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Investment and Fiduciary Analysis for Potential Fossil Fuel Divestment

Phase 2

Identification, Analysis and Evaluation of Investment Risks Posed by Fossil Fuel Reserve Owners

Report DRAFT

Prepared for the Comptroller of the City of New York
As Custodian of the Funds of
The Teachers' Retirement System of the City of New York

By BlackRock Sustainable Investing

Executive Summary

- Fiduciary investors must consider the potential increase of transition risks for fossil fuel reserve-linked securities within their portfolios, as technological advances and regulatory actions signal a global energy transition.

- The potential transition to a low-carbon economy raises the possibility that fossil fuel reserves — which may be unusable in a low-carbon scenario — will face precipitous devaluation or become "stranded assets."

- Low-carbon energy scenarios, such as in forecasts aligned with the objectives of the Paris Agreement, suggest declining long-term demand and production of fossil fuel energy sources — most pronounced in coal and oil — over the ensuing decades.

- To systematically measure a comprehensive view of a company's risk, BlackRock proposes combining two distinct approaches to inform the NYC TRS potential divestment strategy.

- This combination of BlackRock's Carbon Price Sensitivity tool and Low-Carbon Transition Readiness (LCTR) scores analyzes a security's 1) current carbon pricing sensitivity and 2) forward-looking trajectory or preparedness for the low-carbon transition.

- Applying these analytics to the starting universe of fossil fuel reserve-linked securities reveals a distribution of exposures to both carbon price sensitivity as well as forward-looking potential (Transition Readiness).

- Fossil fuel linked-securities in the TRS portfolio have an average -14% earning exposure to a USD $18 carbon tax — with half of the securities demonstrating low-relative forward looking transition preparedness (i.e., are not taking proactive steps to align with low-carbon trajectory).

- In aggregate, the starting universe of securities indicates notable transition risk related exposure; however, there is meaningful differentiation in transition risk within the universe. That is, a distribution of preparedness for the energy transition.

- In combining these two insights — both current exposure and forward looking preparedness — tiers of transition risk exposure emerge ranging from less prepared (both negative carbon price sensitivity and LCTR) to more prepared (positive carbon price sensitivity and LCTR).

- This differentiation of companies provides a lens into potential divestment options (or tiering) of the universe to be analyzed in Phase 3.

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I. Investment Risks of Fossil Fuel Reserve Owners

Key Findings

- Due to the mounting risks of climate change, technological advances and regulatory actions are signaling toward a global energy transition.
- The potential transition to a low-carbon economy presents investment risks to fossil fuel reserve owners, raising the possibility that fossil fuel reserves — which may be unusable in a low-carbon scenario — will face precipitous devaluation or become "stranded assets."
- Low-carbon energy scenarios, such as in forecasts aligned with the objectives of the Paris Agreement, suggest declining long-term demand and production of fossil fuel energy sources — most pronounced in coal and oil — over the ensuing decades.
- Globally, regulatory regimes have increasingly signaled toward more action, with a record 10 new carbon pricing policies passed in the last year alone, and are expected to accelerate the global energy transition.
- These regulatory tailwinds, coupled with technological advances, have driven price reductions and efficiency gains, leading to increasingly cost-competitive sources of low-carbon or renewable energy sources versus fossil fuel equivalents.
- Fiduciary investors must consider the increasing potential transition risks of fossil fuel reserve owners within their portfolios.

More and more investors globally are recognizing the material investment risks of climate change. In the World Economic Forum's 2020 Global Risks Report, a survey of over 1,000 business leaders, investors, and policymakers indicated that, for the first time, issues related to global warming are perceived as the top five risks in terms of likelihood over the coming decade. As a starting point, these risks are often categorized into two primary channels:

1. *Physical risks* associated with changes in climate leading to extreme weather events and long-term changes in temperature and sea-level rise, and
2. *Transition risks* associated with the global energy transition away from fossil fuels and toward a low-carbon economy, generally focused on fossil fuel intensive sectors and companies.

Given the focus on owners of fossil fuel reserves, transition-related risks will be the focus of this analysis. In examining the implications of a transition to the low-carbon economy on fossil fuel reserves, many researchers have analyzed the necessity and likelihood of a significant share of reserves remaining underground, referenced as "unburnable carbon." In one estimate, researchers have predicted that 80% of current coal reserves, 33% of current oil reserves, and 50% of current gas reserves will need to remain unused through 2050 to avoid breaching the 2°C target of the Paris Agreement.[1] As a result, segments of the fossil fuel industry may be threatened by "stranded asset risk," a term that describes the risk of "unanticipated or premature write-downs, devaluations, or conversion to liabilities."

These risks ultimately depend on the forward-looking trajectory of fossil fuel related energy production, the associated emissions, adoption of clean technology and regulation. A common tool for assessing forward-looking transition risk is through scenario analysis, or plausible scenarios of future energy supply and demand to meet societal needs and proposed emissions targets.

1. McGlade C, Ekins P. "The geographical distribution of fossil fuels unused when imiting global warming to 2°C." *Nature*, January 2015.

Scenarios Assessing a Shifting Energy Mix

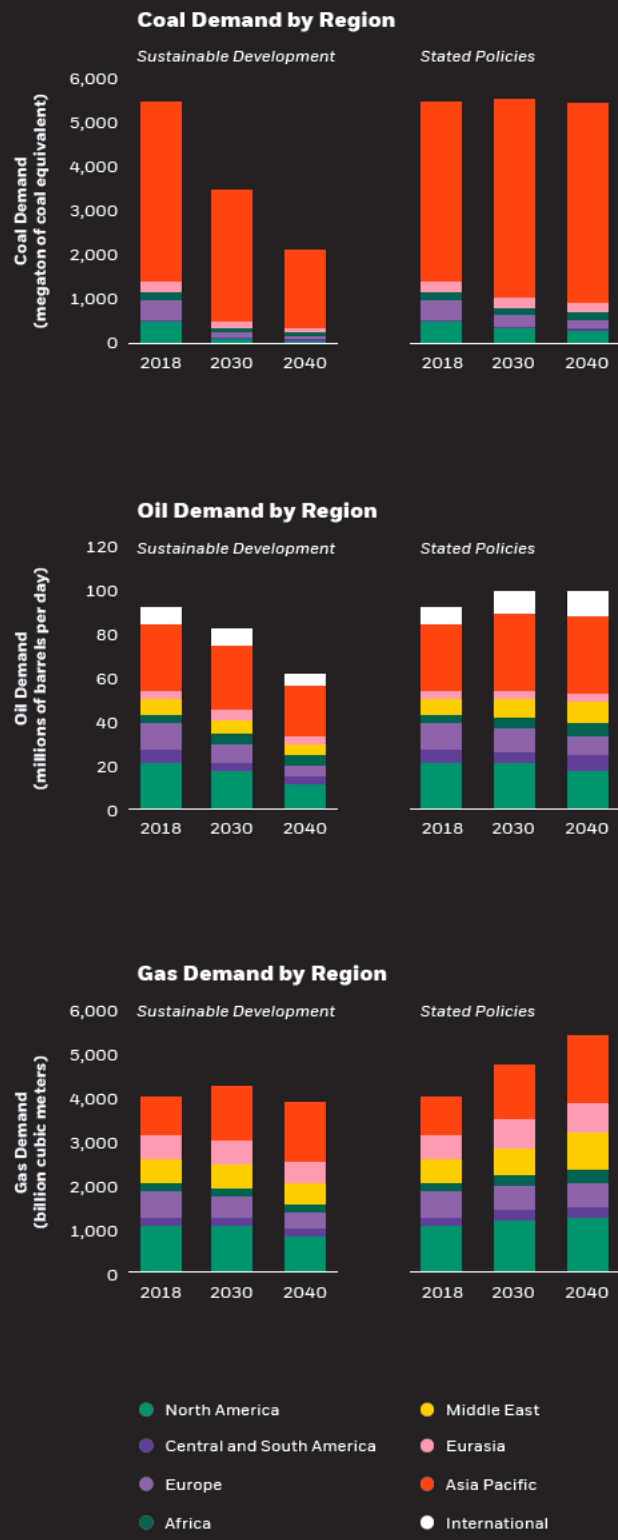
Assessing different possible future scenarios, or pathways that could bring about changes in fossil fuel supply and demand, can serve as a helpful starting point to understand future risks to fossil fuel reserve owners. A commonly cited set of energy projections comes from the International Energy Agency's (IEA) annual World Energy Outlook[1] report. The agency provides three main scenarios for the future global energy market, broken down by region and sector:

- *Current Policies Scenario* (CPS) is a baseline picture of how global energy markets would evolve if governments make no changes to their existing policies and measures.
- *Stated Policies Scenario* (STEPS) incorporates existing energy policies as well as an assessment of the results likely to stem from the implementation of announced policy ambitions.
- *Sustainable Development Scenario* (SDS) sets out a pathway to achieve the key energy-related components of the United Nations Sustainable Development agenda, including universal access to modern energy by 2030; urgent action to tackle climate change (in-line with the Paris Agreement); and measures to improve poor air quality.

These scenarios are modeled based on energy policies, pricing policies, economic outlook, energy price trajectories, production costs, and energy technology costs.[2] For comparison purposes, supply and demand projections to 2040, across regions and fuel types, within the STEPS and SDS are presented.[3]

Coal

As the world's most abundant fossil fuel, thermal coal has historically comprised a significant share of the global energy system. However, its high carbon intensity sets it apart from other fossil fuels — a major reason the industry has contributed over 30% of the planet's average temperature increase from pre-industrial levels.[4] In turn, the coal industry faces the heaviest pressure amid the energy transition. As recent cases to this effect attest: in the last four years the top four largest U.S. coal mining companies have filed for bankruptcy while international producers such as Anglo American, Rio Tinto, and BHP have completely exited or are planning to exit their thermal coal production businesses.



Source: IEA World Energy Outlook, December 2019. IEA projections only extend to the year 2040.

1. The IEA was founded in 1974 to help countries provide secure and sustainable energy for their citizens. Member countries must meet a set of requirements, including a minimum supply of oil reserves to prevent market disruptions.
2. These scenarios do not represent a comprehensive list of existing projections. For example, the UN PRI has released its "Inevitable Policy Response" as an alternative to the IEA scenarios. The UN PRI Inevitable Policy Response is predicated on 8 key po icy forecasts — including carbon pricing, a gas-powered car ban in first-mover countries, and coal phase-outs — which together project an ambitious transition scenario, similar to the SDS.
3. At the time of writing, the IEA has pub ished additional scenarios in light of COVID-19 including a new Delayed Recovery Scenario. The overarching direction and magnitude of change across fossil fuel projections are consistent for the STEPS and SDS scenarios presented above. The largest revision is within the STEPS forecast for coal by 2030, -9% down from previous estimates, whereas oil and gas demand is forecast slightly lower, approximately -2% compared with prior estimates.
4. "Global Energy & CO2 Status Report 2019," IEA, March 2019.

From a global perspective, the IEA has forecasted that the status of coal in Asia will continue to play a major role in the region's energy future, given the region's large coal supply and young coal-fired fleet. That said, forecasts for coal-fired energy vary greatly by the scenario in focus. Under STEPS, the share of coal in the global energy mix is projected to decline from 27% in 2018 to 21% in 2040, falling behind natural gas in the process. However, under SDS, world coal use is 60% lower than in STEPS and its overall share in the primary energy mix falls towards 10%.

Oil

For the oil industry, the STEPS projection shows robust demand growth through 2025, with growth dramatically slowing shortly after. By 2040, STEPS has demand reaching 106 million barrels per day (mb/d).

The SDS, on the other hand, predicts that under dramatic changes to the global energy system, consistent with Paris Agreement conditions, oil demand would peak within the next few years and drop to under 67 mb/d in 2040. Under this scenario, demand is projected to fall by more than 50% in advanced economies and by 10% in developing economies between 2018–2040.

Gas

The projections for natural gas are less stark than coal and oil. Natural gas outperforms coal and oil in both STEPS and SDS. Under STEPS, gas demand would grow by over a third. Under SDS, it would grow at an average annual rate of 0.9% until 2030 and decrease to below 2018 levels by 2040.

Even under a SDS, natural gas growth could be temporarily buoyed by its potential role as a less carbon-intensive bridge fuel. The IEA states that "liquefied natural gas (LNG) is the key to more broad-based growth in the future," with 2019 already marking a record year for LNG investment, despite prices falling to record lows.

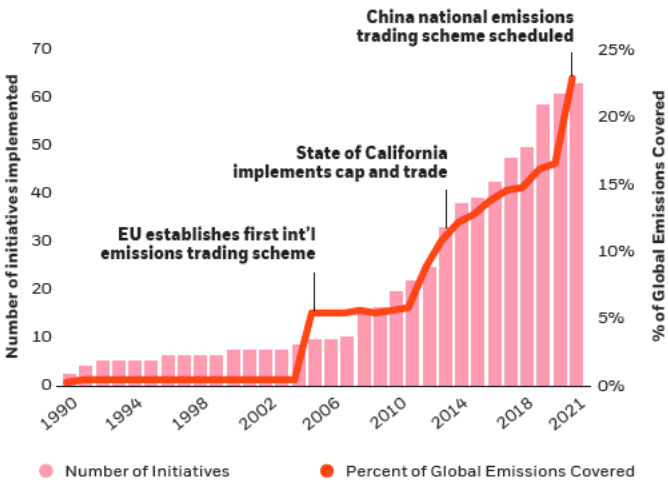
In total, the future of fossil fuel reserve ownership across fuel types will be heavily dependent on whether or not the world tracks more closely to an ambitious SDS. If a SDS materializes, the negative long-term impact will be greatest for coal and oil, while natural gas may fare relatively better, though still maintaining a downward trend through 2040. Regardless, public policy will be a major determinant for the prevailing outcome.

Regulatory Action Promoting the Global Transition

Climate and energy policy are critical drivers for the low carbon transition. Policies can range from industry- or sector-specific to broad emissions taxes and trading schemes. For example, to date, 17 countries have announced the phase-out of internal combustion vehicles;[1] Germany, Canada, and the UK have set explicit timelines to phase out coal-fired power; California has mandated rooftop solar panels on all new homes and banned the sale of gasoline-powered cars beginning in 2035; the EU has increased its 2030 emissions reduction ambition to 55% (relative to 1990 levels) as part of its European Green Deal, a policy roadmap to continental carbon neutrality by 2050; and China has announced a target for carbon neutrality by 2060, with emissions peaking in 2030. Taken as a whole, the passage of climate related legislation is accelerating, roughly doubling every five years since 1997.

One of the more widely-accepted policy instruments for reducing global emissions is carbon pricing, either through the use of carbon taxes or emissions trading schemes. The goal of these policies is to use an economic framework to incentivize energy consumption away from carbon-emitting fossil fuels and towards renewable and zero-emission sources. As of April 2020, the World Bank has tracked 61 carbon pricing initiatives that are either implemented or scheduled for implementation around the globe, covering about 22% of global GHG emissions. The last year alone brought ten new carbon pricing initiatives, the most ever in a single year and equal to the total number of carbon pricing initiatives launched in the last three years combined.[2]

Regional, National and Subnational Carbon Pricing Initiatives
Number and Share of GHG Emissions Covered

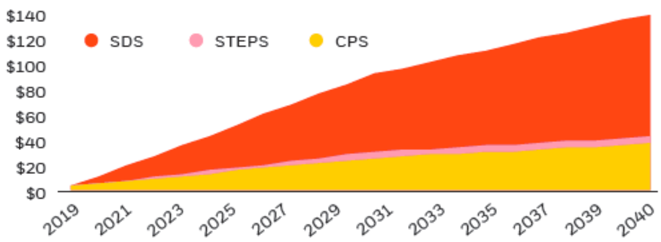


Source: World Bank: Carbon Pricing Dashboard, April 2020. This material represents an assessment of the market environment at a specific time and is not intended to be a forecast of future events or a guarantee of future results.

1. France became the first country to formalize this into law in December 2019 with a 2040 timeframe; https://www.iea.org/reports/global-ev-outlook-2020
2. "State and Trends of Carbon Pricing 2020," World Bank, May 2020

Despite the accelerating growth of carbon pricing schemes, the current global average price remains low: approximately USD $2 per metric ton of carbon.[1] Under the IEA's CPS and STEPS, carbon pricing is projected to reach USD $35 per ton and USD $40 per ton by 2040, respectively. However, under the SDS, global carbon pricing could require prices as high as USD $133 per ton. As a result, there is growing pressure for countries to raise ambitions and coordinate on policies so that a globally consistent carbon price can be established.

Implied Carbon Price Across Scenarios



Source: IEA World Energy Outlook.
Prices are linear interpolations from 2030 and 2040 estimates by scenario.

Even in the absence of policy action, it is important to note that these risks are still present. In fact, there is a case to be made for why the stranded asset risk increases in tandem with policy delays and approaching ecological "tipping points." In a delayed policy scenario, as opposed to one with gradually planned phase-outs and transformations, the eventual transition to a low-carbon economy is more likely to be rapid and hurried, leading to quick obsolescence of fossil fuel reserves.[2] As a result, investors must be increasingly proactive in their risk management as political and environmental milestones approach to ensure they are not caught off-guard by sudden devaluations.

Technological Innovation

Technological innovation, price reductions and efficiency improvements have accelerated the deployment of carbon efficient technologies to replace existing carbon-emitting activities. Intimately connected to public policy, lawmakers play a central role in facilitating renewable energy adoption, whether through policy that deters fossil fuel usage (i.e. carbon pricing) or through active support of the renewable energy market (i.e. subsidies, capital support).

To date, however, the renewable energy market is becoming increasingly attractive on a cost basis, even without comprehensive government support. The following table shows that, in 2019, all types of renewables were cost-competitive, on average, with fossil fuels, whose costs typically ranged from USD $0.05 per kilowatt-hour (KWH) to USD $0.18 KWH. Since 2010, solar and wind power have witnessed the steepest cost reductions. Hydro and geothermal power have become slightly more expensive; however, their average costs were very low to begin with and they remain cost-competitive with fossil fuels.

Electricity Costs by Renewable Power Type, 2010–2019

Renewable Power Type	2019 Global Weighted Average Levelized Cost of Electricity ($/KWH)	2010–2019 Change
Bioenergy	0.066	-13%
Geothermal	0.073	+49%
Hydro	0.047	+27%
Solar Photovoltaic	0.068	-82%
Concentrated Solar	0.182	-47%
Onshore Wind	0.053	-39%
Offshore Wind	0.115	-29%

Source: International Renewable Energy Agency (IRENA), June 2020.
Note: Fossil fuel costs range from USD $0.05 KWH to USD $0.18 KWH.

According to the International Renewable Energy Agency (IRENA)[2], a large number of onshore wind and photovoltaic (PV) solar power plants are already cheaper than fossil fuels, even without subsidy assistance. This year, more than 75% of scheduled onshore wind and solar power will produce cheaper electricity than the cheapest coal, oil, or natural gas-powered equivalents.[3] In coal-intensive India, solar energy has reached the cheapest level in the world — 14% less than the cost of existing coal power generation.[4]

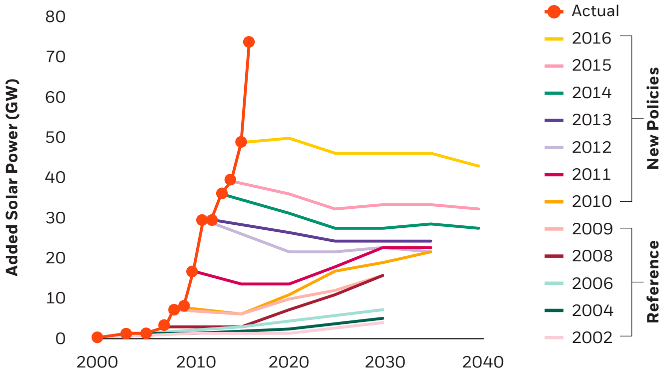
Meanwhile, the average costs of utility-scale battery storage per-unit of energy capacity in the United States have decreased by 61% between 2015 and 2017, with global averages projected to decline up to 67% by 2030 and 80% by 2050.[5] Falling battery storage costs also boost prospects for electric vehicle demand. Totaling just 17,000 vehicles in 2010, the electric vehicle stock grew to 7.2 million vehicles by 2019 and is projected to reach 245 million by 2030 under the IEA's Sustainable Development Scenario.[6]

Notwithstanding, it is worth noting that, thus far, the energy transition is happening more rapidly than previous forecasts have anticipated. For example, the IEA World Energy Outlook has consistently

1. *"State and Trends of Carbon Pricing 2019,"* World Bank, June 2019.
2. IRENA is an intergovernmental organization that supports countries in their transition to a sustainable energy future, serving as the principal platform for international cooperation and as a repository of po icy, technology, resources and financial knowledge on renewable energy.
3. "Too Late, Too Sudden: Transition to a Low-carbon Economy and Systemic Risk," European Systemic Risk Board, February 2016.
4. "Renewable Power Generation Costs in 2019," International Renewable Energy Agency, June 2020.
5. Cole, W. and A. Will Frazier, "Cost Projections for Uti ity-Scale Battery Storage," National Renewable Energy Laboratory, June 2019; "Battery Storage in the United States: An Update on Market Trends," EIA, July 2020.
6. "Global EV Outlook 2020," IEA, June 2020.

underestimated the rate at which renewable power has been adopted and overestimated the demand for fossil fuel energy.[1] The chart below compares actual solar power growth with each of the IEA's projections from 2002–2016. Each year, the IEA has projected modest growth in solar power, despite exponential growth forcing upwards revisions each time. This is the paramount risk for companies and investors — the risk that the transition away from fossil fuels happens quicker and more abruptly than forecasted.

IEA World Energy Outlook: Solar Power Projections
Projected Solar Power Growth vs. Actual Growth



Source: Data from IEA, World Economic Outlook 2002–2016, February 2020. See Hoekstra (2019).

1. Hoekstra, A., "Photovoltaic growth: reality versus projections of the International Energy Agency," January 2019.

II. BlackRock Measurement Approaches

Key Findings

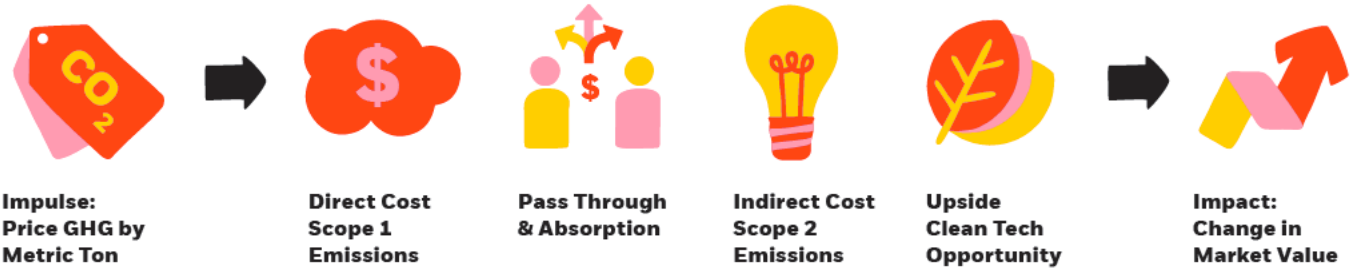
- Fossil fuel reserve owners are faced with high potential transition risks through a shifting energy mix and increasing regulation.
- To systematically measure these risks, BlackRock has developed two distinct approaches that analyze a security's 1) current carbon pricing sensitivity and 2) forward-looking trajectory or preparedness for the low-carbon transition.
- Carbon pricing sensitivity analysis helps investors assess the impact on a company's valuation of an instantaneous carbon pricing scheme. This provides clarity on point-in-time impacts to earnings under different potential carbon taxes.
- Low-Carbon Transition Readiness (LCTR) scores companies' preparedness for the transition to a low-carbon economy, taking a forward-looking view on the evolution of a company's reliance on fossil fuels and ranking each company in relation to its peers.
- For a comprehensive view of a company's risk, both its current exposure and forward momentum should be considered. To this end, BlackRock proposes leveraging both of BlackRock's Carbon Price Sensitivity and LCTR scores — to understand NYC TRS' exposure to transition risk.

Increasing regulatory action and technological innovation is powering a transition toward a low-carbon economy, and some companies are more prepared for this shift than others. In the focus on transition risk, or financial risks that arise from a transition to a lower-carbon economy, both point-in-time exposure to carbon prices and forward-looking assessments of a company's transition readiness are considered. Two BlackRock-developed metrics that measure transition risk — Carbon Price Sensitivity and LCTR — are presented and recommended for analysis.

Sensitivity to Carbon Prices

BlackRock has developed a framework for assessing the sensitivity of company valuations to carbon pricing schemes. This sensitivity is a measure of the impact that a carbon pricing scheme will have on a company's earnings and security valuation. The sensitivity measure is only materialized in the presence of carbon pricing schemes. Without a carbon scheme, there will be no emission costs and the Carbon Price Sensitivity measure will only represent a latent exposure. As the costs of emissions increase above zero, the Carbon Price Sensitivity effect will come into play.

This concept can be used to address the impacts from scenario analysis, such as 2 Degree or Business-as-Usual scenarios, because it is connected to the outcomes of carbon pricing schemes. For the purposes of analysis, the SDS will be referenced, which derives an estimated USD $18 carbon tax per metric ton of GHG in 2021 that slowly increases over time to keep emissions in-line with long-term temperature increases supported by the Paris Agreement. In other words, the USD $18 carbon tax we reference is the global average carbon tax needed for 2021 in order to stay on track with the commitments of the Paris Agreement, according to IEA estimates. The impact of this price will be compared to STEPS, where the carbon price is estimated to be USD $6 per metric ton of GHG in 2021.



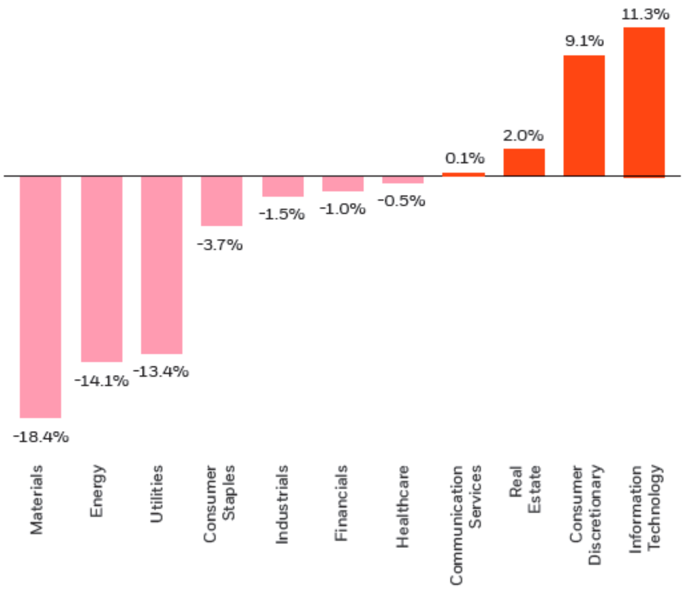
This framework is price invariant, meaning that by calculating exposure to a USD $1 increase in carbon price, there is flexibility to analyze the impact of a range of carbon prices — including those in alignment with other temperature scenarios. However, anchoring toward estimated prices through existing scenarios allows a comparison of potential embedded risk to carbon prices for long-term transition scenarios.

To calculate the sensitivity of fossil fuel reserve owners to carbon pricing, the following approach is taken:

- First, a carbon price results in a direct tax to an issuer based on its direct emissions through owned and operated assets. This can be considered a new cost on its income statement.
- Next, recognizing that companies — depending on the regulation and competition of their industry — have different pricing power, an industry-level adjustment is applied that allows a percentage of the new direct cost to be "passed through" to its consumers or clients through increasing pricing power. One can imagine, for example, that increasing costs for a utilities company will lead to higher electricity prices for consumers to offset a portion of the tax. Because of this pass through, companies that require a large amount of electricity — or have high scope 2 emissions — are penalized in the model, commensurate with their energy requirements.
- Finally, a carbon price will render clean technology substitutes and energy or carbon efficiency products more attractive. For this reason, companies that are providing clean technologies are assumed a revenue benefit subject to the amount of clean technology revenue that they are earning today.
- The result of the costs, both direct and indirect, along with the potential upside or benefit through new technology revenue, is combined into what can be considered adjusted earnings for the issuer. These adjusted earnings reflect the change in earnings to follow an implemented tax on carbon.

With the Carbon Price Sensitivity assessments, investors can understand which companies face larger potential negative earnings impacts — both across and within industries. For example, in examining a broadly diversified equity benchmark, the MSCI ACWI Index, companies within the [redacted] sectors face the largest potential valuation decline following at USD $25 tax on carbon. Within each of these sectors, there is a distribution of performance at the security level. For NYC TRS, this is the proposed first step in examining the fossil fuel reserve owners most exposed to transition today. For additional detail see the Appendix for a whitepaper on the Carbon Price Sensitivity methodology.

Hypothetical Sector Return
Under USD $25 Metric Ton Carbon Price



Source: BlackRock Sustainable Investing. For illustrative purposes only. Initial model covers the MSCI ACWI equity universe. Data as of August 30, 2019. This material represents an assessment of the market environment at a specific time and is not intended to be a forecast of future events or a guarantee of future results. This information should not be relied upon by the reader as research or investment advice regarding the funds of any security in particular.

Transition Readiness: Forward-Looking Transition Preparedness

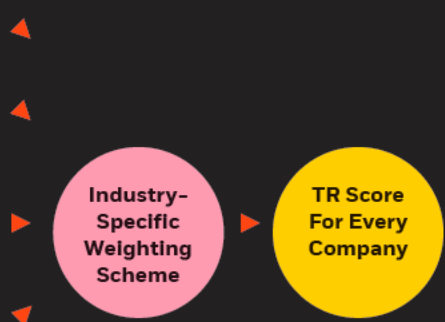
In addition to understanding the current exposure of an issuer to carbon pricing, a forward-looking assessment is required. This is because companies may be taking actions today to mitigate the potential risks or transition their business models toward lower carbon emissions or energy efficient operations. The LCTR assessments are BlackRock's approach to measuring companies' preparedness for the transition to a low-carbon economy. This approach is distinct in two respects: first, it is based on thematic research on the full complement of company activities that reflect its preparedness for the transition to a low-carbon economy, and second, it applies quantitative investment techniques that benefit from understanding and analyzing multiple sources of climate- and sustainability-related company data.

The overarching LCTR research framework has been informed by the output of different long-term scenarios, including the IEAs, but was designed to assess Transition Readiness (TR) without being connected to any particular scenario. In other words, while the assessments are predicated on future global emission reductions, its utility is not contingent on a specific future temperature or emissions outcome. Instead, the goal is to generate a more useful way to assess the costs and opportunities firms could realize in the transition process, even as there remains significant uncertainty about the probability of any one long-term climate scenario unfolding. The result is a forward-looking, within-industry comparison of the companies better or worse prepared for the global energy transition. Since LCTR is a relative measure of transition readiness, unlike the Carbon Price Sensitivity estimation which measures absolute changes to earnings, it is not designed to offer a measure for "sufficient" readiness.

Building upon existing climate and investment research, a new five-part framework of "pillars" was designed to assess a company's preparedness for the low-carbon transition. The pillars are intended to capture key sources of a company's risk and opportunity associated with the transition, categorized by a company's core business exposure (including fossil fuels and clean tech) or natural resource management (including energy, water and waste). Within the pillars, key performance indicators (KPIs) are assembled to measure the company's performance against the theme, over 200 individual metrics are analyzed, and specific insights are "prioritized" or given higher weight in the issue assessment. For example, the rate of change of emissions intensity for fossil fuel production and energy management (i.e., direct and indirect emissions over time), in combination with its relative positioning "level" versus peers, are weighted more heavily than others. The recent trajectory of emissions is correlated with future emissions reductions (or increases). For the clean technology pillar, both low-carbon technology revenue, forward-looking strategy, as well as downstream scope 3 emissions are considered.

Next, each company's assessments for each pillar are combined into a single score by applying an industry-specific "materiality" framework. Materiality refers to our ex-ante view on how financially relevant each pillar should be based on the industry of the company. For example, each pillar's relative weighting for a healthcare company will differ from a utility company. To construct a materiality framework, the Sustainability Accounting Standards Board (SASB) materiality map, which aims to identify financially material sustainability issues by industry, is referenced and modified. The combination of weighted pillar scores results in a TR assessment for each company in the investment universe, or a TR score. For more information on methodology, see Appendix.

Pillar	KPIs	Prioritized Insights	Total KPIs
Energy Prod.	• Reserves amount • Reserves emissions • Product & generation mix	Level & rate of change of direct emissions intensity	24
Carbon Tech	• Carbon efficient tech opportunity • Green building exposure • Renewable energy targets	Level & rate of change scope 3 carbon intensity and environmental opportunities based on current revenue and R&D	26
Energy Mgmt.	• Energy use efficiency & targets • Quality of disclosure • Renewable energy purchased	Level & rate of change of emissions intensity	35
Water Mgmt.	• Water management & policy • Water recycled • Water pollution & impacts	Level & rate of change of water withdrawal intensity	25
Waste Mgmt.	• Packing waste management • Waste mitigation strategy • Toxic emissions from waste	Level & rate of change of total waste produced and waste recycling intensity	39

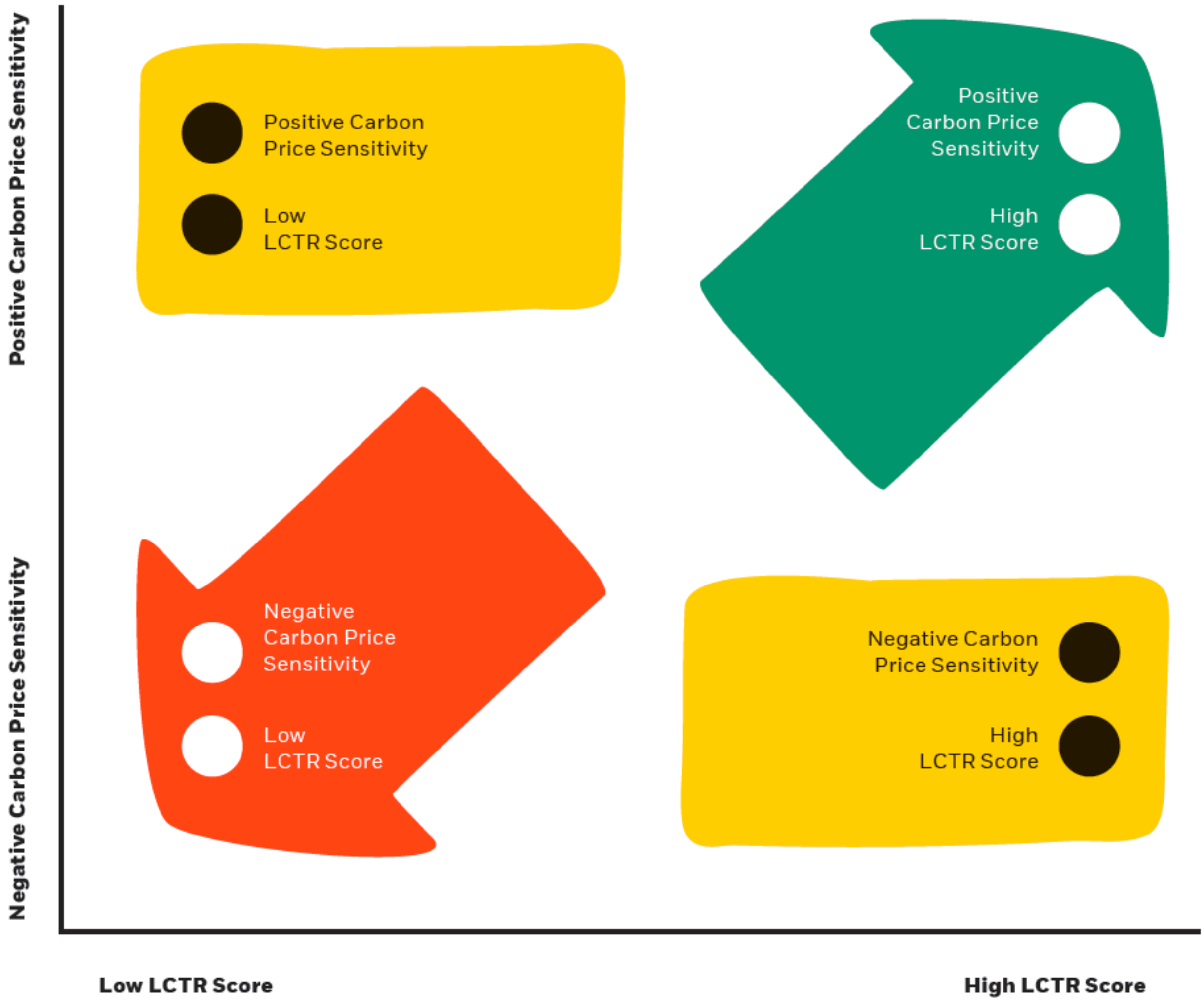


A Combined Approach

A comprehensive view of a company's viability in a low-carbon economy must consider both its current market positioning and its forward-momentum. To understand NYC TRS' exposure to transition risks, an analytic approach that combines the Carbon Price Sensitivity and LCTR assessments of a company to create a new transition risk for fossil fuel owners metric is proposed. Central to this approach will be segmenting the universe of considered issuers into four categories: those with positive Carbon Price Sensitivity and LCTR, negative Carbon Price Sensitivity and LCTR, and each combination of the two. This will highlight the issuers most exposed to transitions risks, or those that have high current negative exposure to carbon pricing, as well as low forward-looking prospects.

Initial carbon prices will start at USD $18 per metric ton, aligned with the pricing estimated for the SDS for 2021. This rank ordered list will then be compared alongside an issuer's transition readiness rating. The joint distribution will determine a final rank-ordered list of issuers deemed most vulnerable to transition risk.

This approach ensures that our investment recommendations are made with both the near-term potential for accelerated carbon pricing and the long-term portfolio and low-carbon resiliency in mind.



III. Portfolio Analysis and Exposure: Results

Key Findings

- The starting universe of fossil fuel reserve-linked securities shows a distribution of exposures to both carbon price sensitivity as well as forward-looking potential (Transition Readiness).
- Of the starting universe, most securities are expected to take a negative earnings hit under the USD $18 carbon tax, with an average earnings adjustment of negative 14%.
- With a forward-looking lens, companies are also distributed in their relative preparedness for the low-carbon transition, with some companies scoring more than negative two standard deviations lower than the average company's preparation for the low-carbon transition.
- In combining these two insights — both current exposure and forward-looking preparedness — tiers of transition risk exposure emerge ranging from less prepared (both negative Carbon Price Sensitivity and LCTR) to more prepared (positive Carbon Price Sensitivity and LCTR).
- This differentiation of companies provides a lens into potential divestment options (or tiering) of the universe to be analyzed in Phase 3.

Carbon Price Sensitivity Results

Across the universe of fossil fuel reserve linked securities, an estimated carbon tax at USD $18 per metric ton is applied. This baseline sensitivity to a USD $18 tax reflects an estimated carbon price in 2021 to align with the Paris Agreement.

Results show company impacts from a potential carbon tax that range from -100% (a company expected to lose 100% of its earnings under the given carbon tax) in a few extreme cases to positive earnings of 50%. The companies with large negative estimates are generally those with high emissions profiles — that is, large Scope 1 and Scope 2 carbon emissions per earnings on unit of good sold – with little to no activity in green or low-carbon solution production. Conversely, companies with large positive estimates, or expected increases in earnings, in general have muted impacts from direct carbon prices and are expected to benefit from a shift toward the green or low-carbon solutions they provide.

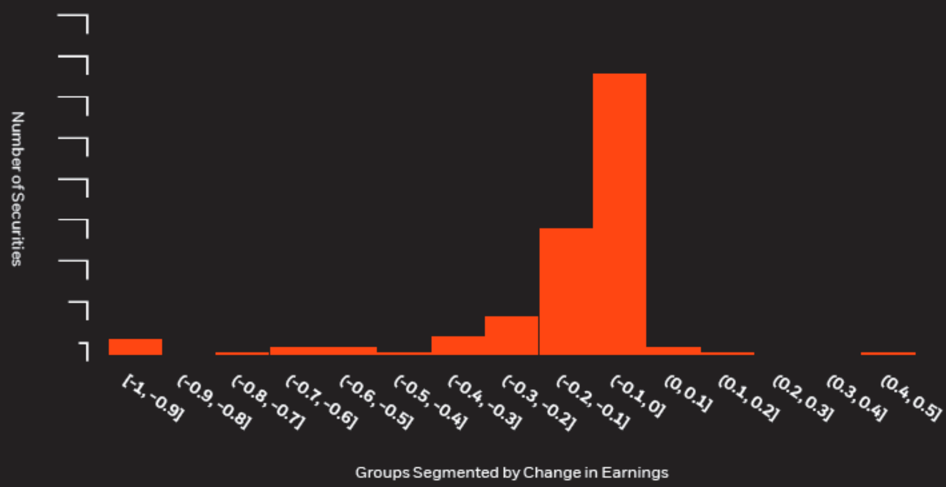
Of the universe, most securities are expected to take a negative earnings hit under the USD $18 carbon tax, with an average earnings adjustment of negative 14%. From a frequency perspective, the majority of expected instantaneous changes in earnings clustered between -5% and 5%. The distribution of estimations reveals several outliers. These companies that are more carbon-dependent fare far worse in this assessment than companies with a more balanced fuel mix.

From an industry perspective, [redacted] issuers that yield a Carbon Price Sensitivity estimation of -100% are from the [redacted] sector, followed by [redacted]s — driven primarily by the intensity of carbon emissions associated with these business operations.

These results illustrate that while the majority of fossil fuel reserve-linked companies are expected to decline in earnings and value in the event of a carbon tax, there is a distribution of companies that are expected to fare better or worse than others.

Key Metric	Value
Minimum	-1
Median	-0.07
Mean	-0.14
Maximum	.5
Standard Deviation	0.22

Table 1: Distribution of Carbon Price Sensitivity Estimates



Example: (-0.2,-0.1) shows the number of securities that would see -10% to -20% decrease in earnings from an $18 per ton carbon tax.

Transition Readiness Results

In contrast to assessing current sensitivity to carbon prices, LCTR scores evaluate companies' preparedness for the transition to a low-carbon economy. This is done by taking a forward-looking view on the evolution of a company's reliance on fossil fuels and ranking each company in relation to its peers.

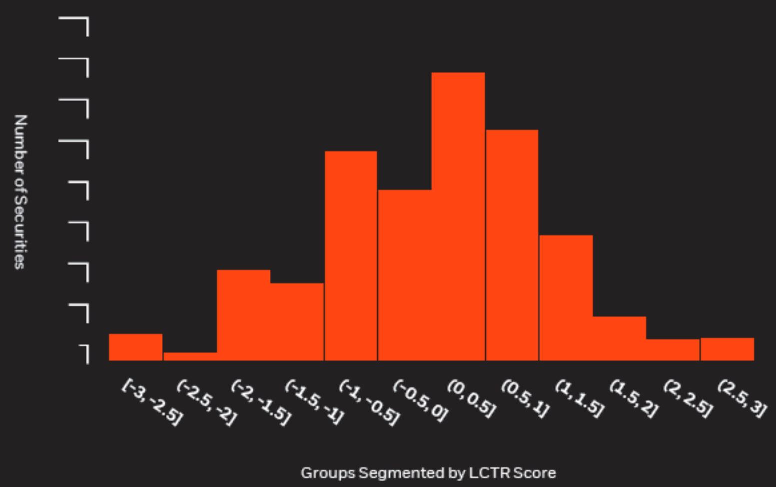
Results of this analysis show fossil fuel reserves-linked companies are distributed across the LCTR score range of -3 (worst) to 3 (best). The dispersion of scores shows that, of the securities flagging, some companies are better positioned than their industry peers to decrease their reliance on fossil fuels in the coming years. While most companies are clustered around 0 (average relative to all companies in the MSCI ACWI universe), a rank-ordered list can be extrapolated from the relative scoring framework to assess which securities are most exposed to transition risk on a go-forward basis.

The distribution of LCTR scores is roughly symmetrical, meaning that roughly half of the securities flagging for ties to fossil fuel reserves are better positioned for the transition to a low-carbon economy than the other half, which are expected to have greater costs associated with complying with any carbon tax or related regulatory effort and decreasing revenue from lower carbon intensive product demand.

The companies with the lowest LCTR scores, or least demonstrated low-carbon transition preparedness, are energy companies — specifically, those that have not implemented a transition policy or strategy. Further, these companies are not expected to capture clean technology revenue opportunities based on their forward-guidance.

Key Metric	Value
Minimum	-3
Median	0.01
Mean	0.01
Maximum	3
Standard Deviation	1.07

Table 2: Distribution of LCTR Scores



Example: (-1,-0.5) shows the number of securities that have a normalized Transition Readiness Score between -1 and -0.5.

Combined Results

For a comprehensive view of a company's risk, both its current exposure and forward momentum should be considered. To this end, BlackRock proposes taking a combined approach — assessing each security's Carbon Price Sensitivity estimation and LCTR score — to understand NYC TRS' exposure to transition risk.

Plotting the two metrics, LCTR and Carbon Price Sensitivity, against one another highlights the necessity of a combined approach. The transition risk carried by each security cannot be explained by one metric alone: for example, companies performing poorly in the point-in-time Carbon Price Sensitivity estimation that are positioned to benefit from a transition to a low-carbon future would carry less transition risk than companies performing poorly in both the point-in-time Carbon Price Sensitivity and forward-looking LCTR assessment. As technological advances and regulatory actions signal a global energy transition, a robust assessment of transition risk is required to properly construct a list of potential divestments.

Based on the distribution of Carbon Price Sensitivity and LCTR assessments, the universe of fossil fuel-linked securities is divided into 3 tiers:

- Tier 1: securities that have a negative LCTR score and negative Carbon Price Sensitivity estimation (i.e., the list of securities carrying more relative transition risk)
- Tier 2: securities with a negative LCTR score and positive Carbon Price Sensitivity and securities with a positive LCTR score and negative Carbon Price Sensitivity estimation
- Tier 3: securities that have a positive LCTR score and Carbon Price Sensitivity estimation (i.e., the list of securities carrying less relative transition risk)

Table 3: Carbon Price Sensitivity vs. LCTR

Tier	Security Count	Immediate Issuer Count	MV % of Flagged	MV % of Total
1	[redacted]			
2				
3				

Positive Carbon Price Sensitivity

Negative Carbon Price Sensitivity

[redacted]

Within Tier 1, those with negative Carbon Price Sensitivity estimation and projected negative preparedness for the transition, [redacted] securities are identified. The vast majority are Energy companies ([redacted] followed by [redacted]. This is broadly in-line with expectations given that those three sectors have historically been very carbon-dependent.

The companies faring worst in the combined assessment have a global makeup and span the Energy, [redacted] sectors.

Breakdown of Tier 1 Securities by GICS Sector

GICS Sector	Security Count
Energy	[redacted]

[redacted]

Conclusion

As technological progress and regulatory pressure build, it is becoming increasingly important that investors account for the potential investment risks associated with a global energy transition. A successful transition to a low-carbon economy raises the possibility that fossil fuel reserves — which may be unusable in a low-carbon scenario — will face precipitous devaluation or become "stranded assets." Projections by the International Energy Agency, aligned with the objectives of the Paris Agreement, suggests we are at the onset of secular decline in both long-term demand and production of fossil fuel energy sources — particularly in coal and oil.

To identify these risks within the NYC TRS portfolio, a combination of two of BlackRock's transition risk analytics are applied. Beginning with BlackRock's Carbon Price Sensitivity tool, the present-day exposure or vulnerability of the starting universe of fossil fuel reserve-linked securities to the transition risks of carbon pricing is measured. Next, BlackRock's LCTR framework is overlaid to measure a forward-looking trajectory or preparedness for the low-carbon transition.

In aggregate, the starting universe of securities indicates exposure to transition risk. More than 90% of securities showed a negative earnings impact from a potential USD $18 carbon tax [redacted]ecurities in universe). When combined with forward-looking transition readiness, approximately 95% ([redacted] securities) of all fossil fuel-linked securities had either or both negative carbon price sensitivity or transition readiness. That said, there is meaningful differentiation in transition risk within the universe. In combining these two insights — both current exposure and forward-looking preparedness — tiers of transition risk exposure emerged, ranging from less prepared (both negative carbon price sensitivity and negative transition readiness) to more prepared (positive carbon price sensitivity and positive transition readiness).

Together, these two analyses will inform potential options for divestment within the NYC TRS portfolio. In the next phase of this analysis, these options will be analyzed side-by-side across historical and go-forward risk dimensions, implementation, and monitoring considerations.

Appendix

Overview of Publicly Available Measurement Approaches

Data Provider	Offering	Approach	Notes
Company Targets & Assessments			
Science Based Target Initiative (SBTi)	• Helps define and validate science based targets aligned with temperature scenarios for companies on a range of criteria such as duration, ambition, and coverage	• Methods rely on GHGs • All companies must include Scope 3 in their emissions inventory; if Scope 3 represents more than 40% of aggregate emissions, the company must set a Scope 3 target • Avoided emissions may not be included • The time horizon for targets is 5–15 years, with the exception of Scope 3 supplier engagement targets (5-year time horizon)	• Target setting, not alignment or scenario-specific
Transition Pathway Initiative (TPI)	• Assesses companies' preparedness for the transition to a low carbon economy; compares companies' emissions intensity per unit of production as forecasted in 2030 (or 2050 for oil & gas) with their sector-specific benchmarks	• Rely on GHGs • Relevant value-chain scope • Forward-looking data based on targets • Two dimensions considered based on publicly available information: management quality and carbon performance	• Forward-looking company-level assessment
Pathway Alignment			
2 Degree Investing Initiative (2dii)	• PACTA: alignment at technology level • Aggregate at sector and portfolio level (expressed as percentage alignment and an Implied Temperature Rise metric)	• Technology exposure for power utilities, oil & gas, coal and automobiles; and GHG intensity for cement, steel, shipping and aviation • Relevant value-chain scope • Forward-looking data based on asset-level datasets	• Forward-looking sector and portfolio assessment (temperature)

Source: Institut Louis Bachelier et al. (2020). The Alignment Cookbook - A Technical Review of Methodologies Assessing a Portfolio's Alignment with Low-carbon Trajectories or Temperature Goal

Carbon Beta: A Framework for Determining Carbon Price Impacts on Valuation

Andre Bertolotti and Michael Kent[1]

Working Paper
August 2019

Abstract

Greenhouse gas (GHG) emissions create a cost liability for firms exposed to the implementation of carbon pricing. We propose a framework for public equities that links Scope 1 and Scope 2 emissions[2] with changes in firm valuation. This framework considers both 1) larger operating costs that lead to a decrease in value as well as 2) new revenues generated by "green" sales that increase the value of firms. From an initial carbon tax "shock", we distribute the tax costs across market sectors based on Scope 1 emissions and estimate higher electricity costs based on Scope 2 emissions. In addition, we consider an increase in revenues for companies generating solutions for mitigation of GHG emissions. The framework relies on a host of assumptions that we outline and test through sensitivity analysis. We find negative price responses in four sectors: Energy, Utilities, Materials and Transportation, while we find positive price responses in several sectors including Automobiles, Software and Capital Goods.

Introduction

Increasing awareness of climate change has prompted regulators to apply financial penalties on companies that contribute to greenhouse gas (GHG) emissions. The goal of these penalties is to use an economic framework to shift energy consumption away from carbon-emitting fossil fuels and towards renewable and zero-emission sources. There is growing trend for countries to coordinate policies using either new carbon taxes or emission trading schemes, as shown in Figure 1. For example, the World Bank is tracking 57 carbon pricing initiatives in 2019 that are either implemented or scheduled for implementation around the globe, covering about 20% of global GHG emissions (The World Bank, 2019).

[1] BlackRock Sustainable Investing, 55E 52nd Street, New York, NY 10055

[2] Definitions consistent with GHGprotocol.org standards for corporate emissions. Scope 1 refers to direct emissions produced by owned or operated assets of a company. Scope 2 emissions refer to indirect emissions resulting from electricity purchased.

Share of Global Emissions Covered by Regional, National, Sub-National Carbon Pricing Initiatives

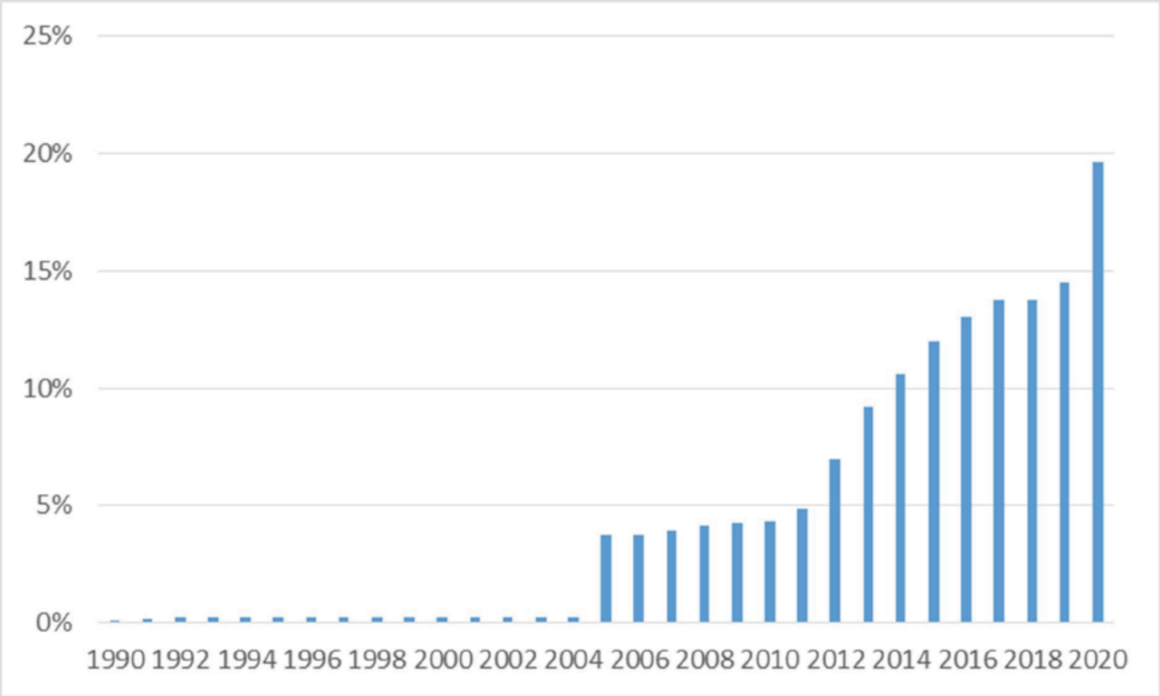


Figure 1 Global GHG Emissions Regulated Source: World Bank, BlackRock

In this paper, we propose a framework for assessing the sensitivity of company valuations to carbon pricing schemes. This sensitivity, which we term Carbon Beta, is a measure of the impact that a carbon pricing scheme will have on a company. As such, it is not a traditional measure of Beta which connects market moves with stock moves. Instead, it is a measure of sensitivity to carbon emissions which is only materialized in the presence of carbon pricing schemes. Without a carbon scheme, there will be no emission costs and the Carbon Beta measure will only represent a latent exposure. As the costs of emissions increase above zero, the Carbon Beta effect will come into play.

The concept of a Carbon Beta can be used to address the impacts from scenario analysis, such as 2 degrees or Business-as-Usual, because it is connected to the outcomes of Carbon Pricing schemes. For example, estimates of the carbon price required to comply with a 2 degree temperature scenario vary between USD $50 - 150 per metric ton of GHG (IPCC, 2018) and (World Bank, 2019). By calculating exposure to a $1 increase in carbon price, we maintain flexibility to analyze the impact of a range of carbon prices – including those in alignment with temperature scenarios – as well as understanding the relative exposure to any pricing scheme at the security level.

We define Carbon Beta as:

$$Carbon\ Beta = \frac{\Delta\ Firm\ Value}{\$1\ Carbon\ Tax}$$

Where the Δ Firm Value is the percent change in the overall firm valuation resulting from the implementation of $1 in Carbon Tax.

Our motivation in developing a Carbon Beta is to gain a deeper understanding of potential financial impacts of imposed prices on carbon – both at the individual company level and extrapolated to sectors and the broader equity investment universe.

Prior Literature

The impacts of regulations setting carbon prices or limiting carbon emissions have been investigated in several studies of the European Union Emissions Trading Scheme (EU_ETS). For example, Smale et alii (Smale, 2006) studied the impacts of the EU_ETS on five sectors and found wide variations across market share and profitability based on a sector's ability to pass on the added costs of carbon emissions. In another study, Clarkson et al (Clarkson, 2015) found that the value of firms under the EU-ETS are related to excess emissions beyond free allowances and that a firm's ability to pass on the cost of the tax varies across market sectors. These results were echoed in a study by Oestreich and Tsiakas (Oestreich, 2015) who found similar benefits to free carbon allowances. In a focused study of the European electric utility sector, Tian et al (Tian, 2019) investigated the impacts of carbon pricing on the cost of electricity and stock price of electric utilities and found a positive and symmetric relationship between carbon prices and electricity prices while the effect on firm valuation diminished over time after implementation of carbon pricing.

Carbon taxes and regulations in Australia and South Africa also provided environments for investigating impacts on firm valuations. Luo and Tang (Luo, 2014) looked at market reactions to carbon legislature events in Australia during 2011 and concluded that carbon taxes had a negative impact on shareholder returns that varied across sectors. Carbon price impacts in the South African market were analyzed by Ganda and Milondzo (Ganda, 2018) who found a negative relationship between carbon emissions and corporate financial performance.

Outside of carbon tax regulations, Garvey et alii (Garvey, 2018) investigated the relationship between carbon emissions and firm profitability. They found that firms which reduced the carbon ratio, or carbon emission per unit of sales, had stronger future profitability and positive stock returns.

In this paper, we extend the approach of Clarkson et alii (Clarkson, 2015) to include 1) positive effects of carbon pricing, 2) cost effects of scope 2 emissions and an 3) explicit connection to firm valuation. We start with a description of the Carbon Beta framework in the next section and then discuss the sensitivity of results to key inputs for the framework. In the final sections, we discuss the results across various levels of carbon pricing and present our conclusions.

Outline of Carbon Beta Framework

We define Carbon Beta as a company's sensitivity to a price of $1 / metric ton of GHG expressed as potential gain or loss of firm value. The framework consists of five steps that originate with the explicit pricing of a ton of Scope 1 emissions and concludes with an impact on the valuation of a firm.

The steps of the framework are as follows:

1. Carbon tax implementation
2. Cost elasticity and pass through
3. Scope 2 emissions as proxy for electric energy usage
4. New green revenue capture
5. Impacts on Valuation

1. Carbon Tax Implementation

Greenhouse gas emissions are a byproduct of a company's operations that are currently not considered in GAAP reporting. Regulatory efforts to limit GHG emissions, however, are a method for explicitly including GHG emissions as a business cost. Regulations in terms of a direct tax on GHG emissions or Emission Trading Schemes impose a price on each ton of GHG emitted and thus give companies a measure of the liability created by emitting GHG.

In our framework, we assume that the cost of Scope 1 emissions can be materialized by a global carbon tax that impacts all companies equally. The cost to each business for GHG emissions will be the carbon tax, in units of dollars per ton of carbon emitted, multiplied by the total amount of Scope 1 emissions.

2. Cost Elasticity and Pass through

The added cost of a carbon tax can be either absorbed by a company, and thus reduce margins, or it can be passed through to customers in the form of higher prices for products and services. Using an industry concentration approach based on the Herfindahl-Hirschman Index (HHI), we posit that in more competitive markets, firms will compete on price and hence are incentivized to minimize the cost-pass-troughs. The less competitive the market becomes, the greater ability a firm will have to increase prices and pass on costs to its customers.

We make this calculation at the industry level but are aware that differences in operational efficiencies across companies will create different abilities to pass on carbon tax costs. Also, the definition of a "market" is important for defining the HHI because a global market will result in more competition than a smaller country or regional market. Here, we assume a global market as a simplification but acknowledge that regional trade barriers will impact pricing power by limiting competition.

We propose the following approach to estimate costs pass through:

1. A carbon tax on Scope 1 emissions raises the operating costs of a firm
2. Based on its pricing power, a company will seek to pass costs on to customers in order to maintain profit margins
3. The amount of costs that cannot be passed through will result in lower profits
4. With time, a firm will rebalance its production and energy mix to maximize profits.

In this study, we adopt the first three steps above since we only consider the period immediately following the implementation of a carbon tax. Over time, however, we are aware that there can be shifts and adjustments that will create a new equilibrium. For example, we exclude the effects of step 4 given the complexity of modeling firm-level cost pass through in the period after the implementation of a carbon tax. We are also aware that higher cost of goods will result in demand shifts as substitution effects develop from customers seeking to minimize their operating costs.

We make an exception for the Utilities sector since these companies are operating in a regulated market. Our assumption that Utilities will be able to pass 75% of a carbon tax cost is consistent with analysis of the European Emission Trading Scheme environment in which utilities were able to pass between 60% and 100% of the carbon tax costs (Sijm, 2006).

3. Scope 2 emissions as proxy for electric energy usage

The cost pass-through from electric utilities will result in higher electricity prices, which in turn will result in higher operating costs and lower margins for electricity users. To estimate the cost impact at company level, we use Scope 2 emissions reported by each company as a proxy for the amount of electricity used. We then distribute the total cost of electricity passed through in proportion to each company's Scope 2 emissions. This process also generates an implied cost per ton for Scope 2 emissions, although this specific figure does not enter in the Carbon Beta framework.

4. New green revenue capture

The added cost of a carbon tax on Scope 1 emissions creates a demand for products and solutions that can reduce GHG emission in a cost competitive way. We assume in our framework that if a company is faced with a carbon tax cost of $100 but can buy a green technology solution for $99 that eliminates its GHG emissions, the company will opt to purchase the technology since it is cheaper than paying the tax.

For companies providing green solutions, we estimate the increase in revenues as a percentage of the total cost of the carbon tax which we then distribute in the market in proportion to the share of green revenues.

5. Impacts on Valuation

A carbon tax will impact the profitability of a company. Costs will increase from the payment of the tax while revenues will increase from additional sales of green technology. The net effect between costs and revenues will change earnings, with decreasing earnings coming from heavy Scope 1 emitters while higher earnings coming from companies capturing the green technology opportunity.

We estimate the change in company valuation through its Price/Earnings multiple. By assuming that a long-term P/E ratio remains constant through the impact of a carbon tax, a change in earnings will translate into a change in price, and hence a change in company valuation.

Sensitivity Analysis

To assess the robustness of our framework and its dependency on any one variable, we examine the sensitivity of Carbon Beta to two key model inputs. First, we explore the impact of adjusting the Utilities pass through ratio for publicly listed companies, or the proportion of costs we expect Utilities companies to pass through to publically-listed purchasers of electricity. Second, we examine the sensitivity of Carbon Beta to the amount of total upside capture available to producers of clean technology. We have selected these variables because they are both based on broader market assumptions and represent downside and upside inputs in our Carbon Beta model. In each case, we review the rationale for our initial assumptions and the impact of adjusting these thresholds on Carbon Beta.

1. *Sensitivity of Utilities Pass-Through Costs to the Public Market*

The Carbon Beta model assumes that in the event of a carbon price, Utilities companies will pass through costs to their consumers, or purchasers of electricity. As noted above, we expect Utilities companies to pass through approximately 75% of their direct costs to the market. However, because purchasers of electricity are not all publically-listed companies (they also include private industry and residential buyers), we must adjust the total pass through costs when reallocating these costs to listed equities. We allocate 33% of total pass-through costs to the public market, based on our understanding on electricity usage by sector. Before reviewing the sensitivity analysis around this 33% ratio, we review our methodology and estimates of electricity consumption by sector.

To estimate the amount of electricity consumed by economic sector, we reference the U.S. Energy Information Administration (EIA) total electric power by industry summary data.[3] We find that approximately two-thirds of annual electricity consumed in the United States can be attributed to commercial and industrial use, separate from transportation and residential consumption. See table below:

Total U.S. Electric Power Industry		
Sales of Electricity to Ultimate Customers		
Sector	*(million kWh)*	*% of total*
Residential	1,378,648	37.0%
Commercial	1,352,888	36.3%
Industrial	984,298	26.4%
Transportation	7,523	0.2%
All Sectors	*3,723,356*	*100%*

We note that publically-listed companies may be categorized within the commercial and industrial sectors as defined by the EIA. Because consumption in these industries may also include private companies, we must estimate the total power consumed by publically-listed companies specifically. To do this, we reference an academic study that compares the investment behavior between public and private firms. Asker, Farre-

[3] See https://www.eia.gov/electricity/annual/ "Total electric power industry summary statistics"

Mensa and Ljungqvist find that approximately 57.6% of sales and 54.5% of spending on plants and equipment can be attributed to private firms in the US.[4] From this, we assume that approximately 50% of electricity consumption from commercial and industrial sectors can be attributed to public companies. This leads us to multiply the total Utilities pass through costs by .33 (.66 of energy consumption to commercial and industrial * .50 publically listed vs. private companies) before allocating costs by companies' Scope 2 emissions. That is, we distribute a third of total pass through costs to publically listed issuers.

We turn now to examine how sensitive Carbon Beta is to this specific assumption. We do this by increasing the pass through rate – or assuming that public companies account for a greater share of electricity consumption than we initially assume. Hence, instead of allocating one-third of pass through costs to public companies, we allocate one-half and two-thirds. Below we examine the return implications specific to the materials sector (as it represents the largest consumer of energy or producer or Scope 2 carbon emissions). We find that by increasing the pass-through to 0.50 and 0.66, or by 1.5x and 2x, we observe approximately -8.3% and -16.2% difference in the estimated return of the Materials sector based on underlying Carbon Beta figures (see table below). In other sectors less reliant on purchased electricity, such as Banking, we find this assumption does not meaningfully impact outcomes.

	Scope 2 Pass Through Assumption		
	33%	**50%**	**66%**
Materials Sector Return	-0.09%	-0.10%	-0.11%
Sensitivity to Model Assumption		-8.30%	-16.20%

Our sensitivity analysis shows that while the pass-through ratio is an important component in our model, variations in its range have a modest impact on Carbon Beta. Put differently, a 2x increase in our assumption does not equal to 2x difference in valuations. Based on our underlying market research and sensitivity analysis, we believe that a 0.33 percent electricity consumption allocation to the public market is reasonable.

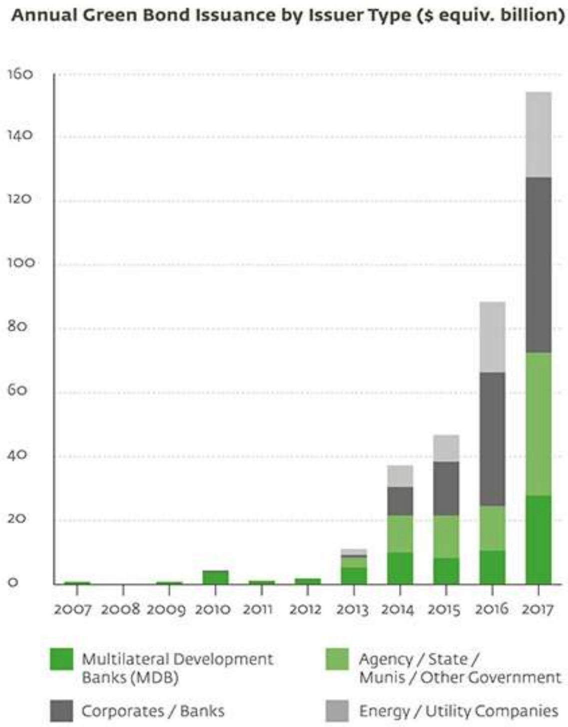
2. *Sensitivity to Clean Technology Capture Ratio*

In our second analysis, we explore our model's sensitivity to the clean technology capture ratio. Under a carbon pricing scenario, we expect companies producing low- or zero-carbon substitute products to experience an increase in earnings, and hence valuation, all-else-equal. To capture this, the Carbon Beta model incorporates an upside capture based on the 1) the total adjusted cost of direct emissions tax and 2) a company's revenue from clean technology. We assume the total clean technology upside opportunity will be equal to, but no greater than, the total direct costs of a carbon tax.

To distribute the potential revenue gains to suppliers of clean technologies, we assume 100% of the direct costs will be redistributed to these companies. We base this assumption on the rationale that green companies can increase output to meet the new

[4] "Comparing the Investment Behavior of Public and Private Firms"
https://pdfs.semanticscholar.org/4728/c9bb32491dff154796eafce0e6962009202a.pdf

demand. To calibrate this assumption, we use comparisons between total costs from the carbon tax and the size of the green bond market. For background, Green Bonds are debt issued by companies, municipalities, and sovereigns for developments ring-fenced for environmental improvement, such as emissions reduction, energy efficiency or other qualifying projects. According to the International Finance Corporation (IFC), annual green bond issuance has grown from zero to nearly $170bn in little more than a decade and in 2019 global issuance is expected to reach a record $200bn.[5]



In view of the growth in green bond issuance, we considered whether the market could absorb the entire new clean technology opportunity created by the carbon tax. That is, in the case of a $25 per metric ton tax on carbon emissions, would the clean technology market be able to supply low- or zero-carbon technologies to meet the new demand? Based on our analysis, we project a $25 tax would create approximately $125B in new clean technology revenue opportunity. Given the current size and trajectory of the green bonds market, we assumed that the 100% of the direct costs could be translated into clean technology revenue. We recognize that this assumption may not hold under higher tax scenarios. For example, an initial tax of $100 per metric ton can produce direct costs of $500B for publically listed companies, more than twice last year's green bond issuance. However, for simplicity we assume that an imposed price on carbon would be initially less than $50 per metric ton and therefore the upside opportunity can be fully absorbed by clean-technology producers.

[5] International Finance Corporation, World Bank Group. Green Bonds. https://www.ifc.org/wps/wcm/connect/news_ext_content/ifc_external_corporate_site/news+and+events/news/perspectives/perspectives-i1c2

To meausure the impact of this assumption on Carbon Beta, we test the impact of a 25%, 50% and 75% capture ratio, compared to the full 100%. We examine the impact on the capital goods sector specifically, in which companies are positioned to benefit for clean technology opportunities through the sale of energy production, efficiency, and storage technologies. Below we show that the industry return expectations move linearly with our capture ratio assumption. That is, the capture ratio moves in-line with expected industry returns. Note that this is applied to the Capital Goods Sector which has the most exposure to the upside potential, whereas sectors without clean opportunity will not be similarly impacted.

	Clean Technology Capture Ratio			
	25%	**50%**	**75%**	**100%**
Capital Goods Sector Return	0.04%	0.15%	0.26%	0.36%
Sensitivity to Model Assumption	-88%	-58%	-28%	

While there is high sensitivity to this particular assumption in our Carbon Beta model, we believe that the full capture ratio is a reasonable assumption given the recent growth in environmentally-linked debt and clean technology revenue. We propose that this upside potential needs to be included in a carbon prince framework to fully capture the impacts of a carbon tax.

Results

We examine the model's sensibility and results across three levels of interest: across tax levels, across sectors, and within sectors. Carbon Beta is calculated at the security or issuer-level but, for simplicity, we aggregate Carbon Beta up to the industry and sector level and also evaluate industry-level returns rather than providing issuer-specific Carbon Beta figures. We do however examine the distribution of Carbon Beta within sectors, as noted in final section of the results.

First, we examine whether Carbon Beta reflects our intuitions with respect to increasing carbon tax and impacts on industry return. We find that as we apply Carbon Beta framework at increasing tax levels, from $25 to $40 and $80 per metric ton of carbon dioxide, we find that a global equity market performance worsens as expected, and individual industry performance diverges by wider margins, both in positive and negative returns. For example, our Carbon Beta assessments predicts that the Software and Services industry will benefit from a price on carbon – for example through increasing sales of energy efficiency and automation software – and is expected to increase from 4.4% industry return in a $25 tax scenario to a 14.1% return in a $80 tax scenario. Conversely, we find the Energy industry is expected to lose value across tax scenarios, with greater severity as the tax price increases. See table below.

Carbon Tax Impact Across Tax Levels by Industry

	$25 tax / metric ton	$40 tax/ metric ton	$80 tax / metric ton
Automobiles & Components	3.7%	7.2%	17.9%
Banks	-0.1%	-0.1%	-0.2%
Capital Goods	4.6%	6.0%	10.6%
Commercial and Professional Services	-1.4%	-2.3%	-3.7%
Consumer Durables & Apparel	1.3%	2.1%	4.3%
Consumer Services	-1.1%	-1.8%	-3.6%
Diversified Financials	-0.8%	-1.3%	-2.4%
Energy	-14.1%	-20.8%	-32.0%
Food & Staples Retailing	-1.7%	-2.7%	-5.2%
Food, Beverage & Tobacco	-1.4%	-2.0%	-3.6%
Health Care Equipment & Services	-0.2%	-0.4%	-0.7%
Household & Personal Products	-0.6%	-1.0%	-2.0%
Insurance	-0.1%	-0.1%	-0.3%
Materials	-18.4%	-23.5%	-33.3%
Media & Entertainment	0.5%	0.7%	2.0%
Pharmaceuticals, Biotechnology & Life Sciences	-0.3%	-0.5%	-0.9%
Real Estate	2.0%	2.6%	4.6%
Retailing	-0.2%	-0.3%	-0.6%
Semiconductors & Semiconductor Equipment	1.9%	3.0%	8.0%
Software & Services	4.4%	6.6%	14.1%
Technology Hardware & Equipment	1.9%	2.6%	4.7%
Telecommunication Services	-0.4%	-0.6%	1.5%
Transportation	-5.4%	-8.9%	-15.4%
Utilities	-13.4%	-18.2%	-24.3%
Market Total:	-1.6%	-2.2%	-2.5%

Next, our results show that carbon taxes will be heterogeneous across sectors. Below we show the expected sector return of a $25 per metric ton tax for a global equity benchmark. Again these results align with our intuition that not all sectors will be impacted uniformly by a carbon tax. In fact, some sectors stand to benefit through increase opportunity to clean and renewable technologies. The sectors hardest hit are those with greatest exposure to both Scope 1 and Scope 2 emissions, without significant clean technology opportunities to offset the potential costs. For example, we see a potential 18.4% loss in Materials, and 14.1% drop in Energy following a $25 tax, while the Information technology Sector may see a potential increase by 11.3%.

$25 Carbon Price Impact Across Sectors

Sector	Return	Sector	Return
Materials	-18.40%	Health Care	-0.50%
Energy	-14.10%	Communication Services	0.10%
Utilities	-13.40%	Real Estate	2.00%
Consumer Staples	-3.70%	Consumer Discretionary	9.10%
Industrials	-1.50%	Information Technology	11.30%
Financials	-1.00%		

Finally, we examine results within sector to explore the Carbon Beta prediction for intra-sector variation. Here we find that a carbon price impact will again be heterogeneous within sector, meaning there will be winners and losers irrespective of the sector in focus. This highlights the potential value of the framework in both security selection within sector and in company engagement initiatives: it identifies companies that are better positioned for a potential change in carbon pricing schemes versus peers that have not taken proactive measures.

Below we highlight the distribution of impact of a $25 tax on the Materials and Information Technology sectors. Both sectors have varying degrees of implications for companies within the sector, including companies the model predicts may lose 100% of market value following the introduction of a carbon price.

Companies with	Materials Sector	Technology Sector
Positive Values	20	140
Negative Values	180	120
100% Loss in Value	31	0

These initial results confirm our baseline sensibilities across different carbon prices and impacts across and within sectors. We believe the results can be used to enhance potential security selection investment processes and decision making, or serve as a starting point for further exploration. In the next section, we examine known assumptions and limitations of the Carbon Beta model, and avenues for future enhancements.

Assumptions and Limitations of Analysis

The initial Carbon Beta model includes a set of underlying assumptions and limitations, which lead us to a set of potential future enhancements to our approach. The table below summaries our 5 key methodological assumptions, ordered by what we consider to have potentially the greatest impact on the outcome of our model:

Key assumptions	Known limitations	Future enhancements
A carbon tax is enacted globally in a coordinated fashion.	This is a simplification to the current regulatory landscape.	Country specific shocks with supply chain linkages.
Reserve and potential “stranded” assets are not considered.	Reserve types and locations will be factored into new prices.	Map reserve assets by GHG intensity and cost of extraction.
Pass through costs are calculated at the industry level.	There may be heterogeneous pricing power within industry.	Develop security level view of pricing power within industry.
Carbon tax benefits are relative to last year’s green revenues.	Current market shares may not scale to future benefits.	Consider supplier-consumer interactions to refine opportunity.
Valuations are consistent with historical averages.	P/E multiples may change under new market environment.	P/E variation based on natural experiments.

Conclusion

Companies that emit greenhouse gases, whether in the form of carbon dioxide or other gases, own a latent liability that is materialized in the presence of carbon pricing. While there is no single carbon price globally, regulators across countries have increased their interest in applying carbon pricing and today about 20% of global GHG emissions are covered.

We showed how a Carbon Beta framework considers the initial onset of a carbon tax and then distributes these impacts downstream through the application of price elasticity, impacts on electricity prices, gains for providers of green solutions and, finally, to impacts on the valuation of companies. Valuation outcomes vary across sectors, with the Energy, Utilities, Materials and Transportation having the most negative valuation impacts, while the Automobiles, Software and Capital Goods sectors show the most positive outcomes. We also find that within sector there is a wide variation in how carbon pricing affects companies, with some companies faring better that others.

Including an upside valuation potential for suppliers of carbon reduction technologies brings into the framework a component of positive impacts from carbon taxes. While we found that carbon taxes pose an initial loss of value in aggregate across the market, green technology companies provide some mitigation to those impacts.

The Carbon Beta model does not incorporate scenario analysis directly. Instead, through the selection of a carbon price, say $50 or $100/ton of CO_2 emitted, it can model the regulatory environment that targets a specific scenario such as 2 deg C or 1.5 deg C. Given the flexibility of selecting a particular carbon price, a variety of other scenarios can be considered.

We tested the assumptions made to arrive at a final Carbon Beta model and found some sensitivity around those assumptions, but we believe the approach yields valuable insights into the impacts of carbon pricing. There are opportunities to improve on the framework and we outlined several that are interesting areas for future research.

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Investing in the Transition to a Low-Carbon Economy: Exploring the Link Between a Company's "Transition Readiness" and Financial Performance

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Working Paper

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This paper describes a new investment framework to assess public companies' "Transition Readiness", or preparedness for a transition to a global low-carbon economy. Unlike prior low-carbon research that focuses on carbon emissions as a source of potential risk, this five-part framework is designed to capture both a company's potential risks and opportunities associated with the transition. We construct the Transition Readiness framework on a relative basis, whereby we identify companies we believe to be better prepared for the transition relative to their industry peers. While the framework is designed to enhance investment performance as the global economy transitions to lower-carbon usage, we find that a diversified portfolio of companies that exhibit superior Transition Readiness characteristics has recently outperformed an equivalent market benchmark on a risk-adjusted basis. Finally, we find that a Transition Readiness portfolio has lower carbon emissions intensity and greater exposure to clean technology revenue relative to the market benchmark.

Climate change and the transition to a low-carbon economy are top of mind for the global investment community. In the World Economic Forum's 2018 Global Risks Report, four of the top five risks projected to have the biggest impact in the next 10 years were environmental in nature – extreme weather events, natural disasters, water crisis and failure of climate change mitigation and adaptation.[i] Further, a recent survey of institutional investors found climate as a leading investment consideration, with more seeking to mitigate climate risks and enable transition to a lower carbon economy than ever before.[ii]

Despite increasing in investment prominence, there have been few attempts to systematically measure companies' preparedness in mitigating risks and capturing opportunities associated with a transition to a low-carbon economy. Previous investment research has focused primarily on the carbon emissions profile of companies, and existing investment approaches focus either on potential risks, through fossil fuel divestment or carbon minimization strategies, or on opportunities, through investments in renewable energy and energy efficiency solutions.

In this paper we describe a public equity investment framework called Transition Readiness, a new approach to assessing companies' preparedness for the transition to a low-carbon economy. This approach is distinct in two respects: first, it is based on thematic research on the full complement of company activities that reflect its preparedness for the transition to a low-carbon economy, and second, it applies quantitative investment techniques that have traditionally not been utilized in the sustainable investing context. We review here our approach to constructing this new investment framework, and present our findings of implementing this investment framework into a broadly diversified equity portfolio, from both a financial and environmental perspective. Our initial results suggest this investment approach can add financially material insights to the growing body of low-carbon investment research.

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Background

Transition risks and opportunities

The transition to the low-carbon economy refers to the global shift to an economy that is more efficient in producing goods and services, one that is less reliant on greenhouse gas (GHG) emissions. While global gross domestic product and emissions have historically grown in tandem, we have recently witnessed a change. Since 2010, global GHG emissions have increased at less than 1/3 the rate of global GDP, reflecting increasing “decoupling” of growth and emissions globally.[iii]

This transition is expected to continue, and by some forecasts, further accelerate. Regulatory action and technological innovation are two important drivers of the transition. On the regulatory front, the number of climate laws passed globally has doubled every five years since 1997.[iv] In 2018 for example, China joined the Netherlands, Norway, France, the U.K., and India in banning fossil-fuel-powered vehicle production; California passed a bill requiring rooftop solar on all homes; and France announced that it will ban oil and gas production by 2040.[v] Overall, the world has adopted clean energy far faster than experts forecasted, and countries have moved aggressively in the past few years to reach their emission reduction targets. This includes the U.S., where despite recent federal legislation, many states, cities, companies, and citizens are taking action on their own to accelerate the transition to a low-carbon economy. Within technological innovation, price reductions and efficiency improvements have accelerated the deployment of carbon efficient technologies to replace existing carbon emitting activities. Within transportation, for example, due to declining production costs and increasing battery storage capacity, the global fleet of electric vehicles is projected to triple in the next two years.[vi]

Looking forward, the trajectory of the low carbon transition is often characterized in the form of specific de-carbonization or low-carbon pathways or “scenarios”. These include widely utilized scenarios from the International Energy Agency’s (IEA) World Energy Outlook,[vii] including a “current policies”, “new policies”, and more aggressive “sustainable development” scenarios.[2] These specific scenarios are valuable for understanding the policy mechanisms required to achieve particular emissions mitigation and temperature goals (the IEA Sustainable Development scenario, for example, is intended to capture an outcome in line with the Paris Climate Agreement). They are also valuable for those asset owners that are interested in aligning their investment approaches with specific emissions or policy goals.

Our research framework has been informed by the output of different long-term scenarios, including the IEAs, but was designed to assess Transition Readiness without being connected to any particular scenario. In other words, while our research is predicated on future global emission reductions, its utility is not contingent on a specific future temperature or emissions outcome. Instead, the goal is to generate a more useful way to assess the costs and opportunities firms could realize in the transition process, even as we face significant uncertainty about the probability of any one long-term climate scenario unfolding.

Previous low-carbon research

There is a significant body of academic evidence on the relationship between a company’s carbon emissions intensity[3] and financial risk. Specifically, research has explored whether carbon efficient companies outperform their high emitting peers, presuming lower emissions reduce exposure to future greenhouse gas regulations and taxes. These analyses generally look at a

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[2] The IEA has defined three specific scenarios for de-carboniza ion and the energy transition: 1) Current Policies Scenario (CPS) considers only policies firmly enacted as of mid-2017 and serves as a benchmark against which the impact of “new” policies can be measured; 2) New Policies Scenario (NPS) incorporates existing energy policies as well as an assessment of the results likely to stem from the implementation of announced policy intentions; 3) Sustainable Development Scenario (SDS) sets out a pathway to achieve the key energy-related components of the United Nations Sustainable Development agenda, including universal access to modern energy by 2030; urgent action to tackle climate change (in-line with the Paris Agreement); and measures to improve poor air quality.

[3] Emissions intensity refers to a company’s scope 1 (direct) and scope 2 (indirect) emissions normalized by annual sales

specific metric of emissions (standardized by the GHG protocol[viii]) normalized by company sales, applied equally across all industries. To this end, Ngwakwe and Msweli (2013) found a significant relationship between carbon reduction and increased dividend per share,[ix] while Griffin et al. (2017) found a negative relationship between higher company emissions and share value using a sample of companies from the S&P 500.[x] Nishitani and Kokubu (2011) found that firms that reduce their GHG emission are more likely to increase firm value as measured by Tobin's Q.[xi] Liesen et al. (2017) find that firms that more actively disclose their carbon emissions, and those with a high net income to emissions ratio tend to have stronger equity returns.[xii] More recently, Garvey et al. (2018) extended this research to focus on the links between carbon efficiency and operational efficiency, showing evidence that carbon emissions exhibit behaviours similar to an input to production along with the more traditional capital and labour. More importantly, firms that produce more than expected relative to their level of emissions tend to outperform in the future both in profitability and returns.[xiii]

We add to this literature by broadening the scope of what is relevant for companies to manage in the transition beyond their carbon intensity, based on their industry. We start with the premise that a company's performance in the transition is dependent on additional characteristics than carbon emissions, such as their investment and corporate strategy to develop carbon efficient technologies. That is, we seek to examine both risks and opportunities in a new investment framework. To test this hypothesis, we develop a five-part framework of company characteristics that are material to its transition readiness, or prospects for future financial performance in the context of a macro transition to a lower-carbon economy. We then assess the relationship between our framework, environmental outcomes, and financial performance.

A New Transition Readiness Framework

Building upon existing climate and investment research, we introduce a new transition readiness framework composed of five investment "pillars" associated with a company's preparedness for the low-carbon transition. These pillars are designed to capture the key sources of a company's risk and opportunity associated with the transition, categorized by a company's core business exposure or natural resource management (see Table II.I).

Table II.I: Five Pillar Transition Readiness Framework

Company Core Business Exposure		
1.	Energy Production	*a company's historical direct emissions as well as their future potential emissions through fossil fuel reserves.*
2.	Carbon-Efficient Technology	*a company's research and development, current revenue and forward-looking strategy in solutions across renewable energy, energy efficiency, carbon-efficient transportation, green building and sustainable agriculture.*
Company Natural Resource Management		
3.	Energy Management	*a company's historical indirect emissions through energy purchased as well as their strategy to manage future energy consumption.*
4.	Water Management	*a company's water efficiency as well as the projected stress and shortages in its water supply.*
5.	Waste Management	*a company's waste production, including hazardous and non-hazardous waste, as well as its strategy to reduce operational and product-related waste.*

To be eligible for inclusion in our framework, each pillar has to meet two conditions: 1) an investment hypothesis, substantiated by existing academic research, linking better management of the pillar to the company's future financial performance, and 2) an environmental hypothesis linking better management of the pillar to the company's future environmental performance. To be clear, the environmental hypotheses are also, in the long run, about future financial performance:

as described above, the structural evolution of the global economy's energy consumption patterns should reward better environmental performance independently.

Based on the breadth of existing research on the relationship between emissions and performance, we include a concept of direct and indirect emissions[4] intensity in Pillar 1 and 3 respectively. Further, a variety of projections, including the IEA's estimates show potential significant upside for carbon efficient technologies like wind and solar energy producers. In addition to energy however, extensive research focuses on carbon technology within the real estate sector, specifically the benefits of "green building" where there is evidence to support that real estate with green building certifications, such as LEED or Energy Star, experience increased market value, occupancy levels, rent, premiums, income, price appreciation, and total returns compared to non-certified assets.[xiv] We use this information to inform the creation of Pillar 2. A number of recent research reports highlight the importance of water related risks, specifically the concept of "water stress" which examines necessary water withdrawal with predictions of aqueduct scarcity overtime.[xv] Finally, there's growing body of examples examining how waste can impact valuations, due specifically to regulatory pressures on waste regulation.[xvi]

The formulation of our five investment pillars is based on investment hypotheses that could each stand on its own when measuring a feature of a transition to a low-carbon economy. Our expectation is that the combination of the five pillars would provide a deeper view into a firm's overall readiness for transition, so we combine the information from each pillar into a unified transition readiness measure.

Measuring a Company's Transition Readiness Performance

After defining our investment framework, we move to calculate a company's Transition Readiness performance based both on 1) a company's firm-specific management of each of the pillars and 2) a company's industry-specific exposure to each of the five pillars. We apply a simple linear combination of components as shown in Equation (1). This approach accounts for company-specific management of the five key transition characteristics, as well as exposure to transition risks and opportunities based on its industry.

$$TR_c = \sum_{p=1}^{5} (M_{cp} * E_{ip}) \qquad (1)$$

Where, for every Company (c):
TR = Transition Readiness
P = Pillars 1 – 5 of Transition Readiness Framework
M = Pillar Management Score for company C
E = Pillar Exposure Score for industry I

Overcoming data challenges

The challenge of ESG data management is one of the central challenges in ESG investing. The data are sparse, heterogeneous, poorly understood, and subject to divergent methodologies. A framework such as ours that takes a high-breadth approach to analyse thousands of individual firms must establish a rigorous approach to cleaning the data, making different indicators comparable to one another and comparable across firms. We need a reliable methodology to separate the signal from the noise.

In our process of measuring each company's management of the five pillars, we address three principal shortcomings of existing transition readiness-related data related to quality, comparability, and availability. On data quality, the prevailing market standard is to assess

[4] Direct emissions (scope 1) refer to emissions owned and produced by companies, indirect emissions (scope 2) refer to emissions indirec ly ied to he company, typically through electricity purchased. See www.ghgprotocol.org

companies either based on their carbon emissions intensity, or on third-party provider "headline" environmental assessments. These headline environmental scores, which are an amalgamation of several measures – like energy efficiency, carbon mitigation strategy and controversies – can offer valuable insight about an issuer, however we believe that many critical insights can be concealed by only using a single rating.

We began with the premise that by assessing a variety of data sources – including MSCI, Sustainalytics, Asset4, and Reprisk – and disaggregating the single rating, or headline score, into its component Key Performance Indicators (KPIs) we would derive a closer estimate of the actual environmental performance and company management of our five pillars. To this end, we qualitatively assessed the applicability of over 2,000 individual KPIs to the five pillar categories based on our review of the literature explored above. From this sorting process, we identify 268 KPIs (approximately 50 per pillar) that meet our minimum criteria for inclusion, based on the direct applicability to our five hypothesis and quality of measurement and methodology.

Next, to systematically compare across data provider assessments, we account for the comparability shortcoming. Each third-party data provider leverages its own unique scoring scale – for example, 0-100 vs. AAA-CCC vs. 0-10 – and time scale, either reporting daily, quarterly or annual basis. To enable comparison of different sources of information, we run a cross-sectional normalization and time-series filling process, whereby each KPI is expressed as a score relative to other firms at that point in time. We convert the percentile rank to a z-score with a mean of zero and a normal distribution function. We then cap the resulting cross-sectional z-score at -3 and +3, to reduce the impact of outliers driven by noisy data idiosyncrasies. The cross-sectional score between -3 and 3 expresses how many standard deviations each indicator is worse (negative score) or better (positive score) that the mean.

Finally, to address specific data availability gaps – where we had financial intuition but limited data to measure across companies – we construct our own information to incorporate in the pillar scores. For example, we leverage insights from the corporate engagement activities conducted by BlackRock's Investment Stewardship team to get an investment sentiment of companies' strategy and governance of carbon emissions disclosure and mitigation efforts. This new data source allow us to capture a view not included in existing third-party data sets.

Constructing a Transition Readiness Score

With the common data limitations addressed, we now have a multi-dimensional set of KPIs for each pillar in each company, but we need to reduce that to a single management score for each pillar in each company. To do this, we utilize a quantitative technique based on a principal component analysis (PCA) to identify the major impulses collectively driving the KPIs.

In order to benefit from the qualitative and quantitative elements of our approach, we deploy here a variation of the traditional PCA approach. For each of our pillars, we use the output of our qualitative research analysis to identify the KPI (or KPIs) from within our overall data universe (again, about 50 KPIs per pillar) for which we have the strongest ex-ante conviction. We then prioritize that KPI (or KPIs) within the PCA, in order to both emphasize data that our qualitative research process suggests is more important, while still including relevant information from our broad data set. For example, within Pillar 1 – Energy Production, we prioritized KPIs that measure the trajectory of direct emissions production as well as fossil fuel reserve types, but was further informed by additional metrics, such as emissions mitigation governance and strategy.

Having generated specific scores for each company for each pillar, we then combine them into a single score by applying an industry-specific "materiality" framework. Materiality refers to our ex-ante view on how financially relevant each pillar should be based on the industry of the company. For example, the relative weighting of each of the five pillars for a healthcare company will be different from a utility company.

To construct a materiality framework, we reference the Sustainability Accounting Standards Board (SASB)[xvii] materiality map, which aims to identify financially material sustainability issues by industry. We make modifications to our materiality framework where we have proprietary views based on internal research or practice.
For illustration, we compare three hypothetical companies, an auto manufacturer, pharmaceutical and wind energy producer (see Table III.I). This shows that while these companies may have the same company-level management scores across the five pillars, their final transition readiness assessment may diverge based on the industry-specific materiality exposure to transition risks and opportunities.

Table III.I: Transition Readiness Scoring Examples

	Automotive Company A		Pharmaceutical Company B		Wind Energy Company C	
	Management	Exposure	Management	Exposure	Management	Exposure
Pillar 1	-1.5	0.2	-1.5	0.1	-1.5	0.1
Pillar 2	1.7	0.2	1.7	0.1	1.7	0.8
Pillar 3	1.2	0.5	1.2	0.7	1.2	0.1
Pillar 4	0.4	0.1	0.4	0.1	0.4	0.1
Pillar 5	-2.2	0.1	-2.2	0.1	-2.2	0.1
TR	**0.4**		**0.7**		**1.3**	

*Management scores range from -3 to 3 (worst to best), exposure values vary by industry (sum to 1)

The combination of weighted pillar scores results in a Transition Readiness assessment for each company in the investment universe, or a Transition Readiness investment score. Before moving to test the financial relevance of this approach, we compare it to existing third party provider assessments of environmental or ESG ratings assessments. We find that the Transition Readiness measurements across a broad selection of companies, using MSCI World ex US Index as a benchmark, has positive but low correlation to existing environmental and headline sustainability performance indicators (see Table III.II). This indicates we have not simply re-constructed an existing environmental rating, but have potentially constructed a differentiated insight into a company's management of transition related risks and opportunities.

Table III.II Correlation between Transition Readiness and Existing Measures

	MSCI ESG	Sustainalytics ESG	Sustainalytics Environmental	Transition Readiness Signal	MSCI Environmental
MSCI ESG	1.00	0.60	0.54	0.18	0.39
Sustainalytics ESG	0.60	1.00	0.87	0.01	0.29
Sustainalytics Environmental	0.54	0.87	1.00	0.21	0.36
Transition Readiness Signal	0.18	0.01	0.21	1.00	0.35
MSCI Environmental	0.39	0.29	0.36	0.35	1.00

*Source: MSCI, Sustainalytics, run over MSCI World Ex US benchmark constituents as of 12/31/18.

Historical Financial Performance of a Transition Readiness Portfolio

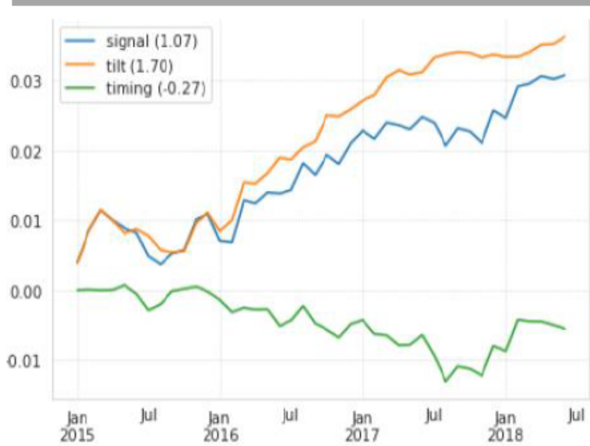
Our investment thesis is predicated on structural changes in the global economy: we expect firms with high Transition Readiness scores to outperform as the low-carbon transition occurs. Therefore, we might not expect them to perform as well in a historical "backtest" as other conventional investment strategies. Nonetheless, we investigate the historical performance of a portfolio constructed with Transition Readiness scores (with high scores overweighted relative to the market, and low scores underweighted) to better understand its behavior in recent years. One common argument against the sustainable investment movement is that the market penalizes sustainability: our historical results show this has not historically been the case.

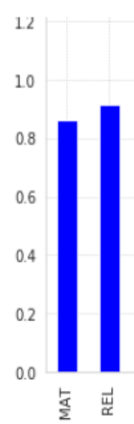
To explore the historical performance of our Transition Readiness investment score, we create a hypothetical portfolio invested in non-U.S. developed market stocks from 2010 to 2018.[5] Going industry by industry, we increase exposure to companies with high Transition Readiness assessments versus their low performing peers. This hypothetical portfolio has an annual tracking error of 100 basis points relative to the broad benchmark, the MSCI World ex-U.S. Index, and is optimized to keep traditional style, sector and country factor exposures similar to the benchmark. The goal of the optimization is to determine if integrating the Transition Readiness signal might have improved an investor's historical risk-adjusted return over that time period.

We find that by overweighting companies with better Transition Readiness characteristics, and underweighting their less prepared peers, results in outperformance of our hypothetical portfolio versus the benchmark index. We show this by calculating the information ratio, or our hypothetical Transition Readiness portfolio's returns above the returns of its benchmark, to the volatility of those returns. See Figure IV.I. Results show that had we implemented the Transition Readiness signal in 2015, we would have generated an information ratio of 1.07 through July 2018. We then attributed this performance by signal tilt (outperformance generated from long-term holdings) and timing (benefits of short-term trading) and find the bulk of the excess return was driven by long-term positioning of the holdings, rather short-term trading in and out of the portfolio. Put differently, Transition Ready firms have not been penalized by the market in recent years; in fact, they have been somewhat rewarded.

Figure IV.I. Financial Validations of Transition Readiness Signal vs. Benchmark and Performance across Sectors

Information Ratio of Hypothetical Transition Readiness Portfolio vs. MSCI World ex US Index	Information Ratio Sector Performance of Transition Readiness Signal in Hypothetical Portfolio





*Based on MSCI World ex US benchmark. Transition Readiness portfolio optimized to 100 basis points of annualized tracking error budget. Information ratio (signal = 1.07) refers to excess return of hypo hetical portfolio over benchmark given tracking error.

Furthermore, we show that the Transition Readiness investment signal performed well across most sectors (see Sector Performance in Figure IV.I). This table shows what would have happened to the hypothetical portfolio information ratio had we removed a specific sector from the portfolio. For example, if the portfolio did not incorporate Transition Readiness information within

[5] We also test the Transition Readiness framework on a US benchmark, the Russell 1000 Index with similar results. For purposes of this paper, we present full findings on the MSCI World Ex US Index

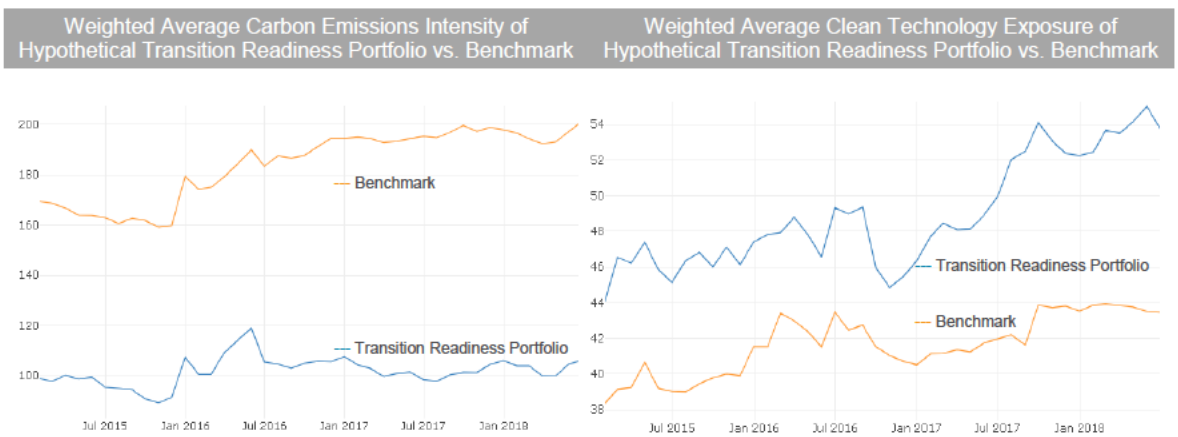
the Materials sector, the information ratio would have declined from 1.07 to approximately 0.89. There are three sectors which over this time period the Transition Readiness signal did not add additional performance benefit: Financials, Information Technology and Consumer Discretionary stocks. This may be a result that these sectors have been less sensitive to broader transition risks and opportunities. However, the minor performance detraction from these sectors, provides confidence that the framework is capturing material financial insights from across industries.

We underscore that while this portfolio has performed well historically, we do not claim to have unlocked some historical market secret—merely to observe that investors have not been punished for taking these positions. Indeed, our central investment thesis rests on the future structural shift to a low-carbon economy.

Environmental Performance of a Transition Readiness Portfolio

In addition to validating our Transition Readiness signal from a financial standpoint, we also assess the environmental outcomes of our hypothetical portfolio versus its benchmark. We do this in two ways: first by assessing our portfolios environmental exposures overtime specific to carbon emissions intensity and clean technology measures; next by analyzing its alignment with available future temperature scenario models. First in examining the environmental exposures, we find a consistent reduction of carbon emissions intensity of ~50%, as well as an increase in exposure to carbon efficient technologies of ~30% in the Transition Readiness portfolio versus its benchmark overtime (see Figure V.I).

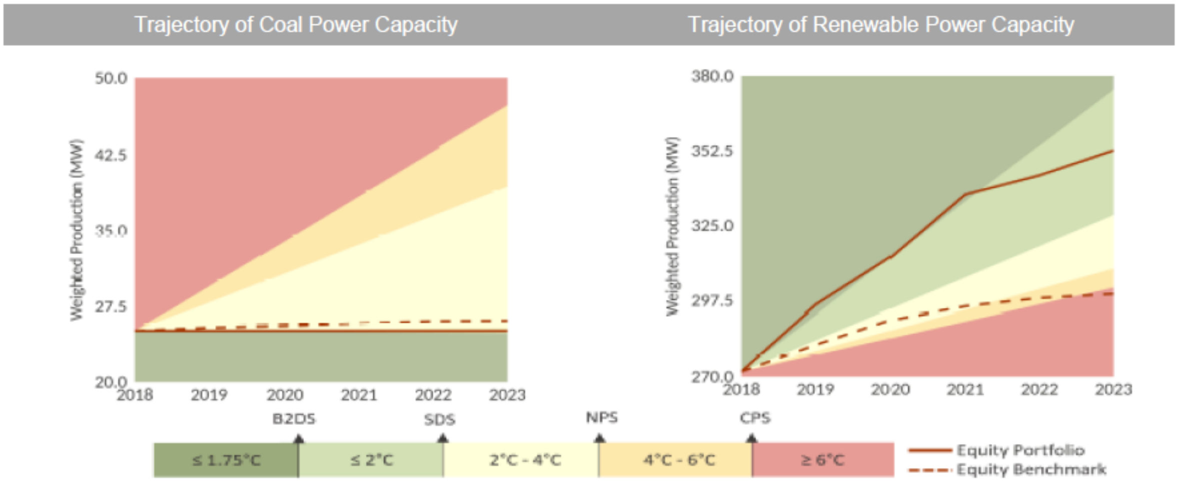
Figure V.I. Environmental Outcomes of Transition Readiness Portfolio vs. Benchmark



Portfolio outcomes calculated as weighted average of covered securities in portfolio vs. benchmark. Emissions intensity figure data is scope 1 & 2 emissions normalized by annual sales. Clean tech revenue is measured on 0-100 scale based on analyst assessment.

Next, to assess the Transition Readiness portfolio alignment with potential energy and temperature scenarios, we leverage an available resource in the Paris Agreement Capital Transition Assessment (PACTA).[xviii] This tool allows a user to upload a specific portfolio and compare, based on planned activities of its holdings, the five-year trajectory of power capacity relative to different temperature outcomes. Below we highlight the planned power capacity of both coal and renewables (see Figure V.II) for our hypothetical Transition Readiness portfolio (solid red line) and a global equity proxy benchmark (dotted red line). We find the Transition Readiness portfolio, based on current holdings, is expected to be aligned with a 2-degree Celsius outcome over the next five years as it relates to coal and renewable capacity.

Figure V.II. Scenario Alignment of Coal and Renewables Capacity of the Transition Readiness Strategy



Based on hypothetical Transition Readiness MSCI World ex US portfolio as of 12/31/18. PACTA includes Equity Benchmark based on all listed public equity and debt issuance.

Conclusion

Climate change and the transition to low-carbon economy are top of mind for the global investment community. Our research attempts to add new financially material insights to the growing body of low-carbon investment research, by introducing a new investment framework of Transition Readiness. We believe this approach is distinct in two respects: first, it is based on thematic research on a broader set of corporate activities that reflect its low-carbon preparedness than has been previously studied, and second, it applies quantitative investment techniques that have traditionally not been utilized in the sustainable investing context. We find that by applying Transition Readiness within a portfolio would have improved historical risk-adjusted return of a broad equity benchmark, as well deliver meaningful reductions in carbon emissions intensity, increases in clean technology exposure and is aligned with near-term 2-degree scenario analysis. Future research applications would include applicability in fixed income, as well as performance of Transition Readiness portfolios during specific macro shocks and climate events.

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