint Metrics

<table>
<tr><th colspan="2">Common Carbon Footprint and Exposure Metrics</th></tr>
<tr><th>Metric</th><th>Supporting Information</th></tr>
<tr><td rowspan="4">Weighted Average Carbon Intensity</td><td>Description: Portfolio’s exposure to carbon-intensive companies, expressed in tons CO_{2e} / $MM revenue. Metric recommended by the Task Force.</td></tr>
<tr><td>Formula: $\sum_{n}^{i}\left(\frac{\text{current value of investment}_i}{\text{current portfolio value}} * \frac{\text{issuer emissions}_i}{\text{issuer \$MM revenue}_i}\right)$</td></tr>
<tr><td>Methodology: Unlike the next three metrics, Scope 1 and Scope 2 GHG emissions are allocated based on portfolio weights (the current value of the investment relative to the current portfolio value), rather than the equity ownership approach (as described under methodology for Total Carbon Emissions). Gross values should be used.</td></tr>
<tr><td>Key Points (+/-):
+ Metric can be more easily applied across asset classes since it does not rely on equity ownership approach.
+ The calculation of this metric is fairly simple and easy to communicate to investors.
+ Metric allows for portfolio decomposition and attribution analysis.
− Metric is sensitive to outliers.
− Using revenue (instead of physical or other metrics) to normalize the data tends to favor companies with higher pricing levels relative to their peers.</td></tr>
<tr><td rowspan="4">Total Carbon Emissions</td><td>Description: The absolute greenhouse gas emissions associated with a portfolio, expressed in tons CO2e.</td></tr>
<tr><td>Formula: $\sum_{n}^{i}\frac{\text{current value of investment}_i}{\text{issuers market capitalization}_i} * \text{issuer emissions}_i$</td></tr>
<tr><td>Methodology: Scope 1 and Scope 2 GHG emissions are allocated to investors based on an equity ownership approach. Under this approach, if an investor owns 5 percent of a company’s total market capitalization, then the investor owns 5 percent of the company as well as 5 percent of the company’s GHG (or carbon) emissions. While this metric is generally used for public equities, it can be used for other asset classes by allocating GHG emissions across the total capital structure of the investee (debt and equity).</td></tr>
<tr><td>Key Points (+/-):
+ Metric may be used to communicate the carbon footprint of a portfolio consistent with the GHG protocol.
+ Metric may be used to track changes in GHG emissions in a portfolio.
+ Metric allows for portfolio decomposition and attribution analysis.
− Metric is generally not used to compare portfolios because the data are not normalized.
− Changes in underlying companies’ market capitalization can be misinterpreted.</td></tr>
<tr><td rowspan="4">Carbon Footprint</td><td>Description: Total carbon emissions for a portfolio normalized by the market value of the portfolio, expressed in tons CO2e / $M invested.</td></tr>
<tr><td>Formula: $\frac{\sum_{n}^{i}\frac{\text{current value of investment}_i}{\text{issuers market capitalization}_i} * \text{issuer emissions}_i}{\text{current portfolio value (\$MM)}}$</td></tr>
<tr><td>Methodology: Scope 1 and Scope 2 GHG emissions are allocated to investors based on an equity ownership approach as described under methodology for Total Carbon Emissions. The current portfolio value is used to normalize the data.</td></tr>
<tr><td>Key Points (+/-):
+ Metric may be used to compare portfolios to one another and/or to a benchmark.
+ Using the portfolio market value to normalize data is fairly intuitive to investors.
+ Metric allows for portfolio decomposition and attribution analysis.
− Metric does not take into account differences in the size of companies (e.g., does not consider the carbon efficiency of companies).</td></tr>
</table>

	− Changes in underlying companies' market capitalization can be misinterpreted.
Carbon Intensity	**Description:** Volume of carbon emissions per million dollars of revenue (carbon efficiency of a portfolio), expressed in tons CO2e / $M revenue.
	Formula: $\frac{\sum_{n}^{i}\left(\frac{current\ value\ of\ investment_i}{issuers\ market\ capitalization_i} * issuer\ emissions\right)}{\sum_{n}^{i}\left(\frac{current\ value\ of\ investment_i}{issuers\ market\ capitalization_i} * issuer\ \$MM\ revenue\right)}$
	Methodology: Scope 1 and Scope 2 GHG emissions are allocated to investors based on an equity ownership approach as described under methodology for Total Carbon Emissions. The company's (or issuer's) revenue is used to adjust for company size to provide a measurement of the efficiency of output.
	Key Points (+/-): + Metric may be used to compare portfolios to one another and/or to a benchmark. + Metric takes into account differences in the size of companies (e.g., considers the carbon efficiency of companies). + Metric allows for portfolio decomposition and attribution analysis. − The calculation of this metric is somewhat complex and may be difficult to communicate. − Changes in underlying companies' market capitalization can be misinterpreted.
Exposure to Carbon Related Assets	**Description:** The amount or percentage of carbon-related assets in the portfolio, expressed in $M or percentage of the current portfolio value.
	Formula for Amount: $\sum \$MM\ current\ value\ of\ investments\ in\ carbon\ related\ assets$ **Formula for Percentage:** $\frac{\sum current\ value\ of\ investments\ in\ carbon\ related\ assets}{current\ portfolio\ value} * 100$
	Methodology: This metric focuses on a portfolio's exposure to sectors and industries considered the most GHG emissions intensive. Gross values should be used.
	Key Points (+/-): + Metric can be applied across asset classes and does not rely on underlying companies' Scope 1 and Scope 2 GHG emissions. − Metric does not provide information on sectors or industries other than those included in the definition of carbon-related assets (i.e., energy and utilities sectors under the Global Industry Classification Standard excluding water utilities and independent power and renewable electricity producer industries).

Table #: The five Carbon Metrics as published and described by TCFD

Source: (TCFD 2017)

Appendix 2: Further Refining Impact through Regionalization of the SCC

An additional method that could be used but is currently beyond the scope of this paper is applying the social welfare functions to the SCC using country level Inequality Human Development Index (IHDI) data. The intention of this step would be to capture the difference in economic impacts of climate change on different geographies. The author believes that by multiplying a global average for the social cost of carbon against a IHDI welfare inequality measure, the inequalities that different countries have for how climate change is impacting them will be better included due to the fact that regional calculations of social costs of carbon are not yet fully developed within the currently available literature. The IHDI has been developed by the United Nations Development Program and is based on the Human Development Index (HDI). The HDI was created by the UN to "emphasize that people and their capabilities should be the ultimate criteria for assessing the development of a country, not economic growth alone" (Programme, Human Development Index (HDI) n.d.). The HDI is a comparative average for individual companies that measures long and healthy life, decent standard of living, access to knowledge. The IHDI expands on the HDI by evaluating how the achievements in an individual countries health, education, and income are "distributed among a countries population by discounting each dimension's average value according to its level of inequality" (Programme, Inequality-adjusted Human Development Index (IHDI) n.d.). The index values of the IHDI will then be included into the welfare inequality measures.

The methodology for doing so will be as expressed in the "Equitable Sharing of Financial and Other Economic Benefits from Deep-Seabed Mining" report prepared for the Finance Committee of the International Seabed Authority released in April of 2019. The steps to establish weights of the SCC based on the IHDI using the inequality welfare factor is as follows:

Step 1: Calculate the ratio of the global average of IHDI over each country's IHDI

Step 2: Raise this ratio to the power of η, which then equals the social distribution weight for country *i*. The weight ω_i is a hyperbolic function of $IHDI_i$.

$$\omega_i = \left[\frac{\overline{IHDI}}{IHDI_i}\right]^{\eta}$$

This value will then be multiplied against the tons of CO_2 gained or avoided multiplied against the SCC price. (Squires 2019) One could also potentially use the Atkinson Inequality index as described in the

1970 paper "On the Measurement of Inequality" as a supplementary way to regionalize the SCC (Atkinson 1970). The author proposes that this could be an appropriate next evolution of this study though not necessary for the current analysis and thus will not be further explored in this paper.

Section 7: Work cited

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