Carbon Quotient™ – how to create accountability for net zero across the investment value chain

Getting to net zero by 2050 is like an endurance auto race across the desert where drivers must traverse dunes, mud, rocks, and barren sand seas. Fans and racers each need a global positioning system (GPS) to gauge the relative position of the competitors and avoid losing their way on an off-road course with no markers.

This paper introduces Carbon Quotient (CQ) analytics, a revolutionary open-source application of well-established accounting concepts to measure, manage and report climate-related financial risk. CQ analytics provide a much-needed GPS to guide decision-making on capital allocation and hold corporations and financial institutions accountable for measurable progress toward net zero over time.

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I. Introduction

A. A GPS for net zero

The world is rapidly committing to carbon neutrality or "net zero" by mid-century.[1] The Net Zero Asset Owner Alliance is an UN-backed alliance of 25 institutional investors with **$**4.7 trillion assets under management committed to transition their investment portfolios to net-zero greenhouse gas (GHG) emissions by 2050.[2] BlackRock, the world's largest asset manager with $9 trillion in assets under management, is calling on all companies "to disclose a plan for how their business model will be compatible with a net-zero economy."[3] Last year, the firm voted against 69 companies and against 64 directors for climate-related reasons, while putting 191 companies "on watch."[4]

To get to net zero on time we will need a global positioning system (GPS) to chart the course, show our past route of travel and current positioning, forecast our estimated time of arrival, and reroute us when we are off track. To guide us in the right direction this GPS must know the coordinates of our current position and our destination. It must measure and report our latitude and longitude, but in terms of climate transition risk and opportunity. And we must trust it. We must understand what it is telling us, and we must turn when it tells us to turn.

Figuring out how to calculate the GPS coordinates for net zero is a critical challenge for corporate managers, asset owners, asset managers, commercial banks, central banks, and macroprudential authorities. New approaches that translate transition risks into forward-looking financial metrics are essential. Commercial and academic climate risk tools are increasing in their level of sophistication. But if the methodologies and outputs from these tools are not relevant and actionable by financial market actors, they will not be used to inform real-world financial decisions. They will not efficiently guide us to net zero.

Financial and non-financial institutions face common challenges in the measurement of climate-related risks, including the need for metrics that account for the appropriate future time horizon and are practically relevant for mainstream risk management.[5] A theoretical foundation and systematic approach towards meaningful climate risk metrics remains elusive.[6] Existing climate risk tools can be difficult to interpret and use. They can also be systematically

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[1] See The Paris Effect: how the climate agreement is reshaping the global economy, (Box 1).

[2] See Institutional investors transitioning their portfolios to net zero GHG emissions by 2050 for further details.

[3] Larry Fink's 2021 letter to CEOs.

[4] BlackRock Chief Pushes a Big New Climate Goal for the Corporate World, New York Times, Jan. 27, 2021.

[5] Prudential Pathways: Industry Perspectives on Supervisory and Regulatory Approaches to Climate- related and Environmental Risks, Institute of International Finance (Jan. 2021).

[6] Semieniuk, Gregor, Emanuele Campiglio, Jean-Francois Mercure, Ulrich Volz and Neil R. Edwards (2020), Low-carbon transition risks for finance, SOAS Department of Economics Working Paper No. 233, London: SOAS University of London.

biased and fail to produce mutually consistent results. As a result, they often lack actionable relevance to financial decision-making.[7]

To meet the need for a net zero GPS, we are introducing a new transition risk tool set we call Carbon Quotient™ or "CQ" for short. The Carbon Quotient tool set measures the transition risk inherent in physical assets that are the source of carbon emissions. By tracking and forecasting progress toward net zero ambitions, CQ analytics are designed to increase accountability of financial institutions and corporate managers for doing their part to deliver emissions reductions in the real economy.

B. The net zero accountability Imperative

In principle, net zero means the owners of every emission-producing asset in the real economy will need to eliminate or offset emissions with a combination of low carbon replacements, energy efficiency improvements, and negative emissions. BlackRock's CEO Larry Fink is correct to say, "there is no company whose business model won't be profoundly affected by the transition to a net zero economy."[8] For their part, asset owners, asset managers, and banks will need to measure and reduce the emissions of the companies and assets they finance.

The transition to net zero must occur within the context of the principal-agent model in which agents carry out actions on behalf of principals. There are four key principal-agent pairings for getting to net zero – (1) beneficiaries-asset owners; (2) asset owners-asset managers; (3) asset managers-corporate managers; and (4) financial institution shareholders-financial institution managers.[9]

To reach net zero by 2050, there must be broad agreement among principals and agents on objectives, the economic barriers and constraints, how performance will be measured, and the consequences of success or failure.

These views must also be translated into passively managed investments, which pose special challenges for accountability.[10] Allocational efficiency, whereby capital is optimally distributed based on all available data, is a property of an efficient market. Passive funds have an implicit status quo bias that rewards incumbents. Passive investors therefore must rely on active investors to ensure allocational efficiency. Figure 1 illustrates how, as passive investment grows relative to active investment, the "tail starts wagging the dog".

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[7] Taming the Green Swan: How to improve climate-related financial risk assessments, section 1 at p. 11.

[8] Too many boardrooms are climate incompetent, Financial Times (Jan. 30, 2021).

[9] See Implementing the Recommendations of the Task Force on Climate-related Financial Disclosures, section D.

[10] See The Passives Problem and Paris Goals: How Index Investing Trends Threaten Climate Action and BlackRock Chief Pushes a Big New Climate Goal for the Corporate World, New York Times, Jan. 27, 2021.

Presently, there is no broad consensus in any of these areas. The existing accountability framework is not working.[11]

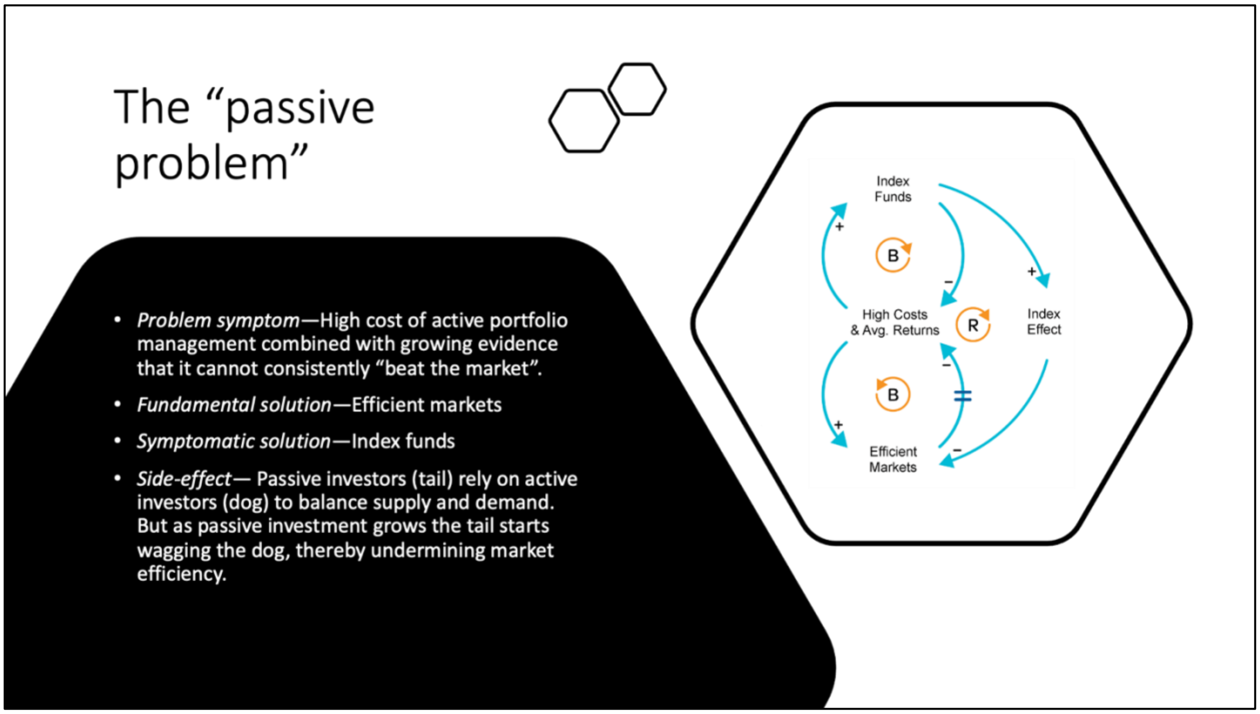

Figure 1 The "passive problem"

A primary purpose of CQ analytics is to increase accountability across the entire investment value chain, which begs the question: accountable for what? This requires that we first explain our view on objectives, barriers and constraints.

[11] See ClientEarth, [Accountability Emergency: A review of UK-listed companies' climate change-related reporting (2019-20)]().

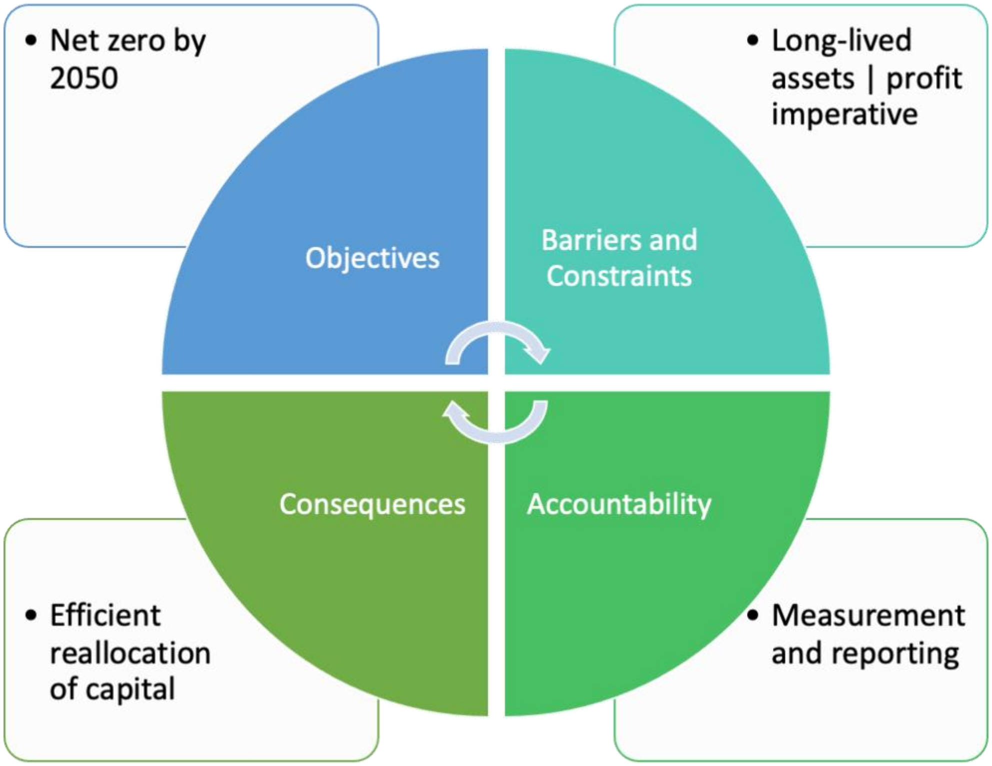

Figure 2 Net zero accountability framework

Figure 2 shows our view of a net zero accountability framework. It starts with an agreed objective – carbon neutrality across the global economy by 2050. The primary barrier to achieving this objective is the world's existing stock of carbon-intensive, long-lived tangible assets and the need to replace them with low carbon alternatives on an accelerated schedule. The primary constraint is that corporate managers must make this transition while maintaining an acceptable level of profitability.

Once objectives, barriers, and constraints are commonly understood and agreed, the measurement system used to assess agent performance must properly account for the key variables that are within the agent's powers – capital allocation, emissions reductions, and profitability – recognizing that there are conflicting objectives that must be reconciled. If principals and agents can properly measure and report performance against these criteria, they will have a chance of achieving them. If they cannot, they will flounder.

C. Preconditions for accountability

Within the financial principal-agent model in Figure 2, the basic relationships consist of the granting or withholding of power and capital (consequences) by the principal. The agent then carries out actions on behalf of the principal and reports results.[12]

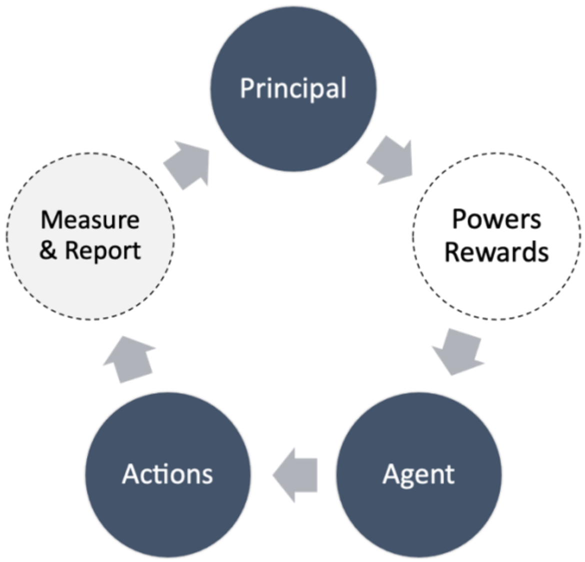

Figure 3 Principal-agent accountability cycle

Accountability requires that agents measure and report the right things in a way that principals can and will act on. Measurement for measurement's sake, without consequences, is illusory. It is the appearance of accountability where there is none. It is noise not signal, or worse, greenwash and paper tigers. Today, financial regulators face the same accountability challenges that investors do.[13] For there to be true accountability, accounting for transition risk must become more like financial accounting.[14]

If agents fail to measure and report the right things, there is the possibility that independent third parties can do so. In addition to compensating for a lack of self-reporting by agents, third party reporting enables comparative measurement – everyone can see how everyone else is performing relative to themselves and others.

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[12] See [Accountability, Accounting Regulation and the Principal Agent Model].

[13] "When companies report climate-related disclosures in varying formats, [U.S. Securities & Exchange Commission] reviewers and investors may find it difficult to navigate through the filings to identify, compare, and analyze the climate-related disclosures across filings, especially given the size of each individual filing." GAO-18-188.

[14] Karthik Ramanna, Professor of Business & Public Policy and Director of the Master of Public Policy Program at the University of Oxford's Blavatnik School of Government, ESG accounting needs to cut through the greenwash, Financial Times, 17 Jan. 2021.

A functional principal-agent-third party accountability cycle (as shown in Figure 4) requires that independent analysts external to the principal-agent relationship have access to the data required to produce measurements that principals can and will act on.

If the necessary data (e.g., emissions data) is not self-reported and independently verified, independent analysts must be able to produce and publish sufficiently reliable data themselves. The data must be developed using observable inputs and objective methodologies or it will not be trusted by market actors. This imposes practical limitations on third party accountability measurement and reporting. Performance measures that rely on unobservable data inputs and subjective methodologies will not improve accountability.

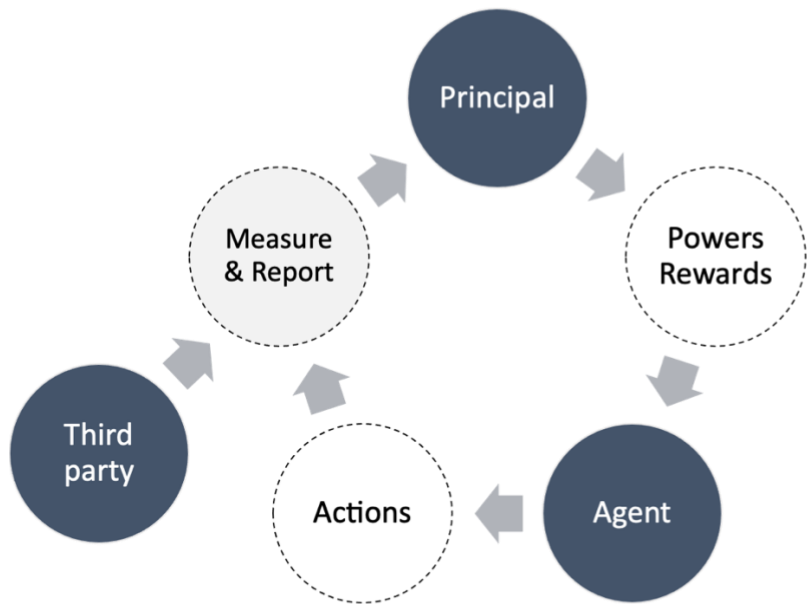

Figure 4 Principal-agent-third party accountability cycle

Accountability must apply to financial and non-financial actors across the investment value chain (Figure 5) – not just to corporate managers in the real economy. To meet their own fiduciary duties to their clients and beneficiaries, investors too must use their existing legal rights and powers to hold companies, directors and auditors accountable.[15]

Ideally, the measurement and reporting framework should assess the performance of all actors – asset owners, asset managers, corporations, and financial institutions – against the same yardstick. Holding all actors accountable for the same performance metric would facilitate accountability across the entire investment value chain.

[15] See ClientEarth, Accountability Emergency: A review of UK-listed companies' climate change-related reporting (2019-20).

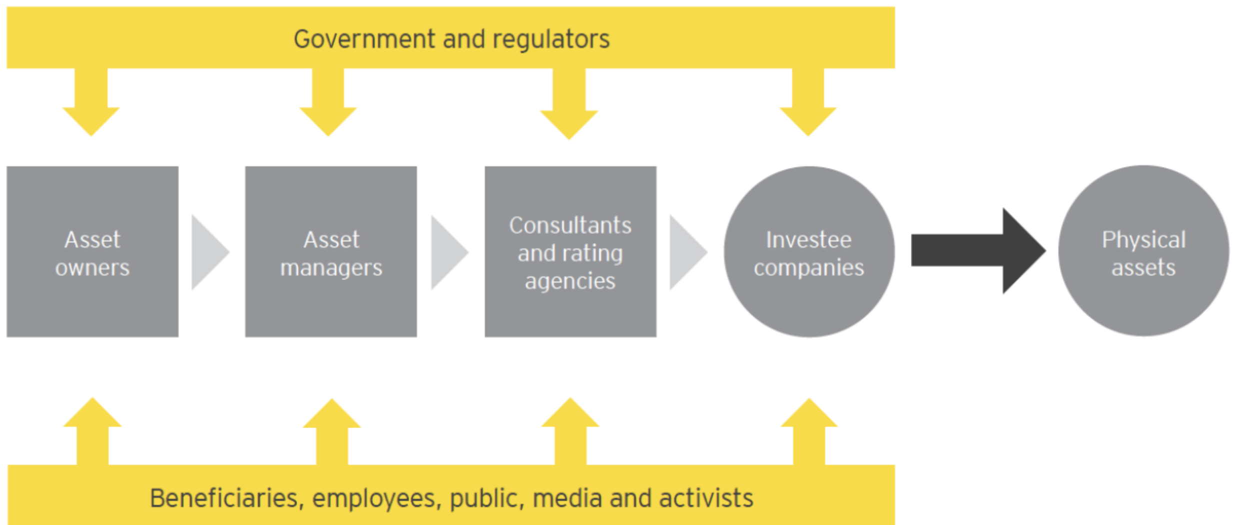

Figure 5 Investment value chain

The following sections describe the new CQ tool set, how it performs against criteria for an effective net zero accountability framework, its relationship to other climate finance measures and initiatives, use cases, and methodology.

II. The Carbon Quotient tool set

The Carbon Quotient tool set comprises a set of concepts, formulas, processes, data, data visualization tools, and quantitative analyses designed to help financial actors and corporate managers allocate capital for optimal long-term risk-adjusted returns. Its major components are – (1) the Carbon Quotient ratio; (2) risk-adjusted financial accounts and ratios; and (3) the net zero GPS.

The Carbon Quotient ratio is defined as:

$$Carbon\ Quotient = \frac{Unrealized\ Carbon\ Expense}{Assets}$$

where *Unrealized Carbon Expense* is *unrealized emissions* (tCO_2e) times an imputed carbon price ($\$/tCO_2e$);

Unrealized emissions are future greenhouse gas emissions (tCO2e) that will result from the continued use of emission-producing physical *assets* over their remaining life, calculated as current period *realized emissions* times *asset life*; and

Assets is the carrying value (cost less accumulated depreciation, depletion and amortization) of emission-producing physical assets.

Mitigating unrealized emissions from long-lived assets is like turning an aircraft carrier. You need to start the turn long before it is to be completed. The power of net zero is that it sets a common destination and deadline. Wherever one starts the journey, the destination is the same. So is the deadline. This means we know when to start turning and how fast to turn the wheel.

It is self-evident but nonetheless worth stating that anthropogenic carbon emissions do not produce themselves. Long-lived tangible assets do.

Examples of long-lived tangible assets, sometimes referred to as real, fixed or physical assets, include land, buildings, machinery and equipment, and vehicles.[16] Examples of carbon-intensive real assets include fossil fuel reserves, coal and natural gas power plants, internal combustion and jet engines (and the factories that produce them), aluminum and cement plants, commercial and residential buildings, and land. These assets appear on the balance sheets of corporations as "property, plant, and equipment." By definition, long-lived tangible assets have useful lives greater than one year.

Emission-producing long-lived tangible assets may be off-balance sheet for a particular entity. For example, scope 2 emissions (i.e., indirect emissions from the generation of purchased energy consumed by the reporting company) are generated by assets upstream of the entity. By definition, scope 3 emissions occur from sources owned or controlled by other entities in the value chain, either upstream or downstream. Accounting for indirect emissions from off-balance sheet assets is important to fairly present an entity's Carbon Quotient ratio.

The redirection of capital toward decarbonization requires that investors understand and account for the future climate impact of the world's existing stock of emission-producing real assets.

Carbon emissions result from the use and operation of long-lived tangible assets. Whereas intangible assets are today responsible for an increasing share of corporate value,[17] tangible assets retain their dominance as the principal source of carbon emissions.

According to the U.S. Environmental Protection Agency (EPA), the primary sources of emissions in the United States are transportation (28 percent), electricity production (27 percent), industry (22 percent), commercial and residential buildings (12 percent), agriculture (10 percent), and land use and forestry (12 percent).[18] These sectors have a common characteristic: they are all capital-intensive.

Because emission-producing real assets have estimated useful lives more than one year, often measured in decades, the climate impact of these assets is greater than the emissions realized from their use in a single year. The climate impact of real assets lies in the "unrealized" future emissions that will result from their continued use over their remaining useful lives. This has important implications for capital investment decisions in the real and financial economy.

[16] CFA Curriculum | Financial Reporting and Analysis | Long-lived-assets.

[17] Baruch Lev, The End of Accounting and the Path Forward for Investors and Managers (Wiley, 2016)

[18] U.S. EPA: Sources of Greenhouse Gas Emissions.

The following chart shows the average technical lifespan of energy-related real assets.[19]

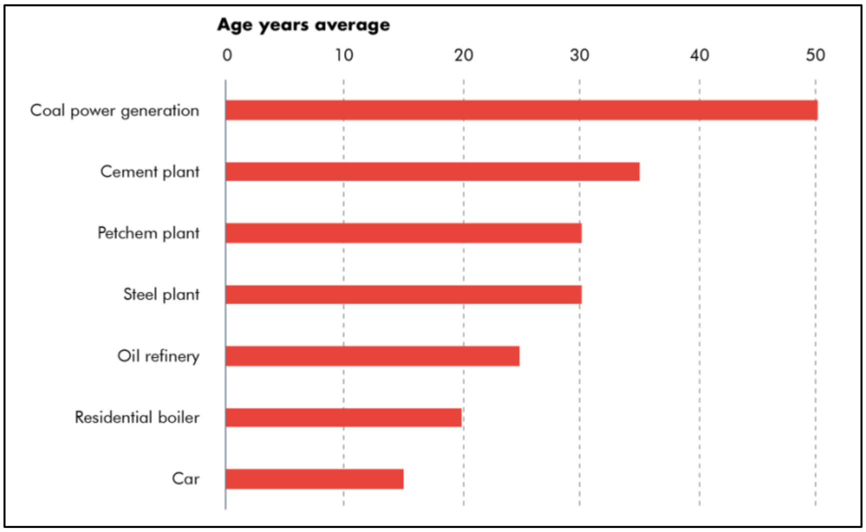

Figure 6 Average technical lifespan of energy-related capital stock

The remaining useful lives of much of the world's stock of emission-producing assets extend to 2050 and beyond. Reducing unrealized emissions on a timeline consistent with the Paris Agreement will require the early retirement and replacement of many of these assets. New investments in carbon-intensive assets will be at even greater risk. Asset impairment, asset stranding, and early replacement costs are the central financial and economic challenge of net zero.

An organization's climate resilience is correlated with its long-lived tangible assets. Aircraft carriers turn, brake, and accelerate slowly compared to speed boats. They are less adaptive to rapid change.

Businesses dominated by long-lived carbon-intensive assets have less adaptive capacity. To survive the transition to net zero, these organizations must successfully seize opportunities to improve efficiency, design new production processes, and develop new products. The Task Force on Climate-related Financial Disclosures (TCFD) has observed that, "Opportunities related to resilience may be especially relevant for organizations with long-lived fixed assets."[20] This is another way of saying that capital-intensive businesses with carbon-intensive assets are especially at risk.

CQ analytics internalize costs for realized (current and past) and unrealized (future) emissions. Emissions are a byproduct of a company's operations with externalized environmental and social costs that fall outside GAAP/IFRS reporting. Future regulatory efforts to curtail emissions

[19] Carbon Tracker, Decline and Fall: The Size & Vulnerability of the Fossil Fuel System.

[20] TCFD Final Report, Section B.2.d at p. 7.

are expected to internalize these impacts, if only partially, as a business cost. Increased carbon costs will reduce profitability, expected future cash flows, and asset valuations.

The Carbon Quotient ratio can be applied to all asset classes covered by the Global GHG Accounting and Reporting Standard for the Financial Industry, including listed equity and corporate bonds, business loans and unlisted equity, project finance, commercial real estate, mortgages, and moto vehicle loans.[21]

CQ analytics also produce risk-adjusted financial accounts (e.g., assets, liabilities, revenues, expenses, and cash flows) and ratios (e.g., profit margin, asset turnover, return on assets, etc.) that account for the externalized costs of realized (past and current) and unrealized (future) emissions.

III. Accountability measurement

An effective net zero accountability framework (Figure 4) requires measurements that:

- Assess past performance against agreed objectives, barriers and constraints – i.e., measurements must be relevant and actionable.
- Provide a reasonable basis for forecasting future performance.
- Produce consistent measurements from one organization to another and from one period to another.
- Integrate with financial accounting frameworks (GAAP/IFRS).
- Assure that reported measurements are what they purport to be and are free of material error or fraud.
- Are as simple as possible.

Principals across the investment value chain can and will act on measurements with these qualities, displacing measurement for measurement's sake without consequences.

A. Relevant and actionable

An effective accountability framework must measure and report information to assess performance against agreed objectives, barriers and constraints. In other words, performance measurements must truly inform investment decisions. They must be relevant and actionable. They must have consequence.

In this case, the term "net zero" itself defines the primary objective. The constraint is that this objective must be achieved while maintaining an acceptable level of profitability. The principal barrier is that to achieve net zero, actors in the real economy must replace much of the world's existing stock of emission-producing assets with low carbon alternatives on an accelerated schedule.

In his *Tragedy of the Horizon* speech, Mark Carney explained transition risk by saying that if the carbon budget estimate of the Intergovernmental Panel on Climate Change (IPCC) is even

[21] PCAF Global GHG Accounting and Reporting Standard for the Financial Industry.

approximately correct it would render the vast majority of fossil fuel reserves stranded, but there was a flipside of transition risk – the opportunity of a sweeping reallocation of resources and a technological revolution, with long-term infrastructure investments at roughly quadruple the present rate.[22] In sum, transition risk and opportunity each arises from the need to accelerate replacement of the world's existing stock of carbon-intensive assets with low carbon alternatives.

One of the essential functions of financial markets is to price risk to support informed, efficient capital allocation decisions. The Financial Stability Board, then chaired by Carney, established the TCFD in 2015 to identify the information needed by investors, lenders, and insurance underwriters to appropriately assess and price climate-related risks and opportunities, both those arising from physical impacts and the energy transition.

The purpose of CQ analytics is to help corporate managers, investors and lenders assess and price transition risks and opportunities.

Understanding how CQ analytics measure transition risk is important for users to correctly interpret its outputs. The elements of risk assessment include hazard, exposure, vulnerability, and impact (probability times severity).

The principal hazards associated with the transition to net zero are policy changes (carbon taxes and constraints), market shifts (supply chain and consumer demand), technology developments, and legal liability. Of these, the root hazard is policy change and its potential impact on carbon emissions and prices. Market and technology risks are largely derivative from policy risk. Expectations of an inevitable policy response are a principal driver for technology development and market shifts.

Litigation risk is also correlated with policy based on proximate causation: emissions cause climatic warming which exacerbates physical hazards which impose added adaptation and response costs on others. Sectors and firms with higher emissions bear higher exposure to policy changes and are also likely to bear higher exposures to market, technology, and legal hazards.

Concerned that a systematic approach and a comprehensive theory on climate-adjusted financial risk metrics is still missing, the Center of Economic Research at ETH Zurich drew on insights from climate science, economics and finance research, to derive a set of important criteria to ensure that climate risk tools provide high quality, comparable, and decision-relevant results.[23] Table 1 describes how CQ analytics account for the various elements of transition risk using the ETH Zurich criteria.

[22] Breaking the tragedy of the horizon – climate change and financial stability, Speech by Mr Mark Carney, Governor of the Bank of England and Chairman of the Financial Stability Board, at Lloyd's of London, London, 29 September 2015.

[23] Taming the Green Swan: How to improve climate-related financial risk assessments, section 4.2 at pp. 28-33.

Risk element	Description	Depth of CQ risk assessment
Hazard	policy risks (carbon taxes and constraints), market (supply chain and consumer demand), technology risks, and liability risk	assumes universal carbon neutrality policy is in place today across all sectors and regions
Exposure	accountability for future GHG emissions	estimates future emissions based on remaining life of emissions-producing assets
Vulnerability	potential severity of impact based on, for example, competitive position, ability to cover or pass-through costs to consumers, and asset impairment or stranding	shows vulnerability to asset impairment, competitive position, and ability to cover costs
Adaptability	ability to mitigate adverse impacts, for example, with input substitution, and climate strategy, climate-aligned R&D or future capex plans	assumes existing stock of carbon-intensive physical assets is the primary constraint on a firm's transition to net zero
Impact	interplay between hazard, exposure, vulnerability and resilience, and adaptability	shows impact of transition risk on financial accounts, financial statements, and financial ratios
Amplification	factors that could cause a sudden asset repricing event	provides an indirect measure of systemic risk arising from sudden, large-scale asset impairment

Table 1 Depth of CQ risk assessment

B. Forward-looking

An effective accountability framework must provide a reasonable basis for forecasting future performance.

Investors cannot navigate the unchartered course to net zero looking only in the rear-view mirror. Past emissions, and carbon intensity measures derived from past emissions, tell us little about where we are headed and where we need to go. The net zero imperative calls for new instruments to help investors spot hazards around corners ahead. We need a global positioning system (GPS) to keep us on course.

The TCFD has indicated growing interest in forward-looking climate risk measurements to inform financial decisions.[24] In June 2021 the TCFD opened a public consultation on proposed guidance on climate-related metrics, targets, and transition plans[25] and the Portfolio Alignment Team's Technical Supplement[26] to learn more about the potential usefulness of climate-related metrics in promoting comparability across financial disclosures and to receive feedback on the proposed changes to climate-related targets and transition plans.

Forward-looking metrics that focus on physical risk and asset valuations are starting to emerge. However, as tools for financial decision-making, these metrics have many shortcomings.[27] Three in four respondents to a recent TCFD consultation reported unease with the methods used to create forward-looking portfolio metrics.[28] Asked what challenges their organizations faced using metrics like portfolio warming potential and climate value-and-risk, 77% of respondents in the financial services industry said "concerns around reliance on assumptions required to derive future company-level emissions" and 74% said "concerns around reliance on assumptions and future uncertainty." Fortunately, there is a simple and objective way to estimate future company-level emissions, based on *past* transactions and events . Carbon Quotient analytics address the need for objective forward-looking measures of transition risk in two ways: (1) accounting for unrealized (future) emissions; and (2) creating a net zero GPS. The CQ methodology enables investors to "trust but verify" corporate statements about future plans and prospects.

1. The future that has already happened

Investors need forecasts based on minimal speculation. Although it is impossible to predict the future, it is both possible and fruitful to identify major events that have already happened and that will have predictable effects in the future. In other words, to achieve net zero, investors should identify and prepare for the future that has already happened.

Investors should ask what are major events that have already happened that will have long-term future climate-related impacts and what are the predictable effects of these events over the next several decades?

CQ analytics answer these questions as follows:

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[24] Task Force on Climate-related Financial Disclosures Forward-Looking Financial Sector Metrics Consultation, October 2020.

[25] TCFD Proposed Guidance on Climate-related Metrics, Targets, and Transition Plans.

[26] TCFD Portfolio Alignment Team's Technical Supplement.

[27] Scientists have expressed concern that physical risk models used by climate scientists may be inappropriately deployed by institutions and climate service providers and produce unreliable financial signals. Fiedler, T., Pitman, A.J., Mackenzie, K. *et al.* Business risk and the emergence of climate analytics. *Nat. Clim. Chang.* **11,** 87–94 (2021).

[28] TCFD Forward-Looking Financial Metrics Consultation: Summary of Responses.

What are major events that have already happened that will have long-term future impacts? *The acquisition, construction and development of the world's existing stock of emissions-producing long-lived tangible assets.*

What are the predictable effects of these events over the next several decades? *The "unrealized" future emissions that will result from the continued use of these assets over their remaining economic lives.*

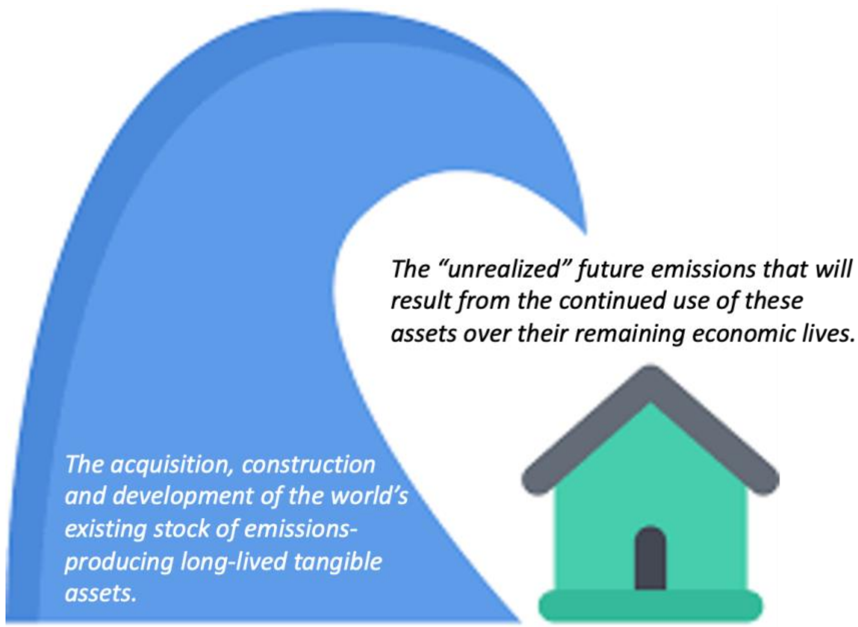

Figure 7 The future that has already happened

2. Unrealized emissions

The TCFD describes the value of *past* emissions data this way:

> Although still useful for decision-making, past carbon exposures provide little insight into potential future exposure. This is particularly the case as a growing number of companies are announcing planned changes to products, strategies, and future emissions targets in line with international climate agreements and national policy goals.

Although past carbon emissions are not a measure of future exposure, they do provide a great deal of insight into potential future exposure. This is because the long-lived assets that produced those past emissions – unless replaced or modified – will also produce tomorrow's emissions.

It is possible to estimate future emissions by accounting for the remaining economic life of existing emission-producing assets.[29] Instead of looking backwards, CQ analytics measure the unrealized emissions that are already "baked in" to existing assets in the real economy.

Net zero by 2050 is a stretch goal but not a fantasy. A recent study from Princeton University[30] found that with a massive, nationwide effort the United States could reach net zero by 2050 using existing technology and at costs aligned with historical spending on energy. The International Energy Agency (IEA) has reached a similar conclusion.[31] But there is a catch. Net zero by 2050 is attainable only if we "immediately shift investments toward new clean infrastructure instead of existing systems."[32] .

A key assumption in net zero projections is timing – when carbon-intensive real assets will be replaced – whether at economic end-of-life, which reduces replacement costs, or prior to economic end-of-life, which would leave some assets impaired or stranded.

Transition risk is directly correlated with asset replacement costs. This has two important implications – (1) *new* investments in carbon-intensive assets are at higher risk of becoming impaired or stranded; and (2) delay in the reallocation of investment toward decarbonization increases the risk of *existing* carbon-intensive assets becoming impaired or stranded as the remaining timeframe for decarbonization is compressed.

Asset impairment risk arising from the transition to net zero is a function of future emissions over the remaining economic life of the asset.[33] Assets with higher emissions and longer lives have higher unrealized future emissions and are at greater risk of becoming impaired or stranded.

Because a carbon pricing scheme is not a reality today, CQ analytics measure a latent threat to uncertain future cash flows. Nonetheless, as illustrated in Figure 8 (reproduced from the final TCFD recommendations), climate-related impacts on expected future cash flows can have immediate financial consequences.

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[29] Taming the Green Swan: How to improve climate-related financial risk assessments, section 4.2 at p. 32.

[30] Princeton University, Net Zero America: Potential Pathways, Infrastructure, Impacts Interim Report.

[31] International Energy Agency, Net Zero by 2050: A Roadmap for the Global Energy Sector.

[32] Big but affordable effort needed for America to reach net-zero emissions by 2050, Princeton study shows, quote from project lead Jesse Jenkins, assistant professor of mechanical and aerospace engineering and the Andlinger Center for Energy and the Environment.

[33] Relevant emissions may include value chain (scope 3) emissions.

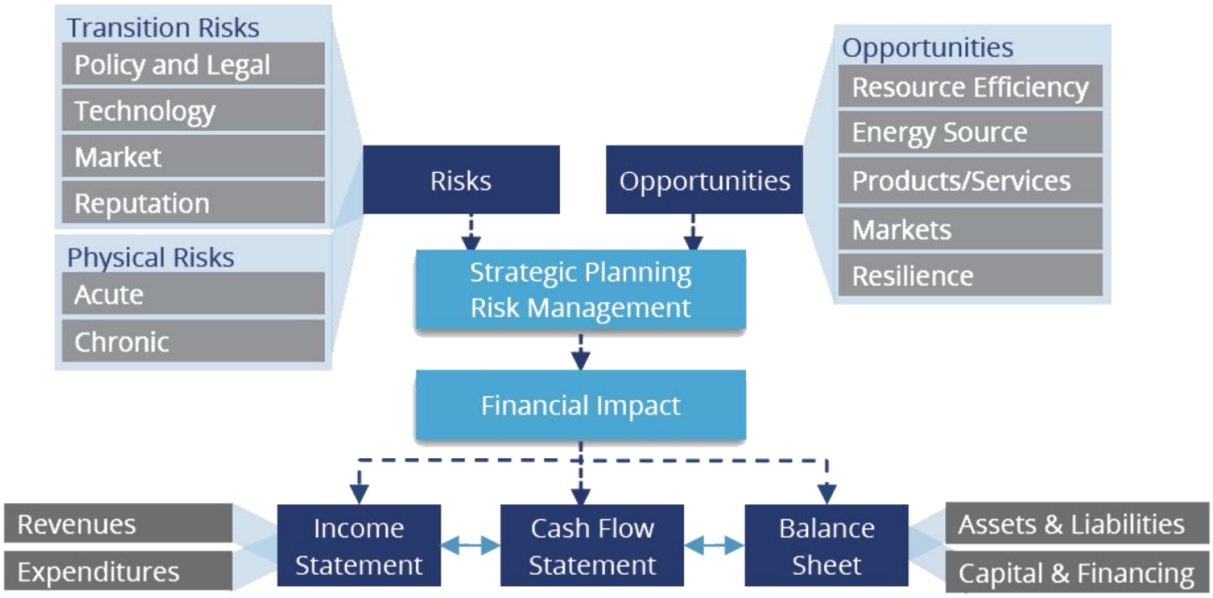

Figure 8 Climate-related risks, opportunities and financial impact

Under U.S. generally accepted accounting principles (GAAP) and International Financial Reporting Standards (IFRS), forward-looking expectations can adversely affect a company's balance sheet – e.g., through asset impairments, accelerated asset retirement obligations, and contingent liabilities.[34] In its final report, the TCFD observed:

> Use of long-lived assets and, where relevant, reserves may be particularly affected by climate-related issues. It is important for organizations to provide an indication of the potential climate-related impact on their assets and liabilities, *particularly long-lived assets*. This should focus on existing and committed future activities and decisions requiring new investment, restructuring, write-downs, or impairment.[35]

3. GPS mapping for net zero

The power of net zero is that its sets both a destination and a deadline. Wherever one starts the journey, the destination is the same – carbon neutrality. So is the deadline. This means one can create a customized map for getting to net zero on time, track progress, and forecast an estimated time of arrival (ETA) for any emission-producing asset or portfolio of emission-producing assets.

The road to net zero will be fraught with failures but also sprinkled with successes. Some firms will fail along the way. Others will survive and prosper. If they are to efficiently allocate capital,

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[34] See Effects of climate-related matters on financial statements; Accounting for climate: Integrating climate-related matters into financial reporting, and Rogers, Financial Reporting of Environmental Liabilities and Risks after Sarbanes-Oxley (Wiley, 2005).

[35] TCFD Final Report at Figure 2 Major Categories of Financial Impact, p. 9 [emphasis added].

investors must have a GPS to track who is on course and who is not, who is winning and who is losing, who should get more capital and who should get less.

CQ analytics produce risk-adjusted financial accounts and ratios that reflect the economics of net zero and correlate realized and unrealized emissions with the real assets that produce them. The GPS maps a course for getting to net zero, shows past course of travel and current positioning, and gives an ETA. When the current course is off track, it shows the degree of rerouting needed to get back on course.

Figure 9 below is an example of a net zero GPS. Once Carbon Quotient calculations are complete, the results can be plotted on a timeline starting at a selected point in the past (e.g., 2010) and extending through a target date for reaching net zero. The data visualization includes the following five key components:

- The Carbon Quotient ratio (y axis)
- Relevant timeframe (x axis)
- An asymptotic exponential trajectory to net zero by a selected target date
- Actual CQ results for past periods (the difference between actual performance and the net zero trajectory is a visual representation of asset impairment risk)
- A trend line forecast through the selected net zero target date

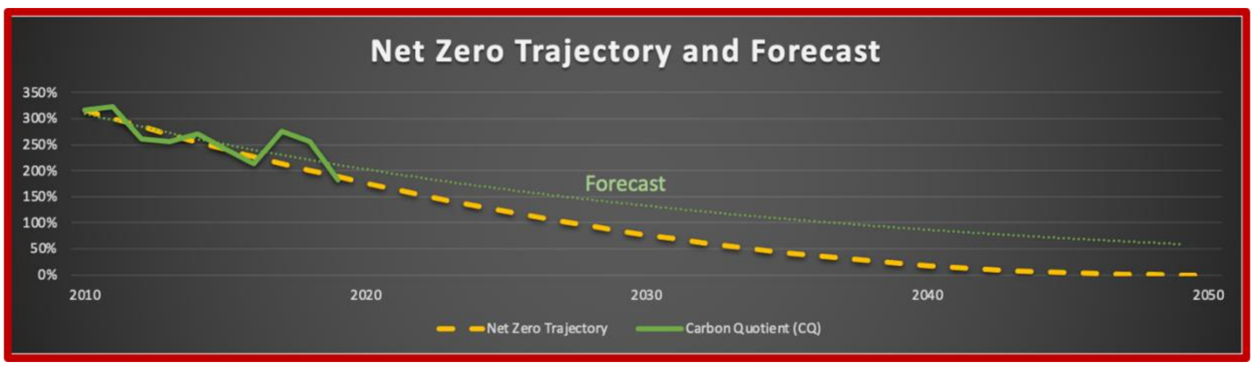

Figure 9 Net zero GPS diagram

C. Comparative measurement

An effective accountability framework must measure and report information that principals can use to assess the performance of one agent against another and by the same agent over time. Considerations include the measurement scale, the unit of measurement, and estimation uncertainty.

Warning, the following discussion is technical but essential. [Measurement](#) lies at the heart of accountability. There are many different ways to measure climate-related financial risk. This section explains the difference in measurements and the difference it makes.

1. Measurement scale

To facilitate comparative measurement, the measurement scale should allow any analyst to compare proportional differences in outputs for different assets, companies or portfolios. Of the four measurement scales – nominal, ordinal, interval, and ratio – only the ratio scale is suitable. Notably, many existing measures of climate risk do not use ratio scale variables.

a) Nominal scale

Nominal scales are used for labeling variables, without any quantitative value. Nominal scales could simply be called labels. Sub-types of nominal scale include dichotomous data with only two categories (e.g. male/female or yes/no) and nominal with order (e.g., cold, warm, hot, very hot).

The Climate Action 100+ Net-Zero Company Benchmark is an example of a dichotomous nominal scale.[36] The framework assesses focus companies based on their publicly disclosed information. It includes eight yes/no indicators (and several sub-indicators):

1. Whether the company set an ambition to achieve net-zero GHG emissions by 2050 or sooner
2. Whether the company has set long-term reduction targets
3. Whether the company has set medium-term reduction targets
4. Whether the company has set short-term reduction targets
5. Whether the company has a decarbonization strategy
6. Whether the company is working to decarbonize its future capital expenditures
7. Whether the company has a Paris-Agreement-aligned climate lobbying position and all of its direct lobbying activities are aligned with this
8. Whether the company's board has clear oversight of climate change

Notably, all eight criteria are qualitative and non-financial. They offer a range of indicators that investors can use to inform investment decisions and stewardship, but they do not provide a quantitative means to track a firm's progress toward net zero over time. The most important criteria – whether companies have a robust strategy to achieve net zero emissions targets and whether they are aligned with the Paris Agreement – are highly subjective, making objective comparison impossible. The criteria cannot be processed and manipulated in a computerized system and cannot be rolled up for investment portfolios.

b) Ordinal scale

Ordinal data is quantitative data with naturally occurring orders but where the difference between values is unknown. Ordinal scales typically measure qualitative concepts like satisfaction, happiness, and discomfort (e.g., 1- Totally Satisfied, 2- Satisfied, 3- Neutral, 4- Dissatisfied, 5- Totally Dissatisfied).

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[36] Climate Action 100+ Net-Zero Company Benchmark.

Environmental, social, and governance (ESG) scores are examples of ordinal scale. ESG indicators are usually in the form of quantitative ratings, that is, they show the ESG performance on a pre-defined numeric scale (e.g., 1 to 100), representing a range from low to high ESG performance or from high to low ESG risk. The difference between a rating of 80 and 60 is not exactly the same as the difference between a rating of 40 and 60. Nor is the difference between a rating of 40 and 80 exactly twice the difference between a rating of 40 and 60.

Many ESG scores also use a best-in class ranking within sectors. This results in high scores for some oil and gas companies relative to their peers, even though the oil and gas sector is the largest source of direct and indirect GHG emissions.[37] This further confounds the analyst's ability to discern the difference between values and to assess portfolio risk.

c) Interval scale

Interval scales are numeric scales that provide both the order and the exact differences between the values. Temperature is an example of an interval scale variable. If an air-conditioned room is 16° C and the outside temperature is 32° C, the outside temperature is exactly 16° C higher, but it is not twice as hot outside than inside.

Implied temperature rise (ITR) is an example of an interval scale variable for measuring transition risk. ITR estimates a company's expected future emissions and translates this into a projected increase in global average temperature warming that would occur if all companies in corresponding sectors had the same carbon intensity as the selected target. The ITR metric is expressed in a single temperature unit or range that is comparable to widely understood potential climate outcomes (e.g., 1.5°C, 2°C, 3.5°C).[38]

ITR is used to assess the alignment of a portfolio with a particular transition pathway.[39] A 1.5°C-aligned portfolio is exactly 2°C apart from a 3.5°C-aligned portfolio. However, it would be meaningless to say that 2.5°C-aligned portfolio is exactly twice as aligned with a 1.5°C transition pathway as a 3.5°C-aligned portfolio.

d) Ratio scale

Ratio scale variables provide order and the exact value between units. Also, because they have an absolute zero, they allow a wide range of statistical analysis. Age, money, and weight are common ratio scale variables. A 60-year old person is both 30 years older than a 30-year old and twice as old.

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[37] Climate Strategies and Metrics: Exploring Options for Institutional Investors.

[38] BlackRock has announced its intent to publish "a temperature alignment metric for our public equity and bond funds, where sufficient data is available." Larry Fink's 2021 letter to CEOs.

[39] See Measuring Portfolio Alignment: Assessing the position of companies and portfolios on the path to net zero and Task Force on Climate-related Financial Disclosures Forward-Looking Financial Sector Metrics Consultation, October 2020.

The true zero characteristic of ratio scale variables is an essential factor in calculating financial ratios commonly used by investors and analysts. These include liquidity ratios, leverage ratios, profitability ratios, efficiency ratios, coverage ratios, and market prospect ratios.[40] Ratios are a cornerstone of fundamental equity analysis because they enable reliable comparative measurement.

CQ analytics use only ratio scale variables – emissions and money. A company with emissions of 100 tCO_2e/year has exactly twice the emissions of a company with emissions of 50 tCO_2e/year. A company with carbon-adjusted net income of $100 million has exactly twice the adjusted net income of a company with carbon-adjusted net income of $50 million. Similarly, a portfolio with a Carbon Quotient ratio of 100% bears exactly twice the transition risk, as measured by the CQ ratio, of a portfolio with a 50% Carbon Quotient ratio.

2. Unit of measurement

Measurement requires either a standardized unit of measurement (e.g., dollar, year, ton, and degree Celsius) or a reference standard (e.g., a tuning fork).

The Carbon Quotient ratio is a standardized unit of measurement for quantifying the transition risk inherent in emission-producing, long-lived tangible assets. It allows users to easily and rationally assess the differential risk in one asset (or portfolio of assets) to another without regard to whether the absolute risk of either can be known with reasonable assurance.

Other standardized units of measurement used to quantify transition risk include emission intensity ratios that calculate the relationship of emissions to corporate revenues, production levels, and investment. The most popular standardized unit of measurement for portfolios is the weighted-average carbon intensity (WACI) ratio. A comparison of CQ analytics to other carbon metrics is provided in the section on "Comparison to other carbon " below.

Portfolio alignment measures, such as implied temperature rise and the Paris Agreement Capital Transition Assessment (PACTA)[41] scenario alignment tool developed by 2° Investing Initiative, use a reference standard (e.g., a 1.5°C-aligned portfolio) to assess transition risk. A drawback to such measures is the absence of ratio scale.

3. Estimation uncertainty

In general, measurements are only an approximation or estimate of the value of the quantity measured and thus are complete only when accompanied by a statement of the uncertainty of the estimate. Climate-related financial risks are subject to *extreme* uncertainty.

Global climate change is unprecedented. Climate-related risks are characterized by deep uncertainties, interdependences, non-linearity, and fat tails. Outcomes and timing cannot be predicted with reasonable assurance. Rather than waiting for ever more accurate climate risk

[40] Investopedia | Ratio Analysis.

[41] 2° Investing Initiative | Paris Agreement Capital Transition Assessment (PACTA).

models, practical actors in the real and financial economy must instead ask, "what is the correct decision today assuming we have no reliable models of climate risk, because we don't?"[42]

Measurements can be direct (absolute) or indirect (comparative). Absolute measurements measure the quantity of a target (asset, company, portfolio) against a standardized unit of measurement or reference standard. Comparative measurements gauge the difference between two or more targets. Where estimation uncertainty is high comparative measurements may be more accurate and decision useful than absolute measurements.

As illustrated in Figure 10, the relative size of two children or the relative height of a child from one year to the next can be quickly ascertained with much greater accuracy than the absolute size of either.

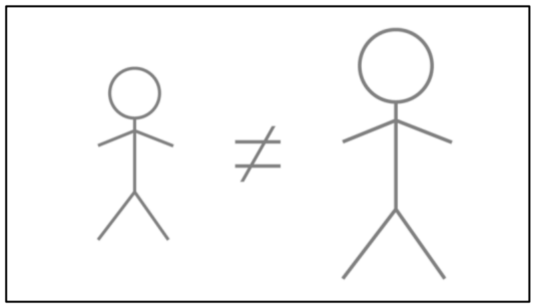

Figure 10 Comparative measurement

This is because comparative measurements eliminate many systematic errors that reduce the accuracy of direct measurements. Systematic errors are those that occur consistently in all measurement regardless of repetition. Systematic errors can arise from data (e.g., emissions estimates), assumptions (e.g., carbon prices, baseline and transition scenarios), or complex methodologies used to account for uncertainty and non-linearities (or the decision to instead ignore them).

As measurement approaches for transition risk increase in sophistication, users may expect that they will become more accurate and decision-useful, but the opposite could be true. As methodologies become more complex, they also become more vulnerable to systematic errors.

As a result, more sophisticated measures of transition risk may create the illusion of precision and accuracy while delivering estimates that are neither (see Figure 11).

[42] Joseph Norman, Rupert Read, Yaneer Bar-Yam, and Nassim Nicholas Taleb, Climate models and precautionary measures, Issues in Science and Technology (Summer 2015).

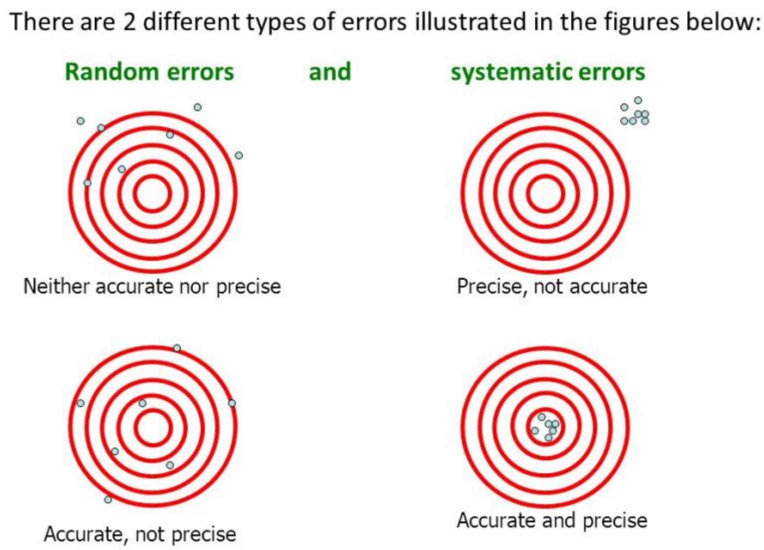

Figure 11 Random and systematic errors in measurement

In practical terms, this means that absolute measurements of transition risk – e.g., the climate-adjusted valuation for company X is Y (based on, for example, climate value at risk) – are not sufficiently reliable to inform investment decisions. They may be relevant, but they are not actionable. Comparative measurements (benchmarking), on the other hand, may have high decision utility by differentiating leaders from laggards on a standard scale.

D. Integration with accounting frameworks

An effective accountability framework must measure and report information that can be easily incorporated into financial accounting frameworks (GAAP/IFRS) used in fundamental equity analysis. This requires that the framework have several attributes. For example, measurements of transition risk must be expressed in monetary terms. This requires monetization (pricing) of emissions. We discuss those below.

1. Risk-adjusted financial accounts and ratios

The Impact-Weighted Accounts Project at the Harvard Business School attempts to comprehensively account for social and environmental impacts, CQ analytics focus more narrowly on the social and environmental imperative of our time: climate change.

The mission of the Harvard project is to create accounting statements that transparently capture external social and environmental impacts in a way that drives investor and managerial decision making. The initiative is based on the premise that impact can and should be measured within an accounting framework with the aim of harnessing the economy to improve society and the planet.[43]

[43] Harvard Business School | Impact-Weighted Accounts.

We share the view that impact-adjusted measurements should be reported with reference to generally accepted accounting frameworks such as GAAP and IFRS in order to facilitate comparative analysis.

To harness the power of capital markets to accelerate decarbonization, externalized climate impacts should be reflected in risk-adjusted (pro forma) financial accounts that can be easily contrasted with financial statements prepared under GAAP/IFRS. This will both facilitate comparative measurement and leverage existing accounting frameworks used in fundamental equity analysis.

2. Emissions pricing

Pricing emissions is necessary to translate transition risk into firm-level financial impacts on revenues, expenses, assets, liabilities and cashflows (as illustrated in Figure 8). Imputing a price on emissions transforms environmental metrics (e.g., absolute emissions, emissions per unit of production, or emissions per euro or dollar of revenue) into risk-adjusted financial accounts (e.g., carbon-adjusted expenses and net income) and ratios (e.g., carbon-adjusted earnings per share and profit margin) that are essential for comparative financial analysis.

Pricing transition policy risk is tantamount to pricing carbon emissions (i.e., $/tCO$_2$e). There are different approaches to pricing emissions based on different objectives, including price projections from climate-related regulation, estimates of the social cost of carbon, internal carbon prices set by companies, estimates of the price required to change business decisions and behavior, and estimates of the price needed to achieve specific climate warming scenarios by a specified future date.[44]

Factoring carbon prices into financial analysis is essential for purpose-oriented and purely financially-oriented investors to prepare for a world with more explicit carbon pricing, whatever form those prices take. Monetizing carbon emissions transforms environmental metrics into risk-adjusted financial accounts and ratios that can be integrated into fundamental equity analysis or used for comparative benchmarking.

a) Carbon pricing

Carbon pricing estimates the carbon price needed to achieve a specified climate transition scenario – i.e., the estimated price of carbon required to limit global warming to a specified temperature increase by a specified future date. Carbon pricing based on a specified climate transition scenario is different than scenario alignment. Scenario alignment references the alignment of financed emissions with one or more transition scenarios. Scenario alignment measures absolute emissions relative to a target but does not monetize them.[45]

[44] How-To Guide to Corporate Internal Carbon Pricing: Four Dimensions to Best Practice Approaches.

[45] See 2° Investing Initiative| Paris Agreement Capital Transition Assessment (PACTA).

Figure 12 provides a schematic illustration of how a specific temperature target is translated into a carbon price, given specific assumptions – e.g., shared socioeconomic pathways (SSPs) – and using a specific climate model – e.g., integrated assessment models (IAMs).

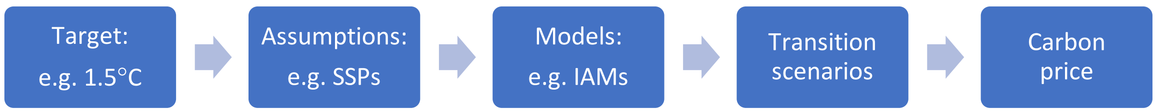

Figure 12 Schematic overview on the translation of climate targets into carbon prices

The Stern–Stiglitz Report of the High-Level Commission on Carbon Prices is an example of carbon pricing. The Commission concluded that the explicit carbon price level consistent with achieving the Paris temperature target (i.e., to hold the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C) is at least \$50–100/tCO_2e by 2030, provided a supportive policy environment is in place.[46]

Carbon pricing is subject to high estimation uncertainty. CFA Institute advises investors to run scenario analysis to see how a carbon price of \$50–\$100/tCO_2e would affect the companies they analyze or hold in their portfolios.[47] BlackRock (Carbon Beta), MSCI (Carbon Delta), and S&P Trucost offer tools for scenario pricing. BlackRock's Carbon Beta uses sensitivity analysis to address the high estimation uncertainty regarding the impact of potential future carbon pricing schemes on corporate valuations.[48]

b) Offset pricing

A simpler alternative to carbon pricing is offset pricing. Offset pricing is based on the cost to remove carbon dioxide from the atmosphere. With offset pricing, a company's carbon emissions are priced at the cost to offset them with negative emissions of an equal amount.

Offset pricing should in theory reflect the lowest cost anywhere in the world to remove carbon dioxide from the atmosphere at scale. A 2019 study from the U.S. National Academies of Sciences, Engineering, and Medicine concluded that a direct removal cost of \$100 or less per ton of CO_2 is economically feasible. It found that several land-based negative emissions technologies are ready for large-scale deployment at costs competitive with emissions mitigation strategies in this cost range. However, the scale needed to meet climate goals would

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[46] https://static1.squarespace.com/static/54ff9c5ce4b0a53decccfb4c/t/59b7f2409f8dce5316811916/1505227332748/CarbonPricing_FullReport.pdf.

[47] Report of the High-Level Commission on Carbon Prices.

[48] Carbon Beta - A Framework for Determining Carbon Price Impacts on Valuation. Key differences between Carbon Beta and CQ are the purpose of the analysis and how emissions are priced. Whereas Carbon Beta is a framework for assessing the sensitivity of company valuations to different carbon pricing scenarios, CQ assesses comparative asset impairment risk and climate resilience using a universal offset pricing scheme.

require unprecedented changes in land use that could affect food availability and biodiversity. The study found that other negative emissions technologies, such as direct air capture, have high potential capacity but are currently limited by high cost ($600/tCO$_2$e).[49]

Offset pricing is more objective than carbon pricing. Carbon pricing relies on highly uncertain assumptions about future socioeconomic and technological developments. Offset pricing relies on less uncertain assumptions about projected costs for negative emissions. In the future, offset pricing will be based on quoted market prices. This does not preclude selection of a reasonable estimate today and adjusting it in the future to reflect market prices.

Offset pricing is also more conservative than carbon pricing. It evaluates a firm's financial condition based on the counterfactual assumption of carbon neutrality in today's economy, not a future economy several decades from now.

Offset pricing is consistent with climate science in that it internalizes 100% of the cost of carbon neutrality today. Leaving aside considerations of economic feasibility, the safest solution for the planet would have been to reach carbon neutrality decades ago rather than in 2050 or thereafter.

The world is already paying a high price for past carbon emissions. Getting to net zero by 2050 will not reverse the damage that has already occurred or the additional damage that will occur during the transition. Ultimately, it may be necessary or desirable to remove all of the carbon that has accumulated in the atmosphere since the start of the industrial revolution.

Asset owners, analysts, and portfolio managers may want to measure a company's sensitivity to carbon prices using a tool like BlackRock's Carbon Beta.[50] However, sensitivity of companies to different carbon prices is less important than the differentiated impact of a uniform carbon price applied consistently across competing firms and investment portfolios. Comparative measurement of transition risk is more reliable than direct measurement, for reasons discussed in Section C above.

A 100% emissions offset approach has the important benefit of benchmarking a firm's past, current and future financial performance against a net zero objective. If net zero is the goal, investors should understand how companies would perform under the constraints of carbon neutrality today, rather than speculate about the nature and timing of future scientific pronouncements and policy responses. The same holds true for investment portfolios.

Past carbon emissions can give rise to a contingent carbon liability. Imputing an emissions offset price for past emissions is analogous to the legal doctrine of disgorgement and thus a reasonable measure of transition risk arising from litigation. Disgorgement is an equitable remedy used to prevent unjust enrichment by requiring a defendant to give up any profits it made as a result of illegal or wrongful acts. Imputing a cost for negative emissions figuratively

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[49] See Businesses Aim to Pull Greenhouse Gases From the Air. It's a Gamble, New York Times, Jan. 18, 2021, and National Academies of Sciences | Negative Emissions Technologies and Reliable Sequestration: A Research Agenda (2019).

[50] BlackRock | Introducing Carbon Beta: What pricing carbon means for investors.

disgorges profits made by avoiding the expense to fully offset the harm to society resulting from past emissions.

Disgorgement is not merely a hypothetical legal risk. Rather it is a contingent liability.[51] The State of Rhode Island recently sued 21 energy companies for climate change impacts that the state has experienced and will experience in the future. Rhode Island claimed that the defendants' sale of fossil fuel products, along with simultaneous concealment of the known hazards of these products, and their championing of anti-science campaigns caused the state's injuries. Among other damages, the lawsuit seeks to disgorge profits earned by the defendants from externalizing social and environmental costs. As an example of unjust enrichment from the externalized costs of past emissions going back decades, the complaint references internal Exxon reports from 1980 stating that "technology exists to remove $C0_2$ from [fossil fuel power plant] stack gases but removal of only 50% of the $C0_2$ would double the cost of power generation."[52]

c) *Uniform pricing*

Both the timing and amount of future carbon prices are subject to significant uncertainty. High accuracy in the forecasting of future carbon prices cannot be expected. Nonetheless, the decision-utility of carbon pricing depends on comparative materiality not accuracy. The objective is to assess the differential impact on companies and portfolios over time. The assumed price does not matter, so long as it is scientifically and economically reasonable and consistently applied.

To facilitate comparative measurement, emissions should be monetized in a manner that allows consistent and uniform peer-to-peer and year-over-year comparisons of companies and portfolios across all sectors and all regions. Regardless of how a carbon price is determined, when comparative measurement is the goal, it should be consistently and uniformly applied, regardless of source or timing. The application of non-uniform pricing, *i.e.,* forecasts, may say more about the forecast than the latent risk embedded in a firm's current business activities and practices.

(1) Source of emissions

To facilitate comparative measurement, emissions pricing should be applied uniformly to all emissions everywhere, regardless of source or location. Applying the same carbon price to all emissions everywhere allows comparability across assets, firms, sectors, portfolios, and regions.

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[51] Under GAAP, a contingency is defined as "an existing condition, situation, or set of circumstances involving uncertainty as to possible gain or loss to an enterprise that will ultimately be resolved when one or more future events occur or fail to occur. Resolution of the uncertainty may confirm the acquisition of an asset or the reduction of a liability or the loss or impairment of an asset or the incurrence of a liability." Statement of Financial Accounting Standards No. 5 Accounting for Contingencies.

[52] State of Rhode Island v. Chevron.

Idiosyncratic emissions pricing using scenario analysis is inherently subjective and ill-suited for comparative measurement. When assumptions used in scenario analysis are unique to the analyst the result is a "black box" analysis that precludes reliable comparative measurement.

Individual financial institutions may appropriately use idiosyncratic scenario analysis and alignment tools for internal purposes, as recommended by CFA Institute and 2° Investing Initiative, to assess how transition risk could affect their portfolios. But accountability requires that financial markets as a whole must have universal objective benchmarks.

Uniform carbon pricing is consistent with the scientific realities of global warming. Carbon emissions are fungible. The climate does not differentiate between emissions in the United States and emissions in China or between carbon removed from the atmosphere in Europe or Asia.

Uniform carbon pricing is objective. A uniform carbon price eliminates the need to consider subjective firm-specific economics. If a firm's mitigation costs for reducing or eliminating emissions is lower than the cost to remove carbon dioxide from the atmosphere, it should rationally choose to mitigate. Conversely, from a public policy perspective, if the cost to remove emissions is lower than a firm's cost to mitigate, the firm should rationally opt for removal.

A uniform carbon price treats all firms in all sectors in all regions the same, regardless of differences in mitigation costs or policy forecasts. This reflects the scientific reality that the climate does not differentiate the warming impact of carbon emissions based on their source or the cost of preventing them in the first place.

(2) Timing of emissions

Emissions pricing should be applied uniformly over time. To gauge a firm's progress toward net zero over time, the imputed price of carbon should remain constant over the period of analysis. Otherwise, investors may mistake false indications of progress resulting solely from changes in carbon prices for real progress toward net zero.

The time period of analysis may be both prospective and retrospective, encompassing the period beginning when reliable emissions data is first available through the applicable net zero target date.

E. Assurance

An effective accountability framework must assure that reported measurements are what they purport to be and are free of material error and fraud. This highest level of assurance allows users to confirm the validity of inputs and independently reproduce measurements.

1. Data inputs

Assurance requires that data inputs are reliable and accessible. CQ analytics rely on three categories of data – (1) current and prior period financial accounts data; (2) current and prior period emissions data; and (3) portfolio data. The reliability and reproducibility of CQ outputs depends on the quality and source of these data.

a) *Financial data*

Self-reported audited financial data (e.g., assets, liabilities, revenues, expenses, net income, cash flows) are widely available for public equities and bonds. Generally accepted accounting principles and audit standards, as well as legal penalties for accounting fraud, provide reasonable assurance of accuracy and comparability.

Users will have public access to financial data inputs that are identical to those used to produce CQ analytics for public companies and portfolios.

b) *Emissions data*

Poor quality and limited availability of emissions data is currently a significant obstacle to the estimation of transition risk and low-carbon investment. Given the largely voluntary nature of GHG reporting – e.g., Carbon Disclosure Project (CDP) reporting – and lack of reporting standards, investors worry about the quality of reported data.[53]

According to the TCFD, the share of MSCI world index companies — collectively around 60% of world market capitalization — that disclose their emissions has stalled at around 50% in recent years.[54] CDP currently provides estimated data for around a third of the Scope 1 emissions and slightly more than half of Scope 2 emissions from the over 5,000 companies it covers.[55] Few companies report Scope 3 emissions,[56] although they could account for more than 50% of the carbon footprint for companies in many industries.[57] Emission scopes are defined in Section II.A.2 below.

For these reasons, a transparent emission data strategy is an important feature of assurance. Considerations include data sources, whether data are third party verified (since emission data databases often use self-reported data, which is less reliable), and how to resolve data gaps.

Looking forward, we expect that increasing levels of accountability will pressure more companies to self-report audited emissions data for all relevant scopes.

Subject to global data gaps, users will have access to emissions data inputs that are identical to those used to produce CQ measurements.

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[53] Climate finance and disclosure for institutional investors: why transparency is not enough.

[54] Task Force on Climate-related Financial Disclosures Forward-Looking Financial Sector Metrics Consultation, October 2020.

[55] CDP, CDP Full GHG Emissions Dataset 2019 Summary, 2019.

[56] According to data available through the Bloomberg Professional Service, only 8% of the nearly 11,500 companies in the BESGPRO Index report Scope 3 GHG emissions.

[57] Kepler Cheuvreux, Carbon Compass: Investor Guide to Carbon Footprinting, November 23, 2015, pp. 20–23.

c) *Portfolio data*

When assessing investment portfolios, portfolio constituent and weighting data are required in addition to financial and emissions data at the constituent company level. The source of portfolio data depends on whether the portfolio is public or private.

Public portfolios include passive exchange traded funds (ETFs) and mutual funds (MFs). The U.S. Securities & Exchange Commission (SEC) regulates ETFs under Rule 6c-11 under the Investment Company Act of 1940 (the 1940 Act). Each business day, an ETF must disclose the ticker symbol of each portfolio holding, the quantity of each security held, and the percentage weight of the holding in the portfolio.[58] The 1940 Act requires MFs to make similar disclosures.[59]

Private portfolios, including actively managed funds and private equity are available only if voluntarily disclosed.

Users will have public access to portfolio data inputs that are identical to those used to produce CQ measurements for ETFs and MFs.

2. Reproducibility

Reproducibility of outputs requires access to identical inputs, transparent methodologies, and elimination of entity-specific assumptions and judgments.

a) *Transparency*

As shown in Figure 3, asset owners (principals) rely on reporting from asset managers (agents) to understand how climate-related risks and opportunities are managed within each of their portfolios. Asset managers in turn rely on reporting from corporate managers to understand how climate-related risks and opportunities are managed within the individual firms in which they invest.

Asset managers are accountable to asset owners just as corporate managers are accountable to shareholders. Transparency is a precondition for accountability. Transparency and accountability are also mutually reinforcing. Transparency strengthens accountability by facilitating monitoring. Accountability strengthens transparency by incentivizing agents to ensure that their actions are properly understood and rewarded.[60]

Transparency and confidentially often conflict. For example, commercial and nonprofit data providers may worry that release of proprietary methodologies used to produce climate scores will give competitors an unfair advantage. Too often the result is ratings produced with black box methodologies and subjective assumptions that impede user validation and comparability.

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[58] 17 CFR § 270.6c-11 - Exchange-traded funds.

[59] U.S. Securities & Exchange Commission | Laws and Rules.

[60] European Research Studies, Volume XII, Issue (1) 2009, Transparency in Financial Statements.

Imagine if financial analysts could not independently reproduce "proprietary" earnings per share figures?

The U.S. Securities & Exchange Commission (SEC) has encountered similar concerns with *non-GAAP measures*. Non-GAAP measures refers to financial information that is calculated and presented on the basis of methodologies other than generally accepted accounting principles (GAAP). Some of the most common non-GAAP measures include EBIT (earnings before interest and taxes), EBITDA (earnings before interest, taxes, depreciation, and amortization), adjusted earnings and adjusted EBITDA, and free cash flow.

In reaction to the significant increase in use of non-GAAP measures the SEC has adopted rules to ensure transparency. When a company publicly discloses a non-GAAP financial measure, SEC Regulation G requires it to provide a presentation of the most directly comparable financial measure calculated and presented in accordance with GAAP and a reconciliation of the differences between the non-GAAP financial measure presented and the most directly comparable financial measure or measures calculated and presented in accordance with GAAP. [61]

Assurance that measures of transition risk, especially those derived from financial measures calculated and presented in accordance with GAAP/IFRS, are not misleading, erroneous or fraudulent, requires that the data inputs and method of calculating outputs are fully transparent to users.

For this reason, we are choosing to fully disclose the inputs, assumptions, and formulas used to produce CQ measurements.

b) Objectivity

All estimates – including forward-looking accounting data, emissions inventories, and measures of transition risk – are subject to estimation uncertainty. Even measures of uncertainty are themselves estimates that are subject to uncertainty.

When producing estimates, assurance requires that subjective assumptions and methodologies used to resolve uncertainty be fully disclosed and avoided where reasonably possible. For purposes of assurance, observable data inputs and objective methodologies are always preferable to unobservable data inputs and subjective methodologies.

Examples of uncertainties in the measurement of transition risk include:

- Carbon budgets
- Current and future emissions
- Business-as-usual scenarios
- Temperature warming scenarios
- Transition scenarios
- Policy responses

[61] SEC Final Rule: Conditions for Use of Non-GAAP Financial Measures.

- Carbon prices
- Market shifts
- Technology developments
- Legal developments
- Remaining useful life of emission-producing assets
- Demand elasticity and tax incidence

Subjective assumptions and methodologies used to resolve these uncertainties may or may not improve accuracy, but they will always reduce objectivity.

For this reason, CQ analytics do not consider, for example, the ability of suppliers to pass carbon costs through to consumers because doing so requires subjective judgment, which undermine comparability, assurance and simplicity. Users can apply their own assumptions about demand elasticity and tax incidence when interpreting CQ outputs in the context of entity-specific analysis if they believe the benefits warrant the effort.

Similarly, probability distributions of possible timing and impact, generated by using transition scenarios, climate targets and assumptions, may provide useful information about the range of uncertainty, but they also impede reproducibility.

By fully disclosing subjective assumptions and methodologies, and avoiding them entirely where possible, CQ analytics enable users to independently reproduce its outputs. Our view is that any resulting loss in accuracy is more than offset by improved comparability and assurance.

F. Simplicity

Methodologies should be as simple as possible. Complex transition risk models can introduce incidental costs in the form of reduced comparability and assurance that are not outweighed by increased accuracy and decision utility.

Added complexity is likely to introduce more systematic errors. Model outputs, such as ”assuming A,B,C for the baseline business-as-usual scenario, and D,E,F for the transition scenario, while disregarding G,H,I, the mean climate-adjusted value at risk for company X is Y,” therefore may lead to a perception of false precision and overconfidence.

If the objective of complex models is to improve accuracy by resolving and measuring deep uncertainties and non-linearities, two questions must be asked – (1) are the absolute measures produced by these models sufficiently trustworthy to inform financial decisions; and (2) do the outputs produced by these models provide better comparative measures than simpler models? If the answer to both questions is negative, complexity may be a fool’s errand.

The CQ methodology is designed to be as simple as possible to enable decision-useful peer-to-peer and year-over year comparative measurements … and no simpler.

IV. Comparison to other carbon metrics

A. Purpose of carbon metrics

A good metric changes the way actors behave in a desired way**.** It is the most important criterion for a metric.[62] What will principals and agents do differently to improve performance against the metric? If balancing the intrinsic value and risk in the world's existing stock of long-lived tangible assets is the central management challenge of net zero, an effective carbon metric should inform that balance. This requires measurement of stocks rather than, or in addition to, flows.

1. Stocks and flows

Economics, business, accounting, and related fields often distinguish between stocks and flows. A stock is measured at one specific time, and represents a quantity existing at that point in time, which may have accumulated in the past. Flows increase or decrease the quantity of stocks and are measured over an interval of time.

Financial accounts for property, plant and equipment and accumulated depreciation are examples of stocks. Annual revenue or production quantities are examples of flows. All figures on a balance sheet are stocks. All figures on an income statement are flows. The amount of carbon dioxide in the atmosphere, the remaining 1.5° C carbon budget, and unrealized emissions from long-lived tangible assets are stocks. Annual GHG emissions are flows.

The most important stocks for transition risk are long-lived tangible assets and the unrealized emissions they will emit over their useful lives. Accountants define assets as "probable future economic benefits obtained or controlled by a particular entity as a result of past transactions or events."[63] Long-lived assets have value based on their probable future economic benefits. Long-lived assets bear transition risk because of their future capacity to harm the climate, measured as unrealized emissions.

Focus on current period flows such as revenues and production activity rather than stocks can distract attention from the underlying cause-and-effect relationships that must be understood and addressed to achieve net zero.

2. Cause and effect

Revenues do not produce carbon emissions. Production outputs do not produce carbon emissions. Real assets do.

Decarbonization does not depend on levels of revenue or production *per se* and focusing on these variables may divert attention from the fundamental financial and management challenge: How to replace the world's existing stock of emission-producing long-lived tangible

[62] See Lean Analytics: Use Data to Build a Better Startup Faster.

[63] Statement of Financial Accounting Concepts No. 6.

assets with low carbon alternatives on an accelerated schedule while maintaining an acceptable level of profitability?

Ratios that correlate emissions with revenues or production may drive undesirable changes in behavior that generate unsustainable or illusory reductions in climate impact. As a result, they may incentivize the wrong behavior or result in no change in behavior at all.

Intensity ratios benefit from lower emissions but can send confusing or misleading signals as to *how* emissions should be reduced. Should emissions be reduced in absolute levels or merely diluted relative to revenues, production or investment? Should managers focus on reducing emissions or increasing revenues, production or investment? What are the fundamental solutions? Is it feasible to achieve carbon neutrality by increasing revenues, production or investment without prematurely retiring and replacing emission-producing real assets?

3. Resistance to gaming and manipulation

By diverting attention from the core financial challenge of net zero, intensity metrics may lead firm managers and investors to pursue and be fooled by illusory gains. For example, measures of revenue intensity may inspire corporate managers to manipulate the timing of revenue recognition. Improper revenue recognition tops the list of accounting fraud cases prosecuted by the U.S. Securities & Exchange Commission.[64] Revenues are also sensitive to exchange rate and commodity price fluctuations, hedging activities, and consumer-based carbon taxes.

Production intensity ratios are less susceptible to manipulation and false signaling but suffer from another weakness that limits their behavioral impact. They lack a standardized unit of measurement, which prohibits their uniform application at the asset, company, and portfolio level.

B. Intensity ratios

Standardized units of measurement commonly used as indicators of transition risk today include the following ratios:

- Financial intensity ratios (i.e., carbon dioxide equivalents per million euro or dollar of sales: tCO_2e/\$M sales). When applied at the company level, this ratio is generally known as "carbon intensity".[65]
- Production intensity ratios (i.e., tCO_2e/m^2 for real estate, tCO_2e/MWh for power utilities, tCO_2e/ton of steel produced for steel companies).

[64] CFO Dive, Improper revenue recognition tops SEC fraud cases.

[65] Academic and commercial climate tools that use carbon intensity ratios as risk indicators, include 2 Degrees Investing Initiative (PACTA), MSCI (Climate VaR), Carbone4 (Carbon Impact Analytics), ISS (ESG), Cambridge Econometrics (E3ME-FTT-GENIE), Oliver Wyman (climate transition risk methodology), PwC/The CO-Firm (Climate Excellence), Right (X-Degree Compatibility Model), SBTI (Sectoral Decarbonization and SDA Transport Tool), S&P Global Market Intelligence (Climate Linked Credit Risk Tool), University of Augsburg (CARIMA), and Vivid Economics (Climate Risk Toolkit).

A significant shortcoming of these intensity ratios is that they employ the wrong numerator – current period emissions. By accounting solely for current period emissions they omit consideration of the unrealized emissions baked into long-lived tangible assets. Measuring transition risk with intensity ratios that consider only current period emissions is akin to assessing the lifetime maintenance costs of a new car based on the assumption that it will last only one year.

Revenue and production intensity ratios also employ the wrong denominator. They use flows when they should instead use stocks.

C. Comparison of CQ analytics to intensity ratios

CQ produces a wide range of risk-adjusted financial ratios that reflect internalized costs for past, current and future emissions. CQ ratios fall into two categories – (1) risk-adjusted versions of financial ratios; and (2) the Carbon Quotient ratio.

Risk-adjusted versions of traditional financial ratios are derived from pro forma risk-adjusted financial accounts. For example, earnings per share can be calculated based either on GAAP/IFRS net income or on net income adjusted for imputed carbon expense.

The Carbon Quotient ratio is an innovative financial metric that correlates the imputed cost of unrealized future emissions with the capitalized value of the assets that produce them. It is designed to drive the behavioral change specifically needed to reach net zero.

The Carbon Quotient ratio has several advantages over revenue and production intensity ratios. For example, the Carbon Quotient ratio:

- captures the impact of future emissions from existing assets
- tracks changes in the underlying source of emissions
- is less sensitive to exchange rate and revenue fluctuations
- can be used where there is no separately accountable business unit (i.e., financed assets)
- reflects asset efficiency (producing more revenues with fewer assets) in addition to revenue intensity
- is less susceptible to short-term manipulation

D. Portfolio emissions

When applied at the portfolio level, carbon intensity (tCO_2e/$M sales) is called weighted-average carbon intensity (WACI). A portfolio's WACI is the weighted average of the carbon intensity of each constituent of the portfolio. WACI indicates a portfolio's exposure to potential climate change-related risks relative to other portfolios or a reference standard. The formula for WACI is:

$$WACI = \sum_{i=0}^{n} \frac{Emissions_i}{\$M\ Revenues_i}\ X\ Weight_i$$

(with *i* = borrower or investee)

The TCFD's final report included a qualified endorsement of WACI:

> The Task Force believes the weighted average carbon intensity metric, which measures exposure to carbon-intensive companies, … can be applied across asset classes, is fairly simple to calculate, and does not use investors' proportional share of total equity and, therefore, is not sensitive to share price movements.
>
> The Task Force acknowledges the challenges and limitations of current carbon footprinting metrics, including that **such metrics should not necessarily be interpreted as risk metrics**. Nevertheless, the Task Force views the reporting of weighted average carbon intensity as a first step and expects disclosure of this information to prompt important advancements in the development of decision-useful, climate-related risk metrics.[66]

Whereas WACI is not a risk metric, the weighted-average Carbon Quotient (WACQ) ratio is a measure of an investment portfolio's transition risk. The formula for WACQ is:

$$WACQ = \sum_{i=0}^{n} \frac{Unrealized\ Carbon\ Expense_i}{Assets_i}\ X\ Weight_i$$

(with *i* = borrower or investee)

Because they are agnostic to ownership share (unlike financed emissions), WACI and WACQ both facilitate comparative measurement with non-equity asset classes.

At the portfolio level, WACQ has the same benefits compared to WACI that the Carbon Quotient ratio has to the carbon intensity ratio at the individual company level discussed above because with WACI: (1) the numerator (current period emissions) is not forward-looking; (2) the denominator is a flow (revenue) rather than a stock (assets); and (3) WACI reflects a portfolio's exposure to carbon-intensive companies instead of its exposure to investment risk based on impairment or stranding of the underlying assets.

E. Financed emissions

Financed emissions are absolute emissions that banks and investors finance through their loans and investments.[67] According to the GHG Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard, emissions from loans and investments should be allocated to the

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[66] TCFD Final Report, Section E.5 at p. 37 (emphasis added).

[67] PCAF Global GHG Accounting and Reporting Standard for the Financial Industry.

reporting financial institutions based on the proportional share of lending or investment in the borrower or investee.[68]

The methodologies for calculating financed emissions in the Partnership for Carbon Accounting Financials (PCAF) Global GHG Accounting and Reporting Standard for the Financial Industry apply the same general attribution principles across all asset classes:

1. Financed emissions are always calculated by multiplying an attribution factor (specific to that asset class) by the emissions of the borrower or investee.
2. The attribution factor is defined as the share of total annual emissions of the borrower or investee that is allocated to the loans or investments.
3. The attribution factor is calculated by determining the share of the outstanding amount of loans and investments of a financial institution over the total equity and debt of the company, project, etc. that the financial institution is invested in.

The following formula calculates the financed emissions of investments in listed equities and corporate bonds and business loans and unlisted equity:

$$Financed\ emissions = \sum_{c} Attribution\ factor\ X\ Company\ emissions_c$$

$$Attribution\ factor = \frac{Outstanding\ amount_i}{Total\ equity + debt_i}$$

(with *i* = borrower or investee company)

For investments in commercial real estate, mortgages, and motor vehicle loans, the denominator in the attribution factor is property value at origination. Otherwise, the formula is the same.

Like WACI, financed emissions should not necessarily be interpreted as a risk metric**.** PCAF says measurement of financed emissions provides the starting point to assess and disclose climate-related risks in line with TCFD recommendations; set science-based targets using emission-based methods developed by organizations like the Science Based Targets initiative (SBTi); and inform climate strategies and actions that direct capital to support the alignment of financial flows with the Paris Agreement's goals.[69]

WACQ and PCAF have different but complimentary objectives and benefits. Whereas PCAF's objective is to measure emissions financed through loans and investments, WACQ's objective is

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[68] GHG Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard.

[69] PCAF Global GHG Accounting and Reporting Standard for the Financial Industry.

to measure carbon risk in a portfolio of assets. Where PCAF reflects a financial institution's alignment with net zero, WACQ reflects the alignment of financed assets with net zero.

The PCAF financed emissions metric differs from WACQ in several important ways:

- It does not consider unrealized (future) emissions.
- It does not measure transition risk in the underlying assets.
- It does not inform pricing of transition risk and opportunity.
- It does not incentivize emission reductions in the real economy.

Loans and investments do not produce carbon emissions in the real economy. Because it focuses narrowly on absolute emissions, the financed emissions metric may divert attention from the more difficult task of differentially measuring and pricing transition risk and opportunity.

This may lead financial institutions to simplistically red-line investments in carbon-intensive sectors and green-light investments in low carbon sectors. At best, overreliance on negative and positive screening as a substitute for fundamental analysis may result in the financing of uncompetitive companies. At worst, it could lead to substantial mispricing and financial instability, which would undermine the long-run ability of the financial system to efficiently allocate capital.[70]

Within every sector, there will be climate leaders who should get more capital and climate laggards who should get less. It's the job of financial markets to differentiate between the two.

Table 2 compares the CQ ratio to other carbon metrics.

Ratio Feature	Financed Emissions	Carbon Intensity	Carbon Quotient
Numerator	Realized emissions	Realized emissions	Unrealized emissions
Denominator	Not applicable	Flow (revenue)	Stock (real assets)
Intended Behavior	Reduce financed emissions	Reduce (or dilute) real emissions	Decarbonize real assets

Table 2 Comparison of transition risk ratios

V. Relationship with climate finance initiatives

Figure 13 (reproduced from the PCAF Global GHG Accounting and Reporting Standard) lists voluntary initiatives aimed at the financial sector for measuring, managing and reporting emissions and related risks and opportunities. Focus areas include high level commitments,

[70] Climate Finance Markets and the Real Economy: Sizing the Global Need and Defining the Market Structure to Mobilize Capital.

scenario analysis, target setting, mitigation, and reporting. The unifying objective of these initiatives is to harness the power of financial institutions to accelerate decarbonization of the real economy.

Measuring and reporting financed emissions is a central focus or supporting element of many of these initiatives.

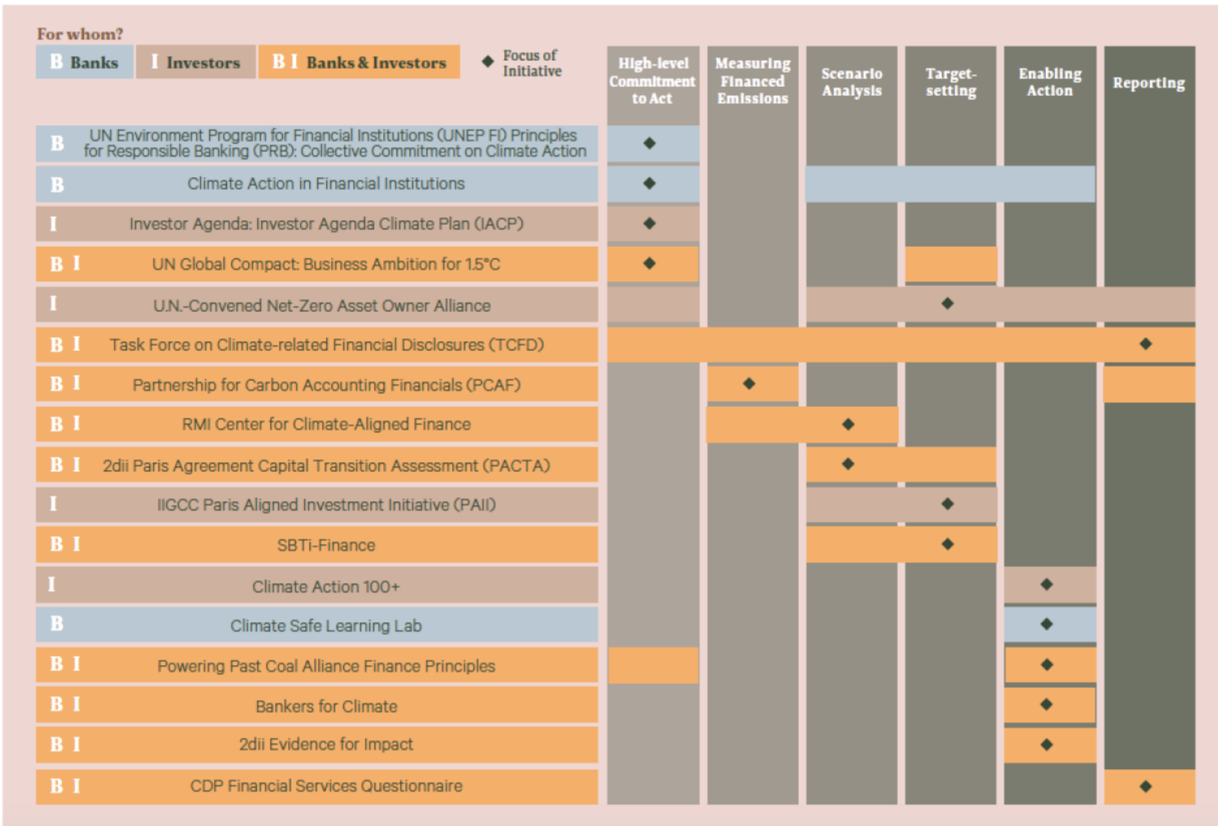

Figure 13 Climate initiatives

Table 3 describes how CQ analytics support the various focus areas of these climate finance initiatives.

Focus area	How CQ analytics support activity
High-level commitment to act	CQ analytics highlight the imperative to immediately shift investments toward new low carbon assets and away from fossil fuel infrastructure.

Measuring financed emissions	CQ analytics supplement financed emissions with a forward-looking measure of a portfolio's exposure to transition risk.
Scenario analysis	CQ analytics use a uniform standardized scenario (100% offset pricing of emissions) to support comparative measurement of assets, companies, and portfolios.
Target setting	The net zero GPS facilitates target setting and increases accountability for results.
Enabling action	By accounting for unrealized emissions and correlating them with the real assets that produce them, CQ analytics focus action on fundamental solutions.
Reporting	CQ analytics improve the decision-utility of TCFD disclosures on governance, strategy, risk management, and metrics and targets.

Table 3 CQ and climate finance initiatives

Figure 14 illustrates how CQ analytics contribute to decarbonization of the real economy by supporting each of these focus areas.

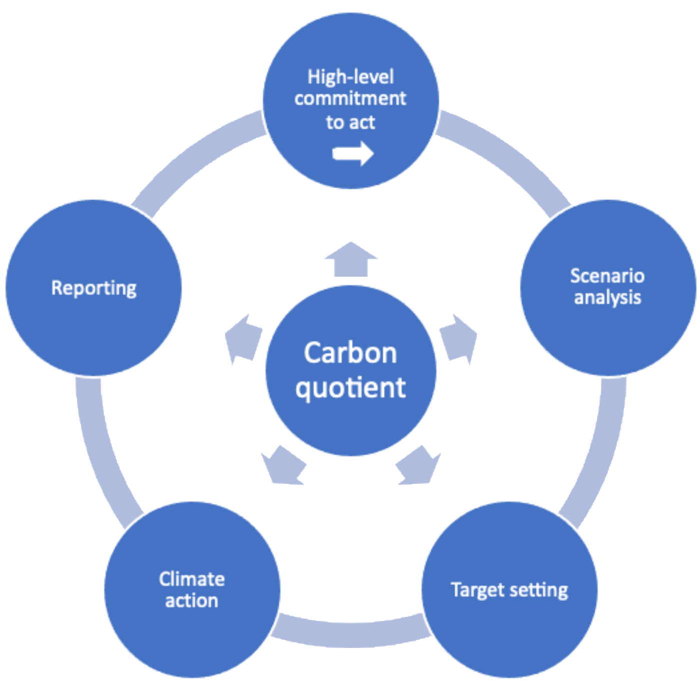

Figure 14 Measuring unrealized emissions as a foundation for other initiatives

VI. Use cases

A. Macro prudential policy and regulation

Central banks can use CQ analytics to guide and operationalize climate-related risk policies. There is a broad consensus among members of the Network for Greening the Financial System (NGFS) that, at the very least, central banks should carefully assess, and where appropriate adopt, additional risk management measures to protect their balance sheets against the financial risks brought about by climate change. However, there is yet no consensus among central banks as to the relevant measures for quantifying climate-related financial risk. The NGFS recognizes that carbon intensity and 2°C alignment metrics provide only a rough indicator of climate-related risks, without delivering a financial quantification of the risks incurred.[71]

B. Asset allocation

Asset owners, active asset managers and corporate managers can use CQ analytics to align their financial investments and capital expenditures with net zero commitments while honoring their fiduciary duty to generate long term risk-adjusted returns. CQ analytics can also assist passive investors in benchmarking transition risk among competing passive investment options.

C. Benchmarking

CQ analytics provide a standardized unit of measurement that organizations can use to evaluate transition risk on an absolute or comparative basis. Firm managers can use CQ analytics to identify strengths and weaknesses relative to competitors. Asset owners and managers can use CQ analytics to differentiate leaders from laggards in the global race to net zero.

D. Disclosure

Self-reporting organizations can incorporate CQ analytics into their TCFD climate-related financial disclosures relating to metrics and targets to demonstrate how they are progressing toward net zero. Disclosure will be especially beneficial where the data inputs are non-public (e.g., unlisted companies and portfolios). Financial institutions can supplement financed emissions disclosures with CQ analytics to give a forward-looking measure of portfolio transition risk.

E. Due diligence

Financial and non-financial organizations can use CQ analytics to identify and assess potential impacts of climate-related risks and opportunities on prospective mergers, acquisitions, and financings.

[71] Network for Greening the Financial System Technical Document: Adapting central bank operations to a hotter world (March 2021) (see Section 6.2 Metrics).

F. Engagement and voting

Asset owners and managers can use CQ analytics to strengthen their engagement with companies in carbon-intensive sectors and to inform proxy voting.[72]

G. Index construction

Asset managers can use CQ analytics to modify existing indices, make their own new indices, or request new indices from index providers.

H. Governance

Boards and senior management can use CQ analytics to inform its processes for strategic direction, risk oversight, financial reporting, stakeholder relations, and corporate citizenship. CQ analytics can also help self-reporting organizations prepare climate-related financial disclosures on governance, as recommended by the TCFD, including the board's oversight of climate-related risks and opportunities and management's role in assessing and managing climate-related risks and opportunities.

I. Risk management

Organizations can use CQ analytics to identify, assess and manage the potential financial impacts of the transition to net zero, as illustrated in Figure 8. In particular, CQ analytics helps organizations assess and respond to the risk that long-lived tangible assets will become impaired or stranded. CQ analytics can also help self-reporting organizations prepare climate-related financial disclosures on risk management, as recommended by the TCFD, including how the organization identifies, assesses, and manages climate-related risks, and how processes for identifying, assessing, and managing climate-related risks are integrated into the organization's overall risk management.

J. Strategy

Organizations can incorporate CQ analytics into their strategic analysis to develop a roadmap of where and how it will compete in a low carbon economy. CQ analytics can also help self-reporting organizations prepare climate-related financial disclosures on strategy, as recommended by the TCFD, including the climate-related risks and opportunities the organization has identified over the short, medium, and long term, the impact of climate-related risks and opportunities on the organization's businesses, strategy, and financial planning, and the resilience of the organization's strategy, taking into consideration different climate-related scenarios, including net zero by 2050.

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[72] See e.g., BlackRock: Our 2021 Stewardship Expectations Global Principles and Market-level Voting Guidelines.

VII. Conclusion – the CQ accountability report card

The world is rapidly committing to net zero by mid-century. To reach this goal, there must be an effective accountability framework that spans the entire investment value chain. An effective net zero accountability framework requires measurements that are relevant and actionable, forward-looking, comparable, integrated with GAAP/IFRS, trustworthy, and simple. Table 4 grades Carbon Quotient analytics against these criteria.

Criteria	Carbon Quotient Analytics
Relevant & actionable	CQ analytics provide a single measure of climate-related asset impairment risk that is relevant and actionable for all actors across the investment value chain.
Forward-looking	CQ analytics accounts for unrealized emissions and provides a GPS for getting to net zero.
Comparable	CQ analytics avoids subjective and entity-specific assumptions that impede comparative measurement.
Integrated	CQ analytics integrate easily into GAAP/IFRS financial accounting.
Trustworthy	CQ outputs can be independently reproduced.
Simple	The CQ methodology eliminates unnecessary complexity.

Table 4 CQ accountability report card

We believe financial institutions and corporate managers can and will act on measurements with these qualities. And because the CQ ratio and WACQ provide a single measure of transition risk that is relevant and actionable for all actors across the investment value chain, we believe it can make an invaluable contribution to net zero accountability.

Follow us on LinkedIn, Twitter, and at carbonquotient.com.

Appendix

I. Definitions and formulas

A. Terms

Asset turnover is a widely used measure of financial efficiency, calculated as revenues divided by *assets*. Alternatively, when applied to physical assets, asset turnover can be measured as British Thermal Units (BTUs) produced or consumed divided by *assets*.

Assets are tangible long-lived assets capitalized on the balance sheet as property, plant and equipment, at cost, less accumulated *DD&A expense*.

Asset life is a measure of the estimated remaining depreciable life of assets, calculated as property, plant and equipment, at cost, less accumulated *DD&A expense* divided by current period *DD&A expense*. See example for Exxon. When applied to unlisted assets, asset life may be estimated using relevant benchmarks, such as IRS Class Lives and Recovery Periods.

Carbon contra asset is a risk-adjusted asset account with a credit balance (e.g., accumulated *DD&A expense*). It is described as "contra" because having a credit balance in an asset account is contrary to the normal or expected debit balance. The carbon contra asset is equal to *unrealized carbon expense*.

Carbon expense is an imputed expense for the unpaid cost to offset a firm's current period carbon emissions with negative emissions – *i.e.,* the incremental cost to achieve carbon neutrality in the current period, calculated as *realized emissions* times *carbon price* less separately reported expenses for carbon taxes and cap-and-trade emissions credits. Carbon expense reduces pro forma net income and EBITDA.

Carbon expense ratio is a ratio calculated as *carbon expense* divided by revenue. Alternatively, when applied to physical assets, the carbon expense ratio can be measured as *carbon expense* divided by BTUs produced or consumed.

Carbon price is a constant value ($/tCO2e) reflecting the cost to remove carbon from the atmosphere at scale. Our analysis uses $100/tCO2e, which is a cost the U.S. National Academy of Scientists says is economically affordable (albeit not yet technically achievable).

Carbon Quotient ratio is a normalized measure of *carbon risk* that represents the imputed cost of future carbon emissions associated with emission-producing assets relative to the capitalized value of those assets. CQ can be calculated as: (a) *unrealized carbon expense* divided by *assets*, or (b) *carbon expense ratio* times *asset turnover* times *asset life.*

Carbon risk, also called transition risk, is a function of the imputed cost of carbon for *realized emissions* and *unrealized emissions*. Carbon risk is positively correlated with *asset life* and *unrealized emissions*.

Contingent carbon liability is a risk-adjusted liability account for unpaid costs to offset a firm's past carbon emissions with negative emissions, calculated as the sum of accumulated *carbon expense* for prior periods.

DD&A expense arises from the gradual expensing of capitalized *assets* over time through depreciation, depletion and amortization in order to match costs to revenues.

Realized emissions are a firm's greenhouse gas emissions (tCO2e) for the current period, including direct and indirect emissions, as appropriate, net of actual emissions offsets.

Unrealized carbon expense is a risk-adjusted contra asset account representing the imputed cost of future emissions, calculated as *carbon expense* times *asset life*.

Unrealized emissions are future greenhouse gas emissions (tCO2e) that will result from the continued use of a firm's assets over their remaining life, calculated as *realized emissions* times *asset life*.

Weighted-average Carbon Quotient (WACQ) ratio is an asset weighted average Carbon Quotient ratio for an investment portfolio. It is a measure of *carbon risk* in a portfolio of loans and investments.

B. Formulas

1. Base formulas

$$Carbon\ quotient = \frac{Unrealized\ carbon\ expense}{Assets}$$

$$Unrealized\ carbon\ expense = \ Realized\ emissions\ X\ Carbon\ price\ X\ Asset\ life$$

$$Asset\ life = \frac{Assets}{DD\&A\ expense}$$

$$Unrealized\ emissions = \ Realized\ emissions\ X\ Asset\ life$$

2. Advanced formulas

$$Carbon\ quotient = \ Carbon\ expense\ ratio\ X\ Asset\ turnover\ X\ Asset\ life$$

$$Carbon\ expense\ ratio = \frac{Carbon\ expense}{Revenues}$$

$$Asset\ turnover = \frac{Revenues}{Assets}$$

3. Pro forma formulas

$$Carbon\ expense = Realized\ emissions\ X\ Carbon\ price$$

$$Carbon\ contra\ asset = Carbon\ expense\ X\ Asset\ life$$

$$Contingent\ carbon\ liability = \sum_{i=1}^{n} Carbon\ expense_n$$

$$Pro\ forma\ net\ income = Net\ income - Carbon\ expense$$

4. Portfolio formula

The weighted-average Carbon Quotient (WACQ) ratio for a portfolio of financial assets is calculated as the sum of the Carbon Quotient ratios of each asset multiplied by the weight of the asset in the portfolio.

$$WACQ = \sum_{i=0}^{n} \frac{Unrealized\ Carbon\ Expense_i}{Assets_i}\ X\ Weight_i$$

(with *i* = borrower or investee)

Unlisted portfolios may include investments in different asset classes – listed equity and corporate bonds, business loans and unlisted equity, project finance, commercial real estate, mortgages and motor vehicle loans. The Carbon Quotient ratio for an unlisted portfolio of assets is calculated as the sum of the Carbon Quotient ratios of each asset multiplied by the weight of the investment in each asset as a percentage of total assets under management (AUM). Measured in this way, the transition risk of an unlisted portfolio can be compared to the transition risk of a listed portfolio.

II. Methodology

Figure 15 shows CQ's inputs and outputs. The process starts with collection of climate data inputs, including information on net zero targets and negative emissions technology, feasibility and costs. We use this information to set a carbon proxy price and to calibrate the net zero GPS (i.e., destination and deadline). Next, we collect financial account and emissions data. We then apply various formulas to this financial and emissions data to produce risk-adjusted financial accounts, the Carbon Quotient ratio, other risk-adjusted financial ratios, and a net zero GPS map tailored to specific assets, companies, and sectors.

For portfolios, we collect constituent and weighting data. With this data, we can produce a weighted-average Carbon Quotient (WACQ) ratio and net zero GPS map tailored to specific portfolios.

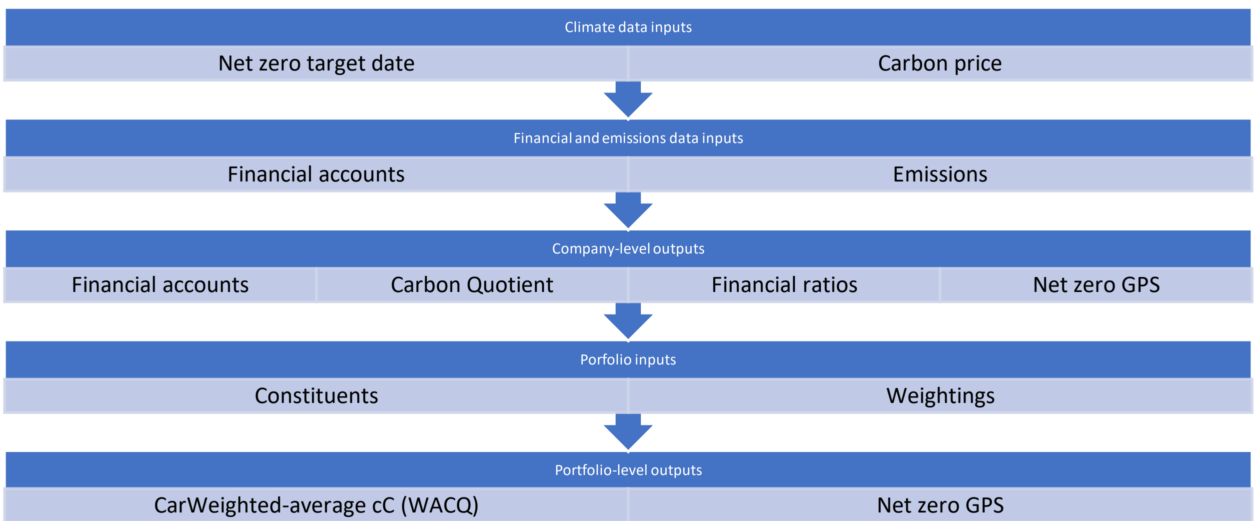

Figure 15 Inputs and outputs to CQ analytics

Figure 16 illustrates the process for converting financial and emissions data inputs into asset and company-level outputs.

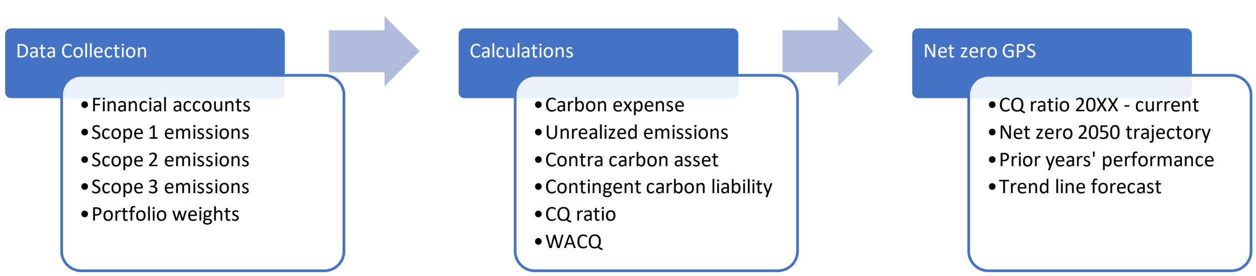

Figure 16 The CQ process

A. Data collection

CQ analytics use three types of data inputs: (1) current and prior period financial accounts data; (2) current and prior period emissions data; and (3) portfolio data. The reliability of CQ outputs depends on the quality of these inputs.

1. Financial accounts data

Current and prior period verified financial accounts data is widely available from a variety of financial data providers, such as Bloomberg.

2. Emissions data

Where available, CQ includes:

- All Scope 1 and 2 emissions.
- Scope 3 emissions for certain sectors where these emissions are highly material and available.
- Verified emissions offsets (if reported separately from gross emissions).

Scope 1 emissions are direct emissions occurring from sources (real assets) that are owned or controlled by the company. These include, for example, emissions from combustion in owned or controlled boilers, furnaces, and vehicles, and from chemical production in owned or controlled process equipment.

Scope 2 accounts for indirect emissions from the generation of purchased electricity consumed by the company. Scope 2 emissions are a proxy for electric energy usage. Pass-through of carbon costs from electric utilities will result in higher electricity prices, which in turn will result in higher operating costs, lower margins, and lower return on assets for electricity users. Inefficient electricity-powered assets have higher scope 2 emissions and are at greater risk of becoming impaired or stranded relative to more energy efficient alternatives.

Scope 3 covers all other indirect emissions. They are a consequence of the activities of the company but occur from sources not owned or controlled by the company. Some examples of scope 3 activities are extraction and production of purchased materials, transportation of purchased fuels, and use of sold products and services. CQ accounts for Scope 3 emissions when they result from the transportation or use of sold products – e.g., fossil fuels and vehicles.[73]

Table 5 lists the implementation schedule for inclusion of Scope 3 emissions under the PCAF Global GHG Accounting and Reporting Standard for the Financial Industry.[74]

[73] See Race is on as carmakers shut, switch or sell combustion engine factories.

[74] PCAF Global GHG Accounting and Reporting Standard for the Financial Industry.

Phase-in Period	Sector
From 2021	At least energy (oil & gas) and mining
From 2024	At least transportation, construction, buildings, materials, and industrial activities
From 2026	Every sector

Table 5 PCAF phase-in by sector for required scope 3 emissions

a) Data sources

Emissions data sources include official company filings and third-party environment, social, and governance (ESG) data providers, such as CDP, Bloomberg, MSCI, Sustainalytics, S&P/Trucost, and ISS ESG.

Data providers, which typically offer scope 1 and 2 emissions data, collect self-reported emissions data, reported either through a standardized framework such as CDP or in official financial filings and environmental reports. They often have their own methodologies to estimate emissions when data are not self-reported.

b) Third-party verification

Self-reported emissions data for public equities and bonds are less widely available than financial data. When emissions data is available, it may lack reasonable assurance of accuracy and comparability.

Accounting standards for carbon emissions exist but they are not as generally accepted and broadly applied as financial accounting standards. Reported emissions are generally unaudited and not subject to legal penalties for fraud or error.

c) Missing data strategy

This topic will be addressed in a separate policy document.

3. Portfolio data

Portfolio data – constituents and weightings – is collected from public sources for listed MFs and ETFs.

B. Calculations

Once the required data inputs are available, the next step in the process is to apply the formulas described above to produce company and portfolio risk-adjusted financial accounts and ratios.

The only subjective variable in these calculations is the assumed carbon price. We propose to use a carbon price of \$100/tCO_2e (undiscounted and uninflated). Users may wish to perform sensitivity analysis with different carbon prices for internal purposes.

C. Net zero GPS

Once the Carbon Quotient calculations are complete, the results are plotted on a timeline starting at a selected point in the past (e.g., 2010) and extending through a target date for reaching net zero. See discussion in III.B.3.