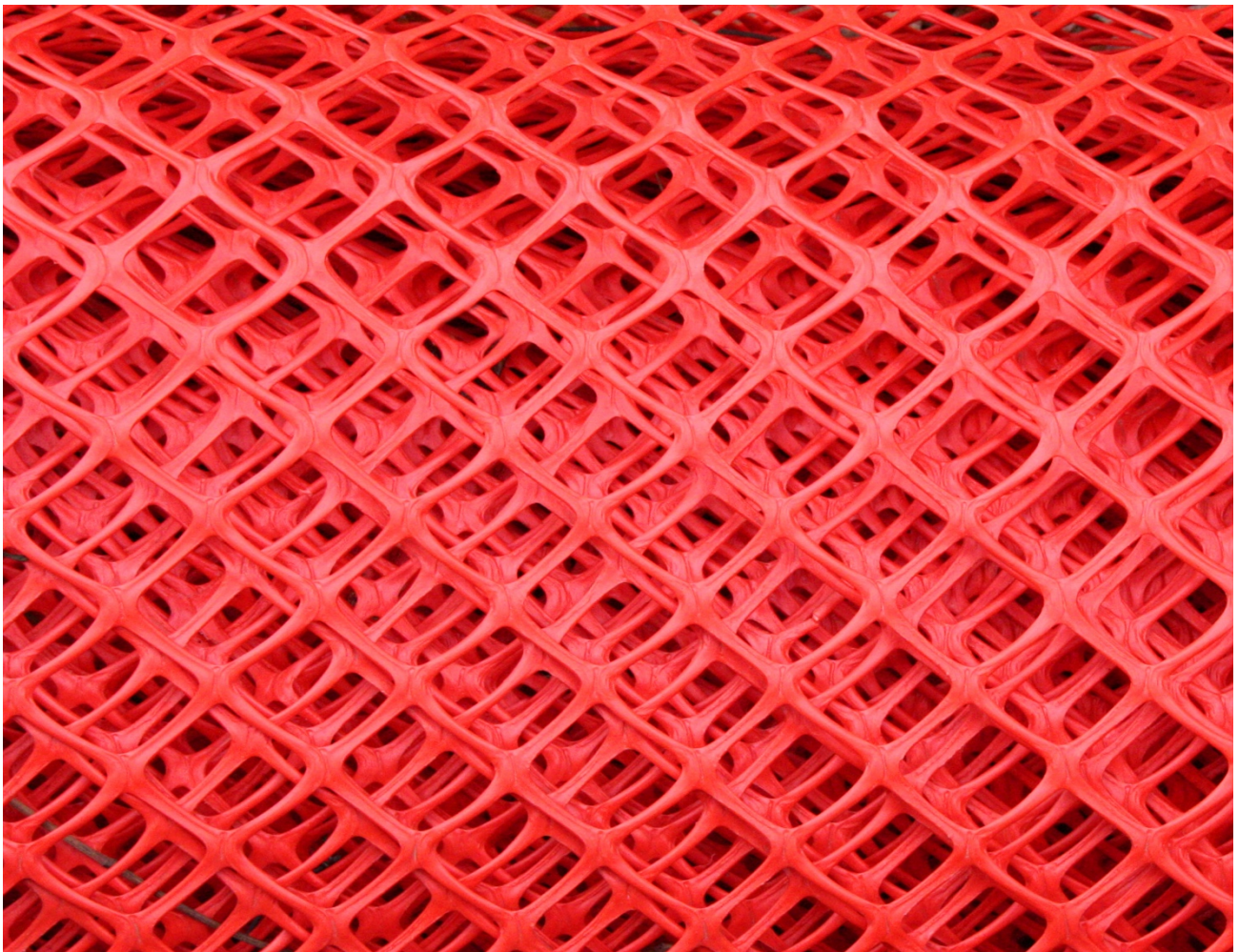


Connecting the dots:

Energy transition scenarios and credit quality



Funded by the
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THE ENERGY TRANSITION RISK PROJECT

The ET Risk consortium, which is funded by the European Commission, aims to develop key analytical building blocks for energy transition risk assessment and bring these capabilities to the market.

1. Transition scenarios:

The consortium will develop and publicly release two transition risk scenarios. The first represents a limited transition that extends current and planned policies and technological trends (e.g. The International Energy Agency's (IEA) Energy Technology Perspectives (ETP) Reference Technology Scenario (RTS) trajectory). The second represents an ambitious scenario that expands on the data from the IEA's ETP 2°C scenario (IEA ETP 2DS).

2. Company and asset data:

Oxford Smith School and the 2° Investing Initiative will jointly consolidate and analyse asset-level information across six energy-relevant sectors (power, automotive, steel, cement, aircraft, and shipping), including an assessment of committed emissions and the ability to potentially unlock such emissions (e.g. reducing load factors).

3. Valuation and risk models:

- a. **The climateXcellence model** – The CO-Firm's¹ scenario risk model covers physical assets and products and determines asset-, company-, country-, and sector-level climate transition risks and opportunities under a variety of climate scenarios. Effects on margins, EBITDA, and capital expenditure are illustrated under different adaptive capacity assumptions.
- b. **Valuation models** – Kepler Cheuvreux (KECH): The above impact on climate- and energy-related changes to company margins, cash flows, and capex can be used to feed financial analysts' discounted cash flow and other valuation models. KECHE will pilot this application as part of its equity research.
- c. **Credit risk scoring models** – Trucost, part of S&P Global: The results of the project will be used by Trucost to explore how the scenarios could be integrated into credit quality models, and determine whether there could be a material impact on a company's credit quality. Trucost is applying S&P Global Market Intelligence's credit analytics tools to assess changes in credit quality, focusing on key risk factors.
- d. **Assumptions on required sector** – Level technology portfolio changes are aligned with the Sustainable Energy Investment (SEI) Metrics, which developed a technology exposure-based climate performance framework, and associated investment products that measure the financial portfolio alignment.



¹ A boutique consultancy and modelling expert specializing in climate- and energy-related risk and opportunity analyses for industry, utilities, buildings, and the financial sector.

Executive Summary

This paper presents findings regarding the implications of climate transition scenarios for credit quality for a sample of nine companies in three high-emitting sectors (power utilities, cement, and steel) that are subject to considerable transition risks and opportunities. The analytical approach uses detailed bottom-up company asset-level data and proprietary financial modelling developed by The CO-Firm for its climateXcellence model. This derives forward-looking climate transition scenarios represented in financial terms, which are applied to quantitative credit quality modelling using tools developed by S&P Global Market Intelligence based on key historical drivers.

Based on this exploratory scenario analysis, consistently worse credit implications were identified for companies if they failed to mitigate potential risks and grasp potential opportunities associated with the low-carbon transition. In most cases, credit consequences were worse for companies under the 'Frozen' adaptive capacity pathway, where the companies fail to mitigate assumed risks so their asset portfolios are not adapted in response to the climate scenarios.² In many cases, credit quality deteriorated by 2025 and continued to worsen in later years, in a number of cases by levels consistent with one- to two-notch reductions in credit scores. The potential credit consequences of inaction supports the financial case for proactive management of energy transition risks.

For more likely adaptive pathways, where companies do alter their strategies to address transition risks and opportunities, there are generally only small changes in credit quality for most companies. For six of the nine high-emitting companies evaluated, this was equivalent to less than one scoring notch change in implied credit quality across all scenarios, plausible adaptive capacity pathways³ and years 2020-2050.

A minority of companies do exhibit credit quality changes consistent with potential shifts in their credit score under some scenarios. Across the two climate scenarios and two plausible adaptive capacity pathways, the results indicated one significant potential move in credit quality for a utility company (equivalent to a near two-notch score improvement). They also indicated two significant potential moves in credit quality for cement companies (with one company's implied score improving by one notch, and the other worsening by up to two notches).

Given that the results of the different scenarios indicated that credit quality shifts could be positive or negative, a key implication is that transition scenarios do not create uniformly negative implications for companies in high-emitting industries. This also suggests that the credit implications of opportunities and a strategic alignment with energy transition drivers can outweigh the effects of risks if the scenarios happen.

² Depending on the specific sector, 2020 or 2022 is the year assets are frozen and no longer change under the 'Frozen' adaptive capacity pathway.

³ This statement refers to the 'Market' and 'Market EBIT' adaptive capacity pathways, but excludes the 'Frozen' adaptive capacity. This latter scenario does not represent a plausible future pathway for all companies, but provides illustrative results of a lack of action to mitigate transition risks and grasp related opportunities by assuming assets are unchanged.

Looking at credit quality implications under a limited climate transition (LCT) scenario versus an ambitious one (ACT), representing a 2.7°C or 2°C temperature rise, respectively, credit quality is estimated to be consistently better under 2°C for all six companies assessed in the utilities and steel sectors. The opposite pattern is evident for the three companies assessed in the cement sector.

There are a number of key takeaways for investors from this analysis. Firstly, the diversity of credit implications, even between companies operating in the same sector, is indicative of the value of granular and company-specific scenario analysis that differentiates at the issuer level between potential forward-looking credit outcomes from climate change. Today, such granular scenario analysis is rarely undertaken by investors, or is sometimes done from a top-down perspective, showing only undifferentiated results by asset class or sector.

Secondly, given the better credit outcomes of most assessed companies under a more ambitious 2°C climate scenario, and with active management of transition risks, the results suggest that there is potential value to investors in actions that seek to achieve lower climate impacts. This could include engagement with regulators on climate policy, as well as engagement with issuers that seek more proactive management of transition risks. As scenario analysis becomes more widespread and institutionalized, there may also be increasing opportunities for investors to identify and select securities from issuers that are deemed to have better prospects under likely transition scenarios.

There are limitations to these exploratory findings, and more research is required to validate and extend them to more generalized results. In particular, this should involve a wider range of companies and industries, using multiple sources of scenarios, methods of modelling forward-looking company results, and approaches for assessing credit quality. Significant value could also be gained by overlaying forward-looking results from scenario analysis with the consideration of fundamental factors related to climate governance, strategy, and management, as well as multiple dimensions of climate risk and opportunity, including physical risks.

Introduction

Investors are facing significant and growing pressure to consider the implications of climate scenarios on the potential risk and return profile of their portfolios. Momentum has grown considerably since the Paris Agreement, which was signed by almost 200 countries globally in 2015. The Agreement commits signatories to maintaining warming well below 2°C and pursuing efforts to keep warming to 1.5°C above pre-industrial levels.

This led to regulatory change and industry-led initiatives that have heightened investor understanding of the financial implications of climate change, and driven a greater awareness of those areas where more work is needed. As a direct result of the Agreement, France enacted a new law (Article 173) that, for the first time, required investors to disclose climate-related risks within their funds and their alignment with international energy transition commitments. Another highly ambitious and transformative initiative is the G7 Financial Stability Board's (FSB) Task Force on Climate-related Financial Disclosures (TCFD), with recommendations relevant to both corporations and investors. For investors, the TCFD recommends disclosure and analysis of transition risks, opportunities, and the physical effects of climate change that may affect portfolio risks and returns. It highlights the need for forward-looking indicators, including scenario analysis, to be at the forefront of this reporting and analysis. Importantly, both TCFD and Article 173 emphasize that such analysis should be across all asset classes, not just limited to listed equities, where much environmental, social, and governance (ESG) analysis and reporting has been focused to date.

These market developments have highlighted several key needs to enable investors to better navigate the increasing complexity of analysis. Firstly, much of the ESG data and analysis in widespread use by investors is not explicitly forward-looking and does not incorporate specific climate-related scenario analysis recommended by the TCFD and others. In addition, ESG analysis is sometimes criticized for failing to address financially material factors, and for being presented in a way that is difficult to integrate into financial modelling. In order to perform scenario analysis and financial stress testing, it is necessary to have more in-depth data on climate-related factors at the company and asset level, forward-looking data, and, where possible, to translate this into financial metrics. Furthermore, most research on the integration of ESG factors – and within that, climate factors – has been limited to listed equities, yet the size and significance of debt markets makes additional research on the potential climate risks and scenario analysis in this field paramount.

This paper has been framed to address these issues. It aims to provide exploratory insights into how energy transition risks could impact levels of credit quality faced by investors in corporate fixed income securities. The analysis road tests a company-level scenario dataset produced by The CO-Firm. As mentioned, it covers a sample of three companies in each of three high-emitting industries (power utilities, cement, and steel) and calculates estimates of changes in credit quality and the likelihood of default for each company. This is done using CreditModel™ developed by S&P Global Market Intelligence, which is a statistical model trained on historical credit ratings from S&P Global Ratings,⁴ a separately managed division of S&P Global.

⁴ S&P Global Ratings does not contribute to or participate in the creation of credit scores generated by S&P Global Market Intelligence. S&P Global Ratings also did not contribute to the analysis of credit quality by Trucost discussed in this paper. Neither Trucost nor S&P Global Market Intelligence is a registered Credit Rating Agency (CRA). Only an authorised CRA can issue credit ratings.

This paper's place within the ET Risk series

This paper has been designed to complement other pieces of research being produced within the ET Risk project. The CO-Firm has undertaken a key innovation within the project by assessing what different energy transition scenarios could mean for company financials going forward. This has made use of asset-level databases, including S&P Global Market Intelligence's World Electric Power Plant database, to develop forward-looking financial results based on plausible future pathways for climate policy and the evolution of each company's individual strategy and portfolio of assets. The ultimate output is the creation of forward-looking assessments of the potential changes, under different scenarios, of financial indicators that are widely tracked by investors and financial institutions, such as revenue, operating profit, and capital expenditure. This bridges the gap between the information that investors need to inform financial modelling and the macro-level climate scenarios that are more widely available and generally produced for scientific research and policy development and evaluation purposes.

Trucost's role in the ET Risk project was to assess the potential implications of The CO-Firm's financially-focused scenario results on credit quality for corporate bond issuers with business activities in high-emitting industries. It most closely complements work that has been undertaken by KECH in assessing the impacts that The CO-Firm's generated climate scenarios could have on equity valuations through the integration of adjusted financial metrics with a discounted cash flow (DCF) model.

Trucost's paper explains equivalent work undertaken to assess the credit quality implications of the scenarios, and makes use of tools available to investors for credit quality modelling from S&P Global Market Intelligence. The objective is to understand the magnitude of any potential impact on credit quality in the different scenarios through quantifying an adjusted credit score and likelihood of default. Collectively, the results from Trucost and KECH provide a framework for integration and a set of results relevant across the two asset classes that typically dominate the asset allocations of many long-term institutional investors, such as pension funds and insurers.

ENERGY TRANSITION RISKS AND MATERIALITY FOR A FIXED INCOME INVESTOR

The impact of climate change and energy transition on debt markets and credit instruments is a relatively new area of research. The aggressive country-level commitments to reduce global warming under the Paris Agreement, and recent warnings from central banks of the potentially catastrophic impacts of climate change on the stability of the entire financial system, have underscored the need for more investor action in this, the largest of asset classes.⁵ As Mark Carney, Governor of the Bank of England says in his seminal *Breaking the Tragedy of the Horizon* speech, made to Lloyds of London in September 2015, “The past is not prologue and the catastrophic norms of tomorrow can be seen in the tail risks of today.”⁶ However, much of the work on climate risks to investors has fallen under the broader umbrella of ESG analysis, and has been criticized for not being explicitly concerned with energy transition and for being backward-looking. This has led to demand for more forward-looking and systematic integration of climate-specific factors and transition scenarios in investment analysis. Furthermore, most work to date has focused on listed equity analysis, possibly because ESG analysis originated in this space and that is where there is the greatest wealth of research. However, fixed income assets form a larger part of global financial markets and often represent the largest part of the portfolio for many long-term investors. This has led to demand for more research and tools on climate risk integration in credit analysis.

In this section, we will provide an overview of the policy landscape, draw links with how this might impact investors and, more specifically, discuss current evidence that energy transition and climate factors may be financially material for fixed income investors. This will provide context for the different energy transition scenarios developed by the consortium partners, and potential implications for changes in company financial metrics. In turn, this will help set the stage for Trucost’s approach to integrating energy transition scenarios in credit analysis.

Climate policy in a post-Paris Agreement era

The Paris Agreement was a landmark event for the global economy, confirming the commitment of 174 countries⁷ to significantly cut carbon emissions to limit global temperature increase to below 2°C.⁸ In order to achieve this transition, the regulatory landscape must tighten considerably for high-emitting industries, which has implications for their cost-benefit dynamics and can lead to changes in consumer demand. In addition, the physical effects of climate change can also impact businesses and, in conjunction with policy and market shifts, have implications for credit quality and asset valuations.

⁵ <https://www.ft.com/content/888616d6-3b07-11e8-b7e0-52972418fec4>.

⁶ Bank of England (2015), *Breaking the Tragedy of the Horizon – climate change and financial stability*, <http://www.fsb.org/wp-content/uploads/Breaking-the-Tragedy-of-the-Horizon-%E2%80%93-climate-change-and-financial-stability.pdf>.

⁷ http://unfccc.int/paris_agreement/items/9485.php.

⁸ United Nations (2015), *Paris Agreement*, https://unfccc.int/sites/default/files/english_paris_agreement.pdf.

Key policy instruments with a direct impact on company costs are carbon pricing mechanisms, such as emission trading schemes and carbon taxation. As part of the Paris Agreement, countries provided Nationally Determined Contributions (NDCs) outlining how they plan to achieve their reduction commitments. Of the 90 NDCs mentioning the use of carbon markets as a policy mechanism to achieve this goal, 42 national jurisdictions have already implemented carbon price regulation.⁹ Such policies can affect the future value of carbon-intensive assets across sectors, and could impair today's asset valuations.

Other policies aim to encourage polluters' willingness to invest in abatement options and stimulate private sector innovation by ensuring cost effectiveness for businesses.¹⁰ This can be directly through subsidization of solution technologies, such as carbon capture and storage (CCS), or indirectly, such as the landmark pledge by the G7 countries to phase out subsidies for coal, oil, and gas by 2025,¹¹ which should lead to an increase in renewable investment. Some jurisdictions have produced explicit targets for the share of energy consumption from renewable energies to support demand and encourage long-term capital expenditure in this area. The EU, for example, has set a target of 27% by 2030 for the minimum share of energy consumption for renewable energy.¹²

Decarbonisation, therefore, also presents investment opportunities in greenhouse gas (GHG) reduction solutions. The IEA has estimated that there will need to be a 60% reduction in fossil fuel power generation to achieve below 2°C of warming, with that capital being redirected to renewable energy in order to maintain required energy supplies.¹³ The growing deployment, scale, and investment into research and development should further improve the competitiveness of renewable energy compared to fossil fuels.¹⁴ Renewable and low-carbon energy supply is also critical for the decarbonization of other high-emitting sectors, such as transport and construction that, in themselves, present many investment opportunities as businesses adapt to a lower-carbon economy.

Transition risks and opportunities

While the precise energy transition pathway we will take is not yet known, it is clear that we need to break the longstanding link between economic growth and rising GHG emissions in order to achieve the aggressive global carbon reduction commitments. This means most sectors will need to substantially reduce their emissions, adapt, and transition. For investors, it will be critical to understand the business risks and opportunities embedded in the potential climate scenarios, and who the winners and the losers will be at a company level.

⁹ Carbon Pricing Leadership Coalition, *Carbon Pricing In Action*, <https://www.carbonpricingleadership.org/who/>.

¹⁰ Laing, T. et al (2013), *Assessing the effectiveness of the EU Emissions Trading System*, Centre for Climate Change Economics and Policy Working Paper No. 126, Grantham Research Institute on Climate Change and the Environment Working Paper No. 106, <http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/2014/02/WP106-effectiveness-eu-emissions-trading-system.pdf>.

¹¹ United Nations Climate Change (2016), *G7 Leaders' Declaration Addresses Paris Agreement*, <https://unfccc.int/news/g7-leaders-declaration-addresses-paris-agreement>.

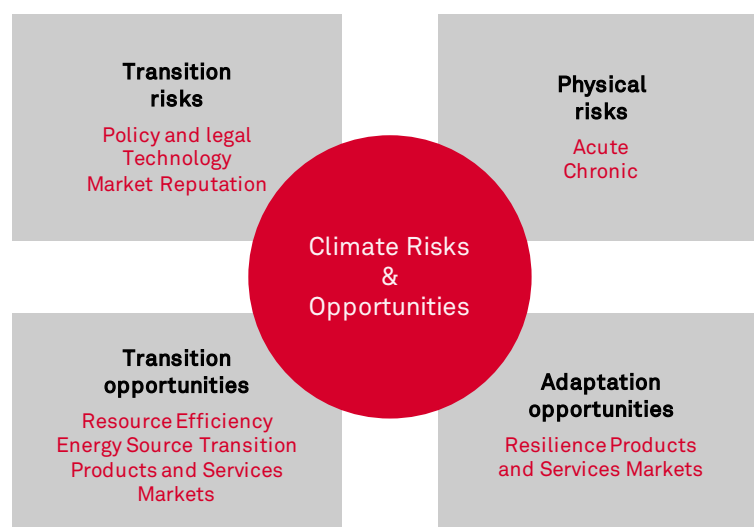
¹² European Commission, 2030 climate & energy framework.

¹³ Ibid.

¹⁴ Ibid.

The TCFD provides a useful framework for understanding these corporate energy transition impacts. It distinguishes between transition risks, factors that create financial or reputational risks associated with the transition, and physical risks associated with the potential physical impacts and failure to adapt to climate change (Figure 1).

Figure 1: Climate risks and opportunities



Source: Task Force on Climate-related Financial Disclosures, 2017, page 5-7

A prime example of a transition risk is “stranded assets”. These can occur if the economic transition renders a company’s assets obsolete or impaired, and leads to premature asset write-downs,¹⁵ thus failing to deliver the expected returns to their financiers. Coal reserves and capital expenditure on reserve exploration and exploitation are particularly exposed given the expectation of a lower use of fossil fuels in scenarios compatible with the Paris Agreement goals.¹⁶ According to research by the Carbon Tracker Initiative, the IEA Sustainable Development Scenario (with around 50% probability of 2°C temperature outcome) would mean no further additional thermal coal mining capacity at all required in the U.S. and China.¹⁷ If all oil, gas, and coal supply chains were taken into account, such a scenario would also mean \$0.9 trillion¹⁸ less capex to be deployed, compared to the currently planned growth, given existing and scheduled climate policies.¹⁹

It is also important to acknowledge that there are not only downsides from the low-carbon transition, but opportunities depending on how companies respond. For example, a number of companies traditionally focused on fossil fuel extraction are now investing in low-carbon energy opportunities. Examples include BP’s recent investment in electric vehicle charging infrastructure, Royal Dutch Shell’s and Total S.A.’s investments in energy storage and distributed energy, and Equinor’s (formerly Statoil) investments in offshore wind power assets.

¹⁵ Lloyds, *Stranded Assets*, <https://www.lloyds.com/news-and-risk-insight/risk-reports/library/society-and-security/stranded-assets>.

¹⁶ Carbon Tracker (2017), *Stranded Assets*, <https://www.carbontracker.org/terms/stranded-assets/>

¹⁷ Carbon Tracker (2018), *Mind the Gap: the \$1.6 trillion energy transition risk*, <https://www.carbontracker.org/reports/mind-the-gap/>.

¹⁸ All values are in U.S. dollars.

¹⁹ Ibid.

Scenario analysis as a way to understand future climate risks and opportunities

In order to understand the potential financial impact of energy transition on their portfolios, investors can undertake scenario analysis of their investments under different potential outcomes. Scenario analysis addressing future macroeconomic eventualities is already familiar to many in the financial sector, and the related concept of stress testing has been part of prudential reporting by banks since the global financial crisis.²⁰ However, the extension of scenario analysis to climate risks is relatively new for the financial sector. The exercises seek to enhance a financial institution's ability to understand and act on potential impacts through taking a forward-looking perspective on the effects of material risk factors.^{21,22} The major difference between stress testing and scenario analysis is the nature of the scenarios being tested. Stress testing typically focuses on adverse scenarios based on short-term macroeconomic trends as defined by the regulators.²³ Meanwhile, scenario analysis does not involve forecasting the precise future condition, but aims to capture the possible outcomes (both negative and positive) under a range of plausible future conditions.^{24,25} From a climate change perspective, this means that financial institutions can better understand possible impacts under different scenarios and formulate their business or investment strategies accordingly.

This is not a straightforward exercise, though. A key challenge when attempting to incorporate climate-related risks into financial analysis is that most climate scenarios are designed for scientific analysis, or for policy formulation and evaluation purposes. Financial indicators are generally not available or not represented in a way that can easily be incorporated into investment decision-making. Another common challenge is the time horizon of climate-related risks. While aggregated carbon budgets and the actions for transition are often projected at the macro level (nationally, regionally, and globally) to the middle or end of the century, there is significant uncertainty attached to these projections given their very long-term perspectives and the large number of variables that can impact the outcome. Furthermore, the potential impact of climate change at the micro or entity level should account for mitigating actions that entities would be expected to take to counteract the potential effects of climate change.

The ET Risk project explores how some of these limitations could be overcome, with scenarios inferring how company business credentials (for example competitiveness, costs, and associated potential future financial outcomes) could be affected in a way that is compatible with company financial analysis. By combining forward-looking scenario analysis and financial implications, Trucost is able to assess the potential impacts on individual companies in this report.

²⁰ Bank of England (2016), *Stress testing of banks: an introduction*, <https://www.bankofengland.co.uk/-/media/boe/files/quarterly-bulletin/2016/stress-testing-of-banks-an-introduction.pdf?la=en&hash=3C57129C772A42925EDABF0145129001AE7B245F>.

²¹ Ibid.

²² Task Force on Climate-related Financial Disclosures (2017).

²³ Bank of England (2016), *Stress testing of banks: an introduction*.

²⁴ Task Force on Climate-related Financial Disclosures (2017).

²⁵ International Actuarial Association (2013), *Stress Testing and Scenario Analysis*, http://www.actuaries.org/CTTEES_SOLV/Documents/StressTestingPaper.pdf.

For investors and financial institutions, the benefits of climate-risk scenario analysis are four-fold, enabling:

1. **Investors to understand the resilience of their strategies to climate change and energy transition scenarios, and thus inform capital allocation.** Climate-risk scenario analysis aims to express risks and opportunities in financial metrics, which allows climate risks to be managed in similar ways as other risks in portfolio management. In the ET Risk project, Trucost assessed the possible impacts on credit quality for debt instruments, while KECH²⁶ assessed the impacts on cost and volatility of equity in both cases, making use of scenario data developed by The CO-Firm.
2. **Climate-related risks to be priced based on risk-adjusted return expectations.** When climate risks are quantified in financial metrics, investors and financial institutions can incorporate them into the pricing of financial instruments.²⁷ The insurance industry has been a forerunner in pricing climate risks with existing models to understand how climate patterns could change in the near future in order to price insurance products in the real estate sector.²⁸
3. **More comprehensive cost-benefit analysis of individual investments.** Scenario analysis on climate risks could be an important complement to existing cost-benefit analysis frameworks, which are often required for specific asset classes to account for externalities. There are signs that this has been recognized, as several key development banks have started applying shadow carbon prices, either in investment appraisals or in cost-benefit analysis.
4. **Meaningful dialogue on climate risks between investors and companies.** A key advantage of scenario analysis is that the risk factors being tested are similar to those applied by investment professionals in company engagement. For example, share of key production and power generation technologies, future supply and demand in the market, cost competitiveness of products, and sensitivity of cost structures to key regulations are all relevant to understand for both financial risks and climate risks.

²⁶ Kepler Cheuvreux (2018), *Climate scenario compass*, <http://et-risk.eu/wp-content/uploads/2018/02/Investor-primer-to-transition-risk-analysis.pdf>.

²⁷ University of Cambridge (2016), *Environmental risk analysis by financial institutions – a review of global practice*, http://unepinquiry.org/wp-content/uploads/2016/09/2_Environmental_Risk_Analysis_by_Financial_Institutions.pdf.

²⁸ Lloyds (2014), *Catastrophe Modelling and Climate Change*, <https://www.lloyds.com/news-and-risk-insight/risk-reports/library/natural-environment/catastrophe-modelling-and-climate-change>.

Literature review of energy transition materiality for a fixed income investor

Investors and market service providers are increasingly interested in the relationship between climate factors and risks and returns of fixed income securities, as demonstrated by the large number of investor and credit rating agency signatories to the Principles for Responsible Investment's (PRI's) Statement on ESG in credit ratings.²⁹ However, publicly available research in this area remains relatively scarce. This highlights the importance of the ET Risk project in meeting this research need. In order to understand the potential financial materiality of energy transition scenarios on creditworthiness, Trucost has conducted a literature review of ESG materiality in fixed income.

While ESG scores generally take into account some environmental issues, it should be noted that they may not specifically incorporate energy transition, and may be qualitative and backward-looking in nature. It is also worth emphasizing that the majority of identified research focuses on listed equities,³⁰ but fixed income securities have a variety of distinct features – for example, their coupons, term structure, call structure, and rates – that can affect their valuation.³¹ When analysing credit risks, one can look at different measures, such as credit ratings and their changes, as well as bond price volatility, credit default swap (CDS) rates, or credit spreads.³² Different studies have focused on a variety of these aspects of credit quality.

Research on ESG and credit ratings

There are a limited number of studies addressing the interaction between ESG and credit ratings. Further, the main focus has not been on environmental factors, but aggregated ESG factors or social and governance concerns. For example, Bauer, Derwall, and Hann³³ argue that companies with strong employee relations benefit from a lower cost of debt and higher bond ratings.

Looking at a sample of Italian and Spanish companies, Devalle, Fiandrino, and Cantino³⁴ researched the question of whether ESG performance influences the credit rating of companies using Thomson Reuters Scores and Moody's ratings. Their findings suggest a significant effect on credit ratings, but only for governance and social issues. No significant results could be found for environmental scores. They state that ESG factors do not yet play a prominent role in the creditworthiness evaluation employed by banks, despite growing interest by financial markets and institutions.

Similarly, Hermes³⁵ analyzed credit ratings and their relationship to ESG risk using proprietary ESG scores. They found that higher ESG scores are associated with better credit ratings, proposing that companies that do not follow the same correlation will have the potential for upgrades or downgrades.

²⁹ Principles for Responsible Investment, *Statement on ESG in credit ratings*, <https://www.unpri.org/credit-ratings/statement-on-esg-in-credit-ratings/77.article>.

³⁰ Principles of Responsible Investments (2013), *Corporate Bonds: Spotlight on ESG risks*.

³¹ Reznick, M. and Viehs, M. (2017), *Pricing ESG Risk in Credit Markets*, Hermes Investment Management.

³² Hörter, S. (2016), *How does ESG affect the credit rating of corporate bonds*, [online] Allianz Global Investors, <https://uk.allianzgi.com/en-gb/insights/esg-matters/2016-09-01-how-does-esg-effect-credit-rating>.

³³ Bauer, R., Derwall, J., and Hann, D. (2009), *Employee Relations and Credit Risk*.

³⁴ Devalle, A., Fiandrino, S. and Cantino, V. (2017), *The Linkage between ESG Performance and Credit Ratings: A Firm-Level Perspective Analysis*, *International Journal of Business and Management*, 12(9), pp.53 – 65.

³⁵ Reznick, M. and Viehs, M. (2017), *Pricing ESG Risk in Credit Markets*, Hermes Investment Management.

However, they also found that, for a given rating band, ESG scores are widely dispersed, suggesting that ESG factors are one of many that affect credit ratings.

Examining a variety of valuation metrics, Macquarie³⁶ looked at the Bloomberg Barclays Global Aggregate and the Bloomberg Barclays Global High Yield Indices and their respective ESG scores from MSCI, along with credit ratings from S&P Global Ratings. The analysis found a correlation of approximately 30%, with lower-rated credit also having lower ESG scores. However, they found that ESG scores have only a small impact on credit spreads. Given the correlation between ESG factors and ratings, but lack of correlation with credit spreads, the authors concluded that it is likely that the market is not pricing ESG factors adequately. Their findings also point out that including ESG factors together with credit ratings produces a better fit for credit spreads than credit ratings alone. However, looking at performance, they found that companies with a lower ESG score performed marginally better between 2014 and 2016. They argue that the outperformance found by other studies is due to other non-ESG factors. When looking at industry impacts, companies with strong environmental scores tend to outperform those with weak environmental scores.

Using Trucost data, In, Park, and Monk³⁷ found that carbon-efficient companies tend to have stronger financials along a number of dimensions that drive higher credit quality. This includes lower book-to-market ratio, higher return on assets, higher Tobin's q, higher free cash flows and cash holdings, higher coverage ratio, lower leverage ratio, and a higher dividend payout ratio. They also found that excess returns from carbon-efficient companies are not explained by traditional equity risk factors of size, value, momentum, operating profitability, and investment. This suggests that carbon-efficient companies have stronger fundamentals, which would imply that this should be recognised and valued by the market.

S&P Global Ratings has also undertaken research on the relationship between ESG factors and credit ratings.

Research on credit risk and probability of default (PD)

A meta-study by Allianz³⁹ shows that the majority of identified research finds higher ESG ratings to be correlated with lower credit risks of corporate investment grade bonds, and showed lower volatility. A study by Barclays,⁴⁰ for example, found that credit spreads of issuers with higher ESG scores have, on average, been lower by 2.8 bps per annum (p. a.).

Looking at bankruptcies, Bank of America Merrill Lynch (BofAML)⁴¹ found that an investor holding stocks only that have better than average environmental and social scores could have avoided 15 out of 17 bankruptcies that occurred between 2008 and 2016. This was among the BofAML U.S. research coverage universe for which Thomson Reuters ESG data was available, representing a universe of 800 to 900 mostly large companies each year.

³⁶ Macquarie (2018). *ESG - Understanding ESG in Credit Portfolios*. Macquarie Group Limited.

³⁷ In, S. Y., Park, K. Y. and Monk, A. (2018), Is 'Being Green' Rewarded in the Market? An Empirical Investigation of Decarbonization and Stock Return, Stanford Global Project Center.

³⁹ Allianz Global Investors (2017). *ESG in Investment Grade Corporate Bonds*. Munich.

⁴⁰ Barclays (2015). *ESG Ratings and Performance of Corporate Bonds*.

⁴¹ Bank of America Merrill Lynch (2016). *ESG: good companies can make good stocks*.

Research on cost of debt

In addition to a lower bond and issuer rating, Bauer and Hann⁴² found that, for a sample of bonds issued by 582 U.S. companies between 1996 and 2016, poor environmental records were associated with a higher cost of debt amounting up to 53 bps p. a.

Deutsche Bank⁴³ conducted a meta-study that supported the argument that companies with a higher corporate social responsibility (CSR) score and ESG rating have a lower corporate cost of capital in terms of their loans and bonds. Similarly, a meta-study by Arabesque Partners and the University of Oxford⁴⁴ showed that for 90% of relevant studies, sound sustainability standards lower the cost of debt through lower credit spreads, after controlling for firm and industry characteristics. The relationships also seem to hold for the opposite direction, where companies that represented environmental concerns experienced higher credit spreads on their loans.

Research on portfolio performance

The majority of studies around ESG and fixed income centre on ESG's impacts on portfolio performance, with the premise that strong ESG practices may lead to increased returns for companies over their peers, and that ESG could represent currently unpriced risk factors.

A number of studies by institutional investors find support for these hypotheses. For example, Barclays⁴⁵ found a small, but long-term, outperformance amounting to 30 bps p.a. of high ESG-scored corporate investment grade bond portfolios. Creating high- and low-scoring ESG portfolios, Barclays found that the highly-scored portfolio outperforms a benchmark by 250 bps over an eight-year period. More specifically, Henke⁴⁶ found an excess return of 65 to 92 bps p.a. in different geographies during bear markets and recessions.

Applying ESG factors on a corporate bond portfolio that tracks the Bloomberg Barclays U.S. Investment Grade Corporate Bond Index, Barclays⁴⁷ found a small, yet steady, performance benefit. Yet, negative ESG factors did not result in a negative performance effect. A deep dive shows that the effects are strongest for governance and weakest for social factors. Yet, ESG had no effect on the price of corporate bonds, and there was no evidence that the performance advantage was based on a change in relative valuation over time. When looking at credit ratings, companies within the index with high ESG scores had a one-notch higher credit rating, on average, than those with low ESG scores, with the universe split into equal-sized buckets of high, medium, and low ESG-scored issuers. This was most pronounced for environmental factors. However, the firm avoids conclusions on causality, noting that companies with higher credit ratings are financially stronger, so may be better able to comply with environmental constraints than companies

⁴² Bauer, R. and Hann, D. (2010), Corporate Environmental Management and Credit Risk. Maastricht: European Centre for Corporate Engagement.

⁴³ DB Climate Change Advisors (2012), Sustainable Investing – Establishing Long-Term Value and Performance.

⁴⁴ Clark, G. L., Feiner, A. and Viehs, M. (2014), From the stockholder to the stakeholder – How sustainability can drive financial outperformance.

⁴⁵ Barclays (2015), ESG Ratings and Performance of Corporate Bonds.

⁴⁶ Henke, H.-M. (2016), The effect of social screening on bond mutual fund performance, Journal of Banking & Finance, 67, pp.69 – 84.

⁴⁷ Barclays (2016), Sustainable investing and bond returns – Research study into the impact of ESG on credit portfolio performance.

with lower credit ratings and tighter financial constraints, rather than environmental performance necessarily driving credit ratings.

Not all studies find environmental factors to be a significant performance driver. On the contrary, Leite and Cortez⁴⁸ analysed the performance of European SRI bond funds and found no statistically significant difference in performance when compared to conventional funds. However, when drilling into country-specific funds, they found that French SRI bond funds perform similarly to conventional funds, German SRI funds slightly outperform their counterparts, and U.K. funds slightly underperform their counterparts.

Research on CDS

Looking at CDS spreads, Kölbel and Busch⁴⁹ found that negative media coverage of CSR issues results in wider CDS spreads. In other instances, they found little evidence of a link between ESG performance and financial outperformance, yet find evidence of ESG performance being linked to the cost of capital.

CDS spreads are also the focus of Hermes' research,⁵⁰ which compared them to the internal Hermes ESG score. In this research, companies with the lowest scores tend to have wider CDS spreads, as well as a broader distribution of annual CDS spreads, implying a more unpredictable investment return. Oikonomou's research⁵¹ supports this, finding that good CSR performance is associated with lower credit spreads and reduced risk premia and related cost of debt. It also suggests that these relationships are stronger for bonds with long-term maturities

Transition risks

While most studies look at ESG scores at an aggregated level, fewer look at environmental risk factors independently. Even fewer studies focus on the relationship between transition risk and performance of companies. Several papers do look at climate risk factors specifically for equities. One is Tian, Akimov, Roca, and Wong⁵² that analyzes the impact of carbon market regulations. The findings show that, while the carbon market significantly affected the stock prices of electricity companies in Europe in Phase I of the EU ETS, Phase II showed no effect. This implies an impact in the short run that diminishes over time, although this may also be related to an oversupply of allowances in Phase II.

Also from an equities perspective, Trinks et al.⁵³ investigated the link between the cost of equity and industry-adjusted GHG emission intensity for 1,920 publicly-listed global companies between 2002 and 2016. They found that for every unit of GHG emission-intensity increase, the cost of equity increases by 15 bps. Their analysis diverges from others by looking at GHG emission intensity instead of aggregated ESG scores.

⁴⁸ Leite, P., and Cortez, M. (2016), The Performance of European Socially Responsible Fixed-Income Funds.

⁴⁹ Kölbel, J.F., and Busch, T. (2013), The effect of bad news on credit risk: a media based view of the pricing of corporate social responsibility, Duisenberg School of Finance Policy Paper.

⁵⁰ Reznick, M. and Viehs, M. (2017), Pricing ESG Risk in Credit Markets, Hermes Investment Management.

⁵¹ Oikonomou, I., Brooks, C. and Pavelin, S. (2014), The effects of corporate social performance on the cost of corporate debt and credit rating, *Financial Review*, 49(1), pp.49 – 75.

⁵² Trinks, A., Ibikunkle, G., Mulder, M., and Scholtens, B. (2017), *Greenhouse Gas Emissions Intensity and the Cost of Capital*, Griffith University, Australia.

⁵³ Trinks, A., Ibikunkle, G., Mulder, M., and Scholtens, B. (2017), *Greenhouse Gas Emissions Intensity and the Cost of Capital*, Groningen: University of Groningen.

Climate scenario analysis

Taking a forward-looking approach, Mercer⁵⁴ considered how different asset classes could be impacted by multiple climate risk factors across different future scenarios. The risk factors included in the analysis are technology, resource availability, impact, and policy. These are tested in scenarios of transformation, coordination, fragmentation with lower damages, and fragmentation with higher damages, representing warming outcomes of 2°C to 6°C.

Overall, only the developed market global equity asset class experiences a negative impact across scenarios, while other asset classes investigated, including fixed income, either have negative or positive impacts on their returns depending on the scenario used. Mercer found that developed market sovereign bonds are not sensitive to climate risk, but are driven by other macroeconomic factors, with some exceptions, such as Japan and New Zealand. Looking across different corporate fixed income classes, the impact on returns is among the smallest for multi-asset credit, investment grade credit, and private debt when compared to other asset classes. While limited, the impact remains mostly negative. In comparison, the asset classes with the biggest variability in terms of returns (both negative and positive) are agriculture, infrastructure, and timber. Looking at the risk factors for fixed income, investment grade credit is negatively affected by all factors, except technology that has a positive impact. High-yield debt remains neutral to technological risks, with the remaining factors having a negative effect.

Oliver Wyman, together with Mercer and a working group of 16 banks, developed a scenario-based methodology for assessment of the potential impact of climate change on a bank's corporate lending portfolio, analyzing both physical and transition risks. In the methodology, they combine 2°C transition scenarios with borrower level calibration, specifying how the scenarios would affect the individual borrowers, as well as a portfolio impact assessment, which extrapolates the calibration process to the entire portfolio.

Using the REMIND 2°C Integrated Assessment Model from the European Commission-sponsored CD-Links project, the working group is testing the methodology on their portfolios. Within the paper, a Barclays case study of 35 electric utilities in the EU and the U.S. from the working group found that, under a 2040-2°C scenario, the climate-stressed Exposure at Default weighted average portfolio PD to be 2.2 times greater in the U.S. and 2.3 times in the EU, relative to the 2017 baseline PD. However, the results also show that, due to the investment grade nature of the borrowers, the portfolio remains largely within the investment grade or high non-investment grade credit categories.

Another case study from the working group focusing on the metals and mining sector demonstrates the variability of impacts across credit ratings. With investment grade borrowers ('BBB-' or above), the 2030 and 2030 PD show no change from their current PDs, demonstrating a strong resilience to climate change. However, for strong sub-investment grade borrowers ('BBB-' to 'BB'), the PDs experience a one-notch downgrade, while two-notch downgrades are experienced by weak sub-investment grade borrowers (below 'BB').⁵⁵

⁵⁴ Mercer (2015), *Investing in a time of climate change*.

⁵⁵ Oliver Wyman and Mercer (2018), *Extending our horizons – Assessing credit risk and opportunity in a changing climate: Outputs of a working group of 16 banks piloting the TCFD Recommendations. Part 1: Transition-related risks & opportunities*.

The Economist's research,⁵⁶ based on the Dynamic Integrated Climate Economy (DICE) models, has shown that the estimated value at risk to 2100 due to climate change are \$4.2 trillion discounted to present value based on a mean temperature rise. This represents around 3% of the world's estimated global manageable assets. The research states that sectors concerned with physical assets or natural resources will have a more localized risk impact and are more vulnerable than other sectors. However, it also suggests that most of the impact will materialize through weaker growth and lower asset returns (i.e. indirect impacts). Expanding the analysis to a 5° or 6° rise, the present value at risk rises to \$7.2 trillion and \$13.8 trillion, respectively.

Limitations to results and directions for future research

Inderst and Stewart⁵⁷ make a number of pertinent points on the limitations of some research on ESG risks and credit risk. First, the literature is relatively sparse – a meta-study by Friede, Busch, and Bassen⁵⁸ notes only 36 bond market studies among over 300 distinct vote-count studies surveyed that examine a specific asset class, or 11% compared to the 87% of such studies focusing on equities. Second, studies often find correlation, but not necessarily causality. Research results use historical data, and such data is typically only available and analysed over very limited historical periods, potentially not including a full market cycle, let alone multiple market cycles. As such, results may not reliably persist in future.

Given the need of investors to make forward-looking decisions, and the potential for economic and market structures to change over time, there are limitations to the ability of practitioners to apply historical results to today's decision-making. This issue becomes increasingly relevant as ESG and climate analysis is encouraged to take a forward-looking and scenario-based orientation. In this context, the limited number of studies that consider granular issuer-level or asset class-level impacts of climate scenarios is striking and indicative of the need for further research. These will necessarily have different characteristics to the scope and style of many existing studies, given the prospective nature of future possible scenarios and the exploratory conclusions that might be derived. However, other forms of scenario analysis are in wide application throughout the finance industry, including in credit analysis, providing possible inroads for such an analytical framework to be adapted to include climate factors.

⁵⁶ The Economist Intelligence Unit (2015), The cost of inaction: Recognizing the value at risk from climate change.

⁵⁷ Inderst, G. and Stewart, F. (2018), Incorporating Environmental, Social and Governance (ESG) Factors into Fixed Income Investment, World Bank Group publication, April 2018.

⁵⁸ Gunnar Friede, Timo Busch & Alexander Bassen (2015), ESG and financial performance: aggregated evidence from more than 2000 empirical studies, Journal of Sustainable Finance & Investment, 5:4, 210-233, DOI: 10.1080/20430795.2015.1118917.

Case studies of integration in practice

While the research documented in this chapter surveys identified systematic linkages between ESG factors and different financial indicators, there also exist a wide range of case studies of implementation of ESG analysis to debt investments by practitioners.

PIMCO, an asset management firm, has declared the adoption of ESG investments as intrinsic to its fiduciary duty⁵⁹ and is focusing on long-term sustainable risk-adjusted return.⁶⁰ PIMCO argues that the competitiveness of investments needs to be guaranteed today, as well as in the long-term, which requires an assessment of ESG. For example, it views structural changes within the utilities sector to be associated with ESG trends. When analyzing credit risks for European utilities, PIMCO states that it takes into account companies' carbon intensity, power production mix, the share of power generation within the overall business, dependencies on regulated activities, exposure to regulations, and litigation and clean-up risks.

Banks are also increasingly incorporating ESG and climate factors into their consideration of credit risks. Australia's ANZ Banking Corporation⁶¹ requires its customers to satisfy a range of questions on both social and environmental issues, which are reviewed regularly. The firm incorporates climate change and changes to laws, regulations, and policies, such as carbon pricing and adaptation or mitigation policies, with the risk framework covering the entire credit lifecycle (for example, transaction structuring and risk grading). In its statement of material risks, mandated as part of its stock market listing, ANZ specifically cites climate transition risk as a factor that could affect its credit risk profile.

ANZ is also one of 93 financial institutions that have signed the Equator Principles,⁶² an environmental and social risk management framework committing it to implement the framework across its project finance loans, and restricting its loans to projects and clients that meet the requirements.

Similarly, Lloyds Bank, working together with Trucost,⁶³ implemented a green loan program, offering a discount to its real estate clients of up to 20 bps if they meet certain sustainability targets, increasing their exposure to lower-risk companies. The Green Lending Fund forms part of the bank's strategy on the risks and opportunities created from a low-carbon economy transition.

Looking at company-specific case studies, the PRI shines light on cases such as BP, TEPCO, and Lonmin, which all experienced significant financial losses due to non-traditional risk factors. Cost of capital rose for these companies, with BP's yields rising to 8.7% following the Deepwater Horizon Spill. At the same time, the value of their outstanding bonds fell dramatically.⁶⁴

⁵⁹ Rundell, S. (2015), PIMCO adopts ESG investments as intrinsic to its strategy, [online] Investment Magazine, <https://investmentmagazine.com.au/2015/09/pimco-adopts-esg-investments-as-intrinsic-to-its-strategy/>.

⁶⁰ Schütz, C. (2017), ESG in Action: Evaluating European Utilities. PIMCO.

⁶¹ ANZ Banking Corporation (2018), 2017 Annual Review.

⁶² Equator Principles (n.d.), About the Equator Principles, <http://equator-principles.com/about/>.

⁶³ Trucost (2016), Lloyds Bank launches first of its kind £1bn green lending fund for commercial property. <https://www.trucost.com/trucost-news/lloyds-bank-launches-first-kind-1bn-green-lending-fund-commercial-property/>.

⁶⁴ Principles of Responsible Investments (2013), Corporate Bonds: Spotlight on ESG risks.

INCORPORATING SCENARIOS INTO RISK CREDIT ANALYSIS: METHODOLOGY AND MODEL SELECTION

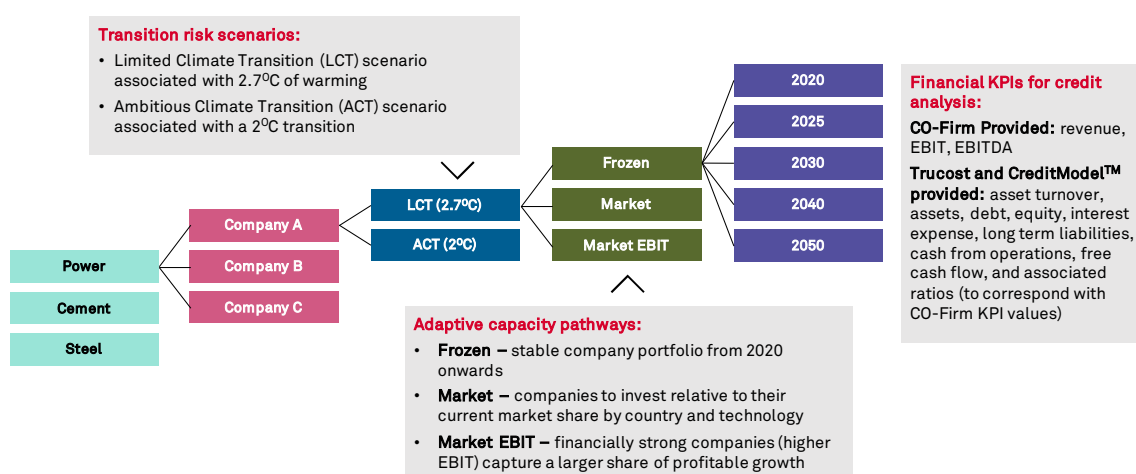
The core role undertaken by Trucost within the ET Risk project was to provide insights into how forward-looking energy transition scenarios could be integrated into credit risk assessment processes to determine if potentially material impacts on company credit quality are implied. In doing so, Trucost applied S&P Global Market Intelligence's credit analytic tools to assess credit implications derived from The CO-Firm's climateXcellence scenarios, focusing on key risk factors most predictive of changes in default risk.

Climate scenario data inputs

The credit risk modelling process undertaken integrates a climate transition scenario dataset comprising estimates of potential future financial implications for specific companies under a range of transition-risk scenarios. The scenario dataset used was developed within the ET Risk project by The CO-Firm. The CO-Firm's climateXcellence dataset incorporates two alternative transition scenarios, entailing two different temperature rise outcomes – a 2°C scenario (ACT) and a 2.7°C scenario (LCT) modelled on the basis of the IEA's 2°C scenario and reference technology scenario, respectively. Overlaid on this are three alternative potential adaptive capacity pathways, representing how individual companies might respond and adapt their asset portfolios in response to the risk and opportunities of each transition pathway. For each adaptive capacity assumption, financial variables are generated at the individual company level for a series of years from 2016 to 2050. This scenario data structure is illustrated in Figure 2, while more details of The CO-Firm's modelling process is detailed in Figure 3.

In the summary of results that follows, each potential outcome in the scenario data structure is referred to as a scenario-adaptive capacity-year combination. For example, one combination is LCT scenario-Market adaptive capacity in the year 2030 for a company in the utilities sector, while another combination is ACT scenario-Market EBIT adaptive capacity in the year 2040 for a company in the cement sector.

Figure 2: Scenario data structure



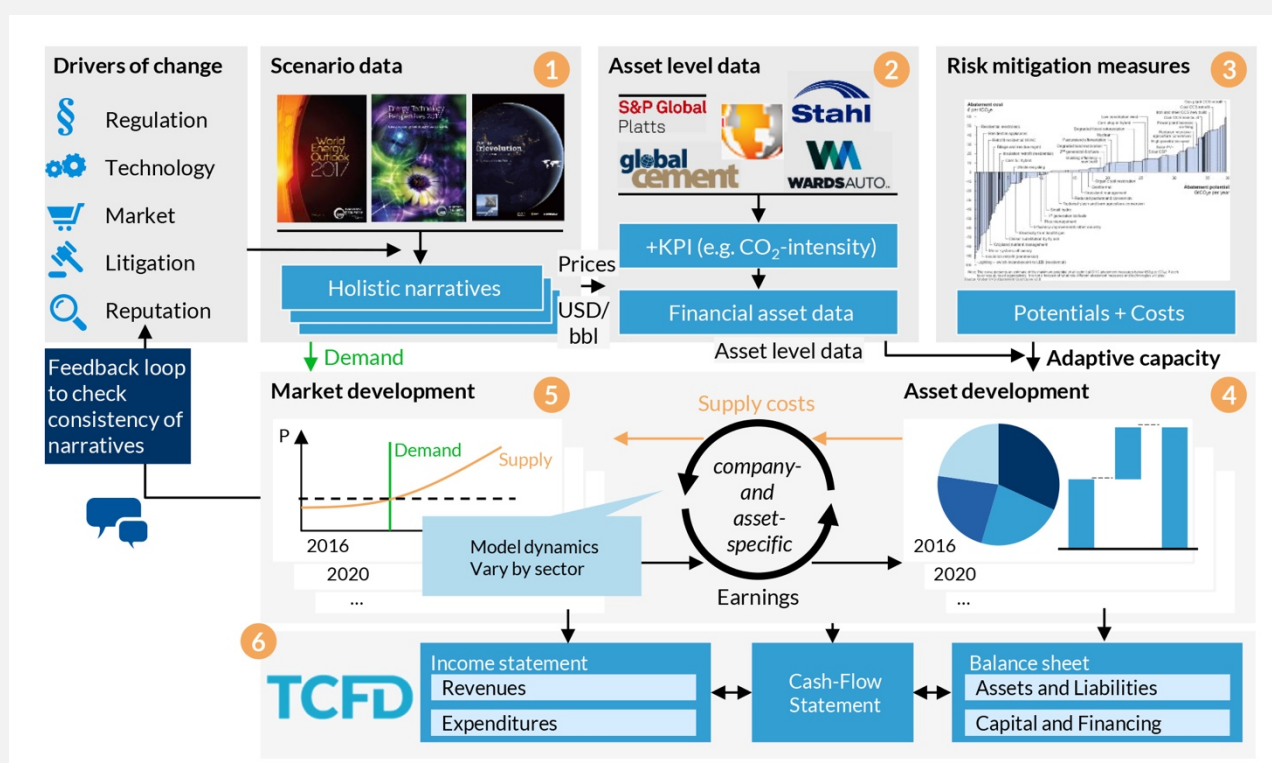
Source: The CO-Firm, Trucost

The CO-Firm's climateXcellence model

The CO-Firm's climateXcellence model is a scenario-based, bottom-up market model of plausible future financial pathways of companies, focusing on high GHG-emitting industries that are subject to significant transition risks and opportunities. The following overview explains the six central steps to the bottom-up modelling process.



Figure 3: Financial modelling of climate transition risks



Source: The CO-Firm

Six central steps to The CO-Firm's climateXcellence model

Step	Why?	How?
1. Derive the key risk drivers based on the narrative behind a scenario	Scenarios typically present decarbonisation pathways for a specific sector (or national economy) e.g. changing technology trajectories (wind, coal, etc.) or demand (e.g. rise/drop in electricity demand). However, scenarios are mostly unspecific about the drivers (e.g. CO2 certificate prices, technology costs and their development over time, technology diffusion, command and control policies, etc.) that will lead to and explain such changes.	Use backward induction approach to connect the dots between the transition drivers and scenario data, e.g. what battery prices are needed for cost parity and for consumers to switch from fossil fuel to electric cars (see step 5).
2. Built asset/product database based on relevant and meaningful information on individual physical assets/products for the risk and opportunity assessment	Since climate transition impacts companies' physical assets and product portfolios differently – even within the same sector – building (enhancing) an asset database that is relevant and meaningful for assessing climate-related risks and opportunities is central to the modelling. Having a sound asset database at hand allows differentiated financial impacts of climate transition on companies to be derived.	Commercially available databases holding technological information, such as capacity, asset type, and start-up year can be a viable basis, but need to be extended by i.e. energy and carbon intensities and financial meaningful data.
3. Techno-economic assessment of assets' adaptive capacities for risk mitigation	Financial modelling of climate risk must consider companies' ability to anticipate transition risks and develop mitigation strategies, as it impacts future asset development and companies' financial performance. Adaptive capacity allows a true and fair view of risks and opportunities to be presented. Not considering it might overestimate climate risks.	Explore adaptive options, such as product, business, and technology switches. GHG Marginal Abatement Cost Curves (MACC) can be a starting point to explore technological options. All options should be tested for economic soundness, i.e., the underlying business case for the adjustment.
4. Forecast companies' asset or product portfolio development with and without adaptive capacity under different scenarios.	Climate-risk assessment is conducted over long time periods e.g. up to 20 or 30 years, over which companies develop and can change their market share, business strategy, product portfolio, and production technologies. Outside effects, like market-driven volume (e.g. more electricity demand), and price effects can further impact companies' line-up. Not anticipating companies' development might also overestimate climate risk.	The development of companies' asset base or product portfolio is basically a function of the demand development (see step 1), company's current assets (see step 2), its adaptive capacity (see step 3). Considering the inherent uncertainty, it can be helpful to analyse two or more pathways to derive impacts that result from different business strategies.
5. Forecast market development based on the demand and supply assumptions to derive prices and revenues in the scenarios.	The different future worlds of climate scenarios will result in price and volume effects on markets. First, modelling product markets allows us to calculate market development consistent with the scenario. Second, it enables us to derive companies' future earnings and sales volumes considering their competitiveness. Third, it helps in backward induction missing scenario data such as CO2 prices (see step 1).	Markets in their simplest form can be modelled with supply and demand cost curves. The aggregation of companies' asset developments (see step 4) yields the supply cost curve and the scenario data (see step 1) serves as the inelastic demand curve for a given scenario. The price is settled where supply and demand intersect.
6. Mapping financial impacts on assets/products to companies	For assessing climate risk, companies can be perceived as superset of physical assets with technology and country combination. In the last step, the asset-specific risk needs to be mapped to the company's portfolio to derive total financial impacts.	Market modelling in step 5 provides country-asset-specific earnings based on price, volume and supply costs, while step 3 provides asset-specific changes in depreciation and capex. With the help of step 4, the country-asset-specific financial impact can be mapped to countries.

Source: The CO-Firm

Credit risk: fundamental assessment versus modelling

Corporate credit risk analysis can take various forms, from more qualitative measurements to strictly quantitative analysis of a borrower's ability and willingness to service the obligations. These can be categorized along different dimensions, with the most common distinction being between fundamental analysis versus more standardized statistical modelling.

At a high level, a fundamental analysis takes into account quantitative measurements of financial Key Performance Indicators (KPIs), as well as qualitative assessments of a range of business risk factors. These qualitative assessments can be based on both public and, if available, non-public sources, as well as assessments of the management, shareholders and any sponsors, and business environment. In a fundamental analysis, the credit quality of a borrower is based on past and, if possible, projected financials and business information, the character of their management, governance, industry risks, sovereign and country risk, and any enhancements (i.e. collateral, guarantees, or structuring of instruments or commitments). There are several publicly-available corporate credit risk assessment frameworks that detail the above factors relating to a debtor's capacity and willingness to service its obligations from the five C's of credit⁷¹ to the ones used by the major credit rating agencies, with sector- and instrument-specific methodologies.

Quantitative modelling uses deterministic approaches that are either calibrated based on certain historical datasets, or parameters defined via expert judgement, to link financial and non-financial KPIs with high-explanatory power to quantitative indicators of credit risk within a certain timeframe (credit scores, PDs, or distance to default). Qualitative factors can be implied in the modelling when they are based on past credit scores, credit ratings, or observed default rates.

Quantitative credit models can be grouped along different dimensions depending on whether they are based on structural assumptions of the company's assets and liabilities and their distribution, quantifiable fundamentals (financials, ratios, and other macroeconomic variables), or models that infer default risk from market (e.g. bond) prices or spreads (market based or reduced form models).

The Z-Score, developed by Edward Altman, was the first model for predicting financial distress, and perhaps the most widely known. Its alternative versions are still used in practice by credit bureaus. The option pricing model, developed by Black and Scholes in 1973, paved the way for Merton's model in 1974 that, in turn, provided the foundation upon which structural credit models were built. The modelling of credit risk as a statistical process was enhanced by Jarrow and Turnbull, who introduced reduced forms of models that do not require a specific knowledge of the balance sheet structure of the company, but are based on market prices of the debt instruments, as well as assumptions on the market structure.

Since development of the Altman, Merton, and Jarrow-Turnbull concepts, an evolution of credit risk models has helped to overcome the constraints and assumptions of their predecessors and allow for better performance in predicting credit risk and default out of sample.

⁷¹ Referring to character, capacity, capital, collateral, and conditions.

As a result, a family of statistical models has emerged in recent decades that combine financial ratios and macroeconomic factors with advanced mathematical techniques to efficiently estimate the credit-worthiness of companies has emerged.

Corporate credit risk can be operationalized in different ways: as a risk of monetary loss from default or an increase in PD on a specific financial obligation, an increase in severity of losses at default due to either increased exposures, or recovery possibilities based on changing collateral characteristics. Together, these cover the elements of the traditional Expected Credit Loss (ECL) equation:

$$\begin{aligned} \text{Expected Credit Loss} &= \text{Exposure at Default} \times \text{Loss Given} \\ &\quad \text{Default} \times \text{Probability of Default} \\ \mathbf{ECL} &= \mathbf{EAD \times LGD \times PD} \end{aligned}$$

Overall, ECL as a measure of credit risk is dependent on the capacity and willingness of the debtors to service obligations, external conditions, the type of the financing instrument (i.e. its inherent characteristics), and the availability of risk mitigation possibilities. There is a chance for interplay between the various parts of the above equation, however this correlation is not always assumed.

Model selection

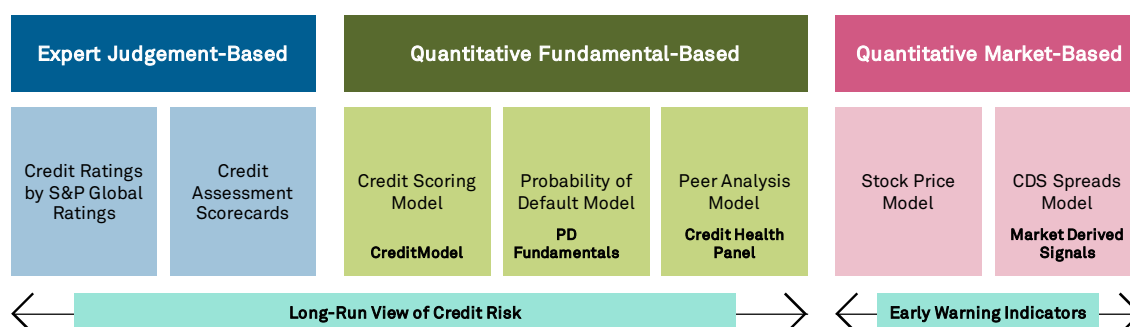
The credit risk analysis was undertaken using the quantitative fundamental assessment model, CreditModel™ Corporates 2.6 (CM2.6), mentioned earlier. CreditModel™ was selected by Trucost as providing the best fit for assessing the credit risk implications of the climateXcellence scenario data based on the need to meet the following criteria:

- The need to calculate long-term estimates of credit risk
- The nature of the scenario data available, comprised of several key company financial variables modelled across scenarios
- Other missing company financial variables could be imputed based on their most likely values based on the available modelled financial data
- No need for qualitative inputs
- The underlying characteristics of the companies being assessed, which are large publicly-listed companies

Other credit risk assessment tools, including Credit Assessment Scorecards,⁷² were considered, but ruled out due to the breadth of inputs needed, including assessments of qualitative factors. Many assumptions would have needed to be separately made where relevant information was not available from the climateXcellence dataset.

⁷² Scorecards are fully-transparent Excel®-based tools that use point-in-time and forward-looking qualitative factors, converging trends, and relationships between key drivers to derive a standalone PD/LGD risk assessment that is broadly aligned with S&P Global Ratings criteria, and further supported by historical default/recovery data back to 1981.

Figure 4: S&P Global credit risk assessment tools



Source: S&P Global Market Intelligence

CreditModel™ takes a statistical modelling approach to estimating credit risk. It utilizes historical financial data from corporates and the most relevant macroeconomic data to generate a quantitative credit score that statistically matches a credit rating issued by S&P Global Ratings, prior to any parental or government support consideration (Stand Alone Credit Profile, SACP).^{73 74} The model's primary output is a lower-case letter grade score (Table 1). Lowercase nomenclature is used to differentiate S&P Global Market Intelligence's credit model scores from the credit ratings issued by S&P Global Ratings. In addition, each score can be mapped to implied default rates calculated by S&P Global Market Intelligence over multiple time horizons, extending as far as 35 years. This uses observed historical default rates for the entire rated universe of S&P Global Ratings.

For the purposes of this paper, Trucost provides indications of how climate transition scenarios can affect credit scores as credit risk indicators. Other variables defining credit risk are not modelled in Trucost's analysis and could be assumed unchanged, or modelled separately.

While credit risk implications of the energy transition can be assessed in the framework of expected losses, as described above, scenario analysis can reveal the potential for previously unexpected losses or opportunities. These can arise in the context of energy transition in cases where risks that were previously not visible appear within a short period of time, or risks that were previously deemed immaterial or too long term and uncertain are re-evaluated. A scenario analysis can present these potentially unexpected losses, as well as shine light on opportunities, transforming them to the framework of expected credit losses.

⁷³ S&P Global Ratings does not contribute to or participate in the creation of credit scores generated by S&P Global Market Intelligence. Lowercase nomenclature is used to differentiate S&P Global Market Intelligence credit model scores from the credit ratings issued by S&P Global Ratings.

⁷⁴ S&P Global Market Intelligence (2018), *CreditModel™ Corporates 2.6: A Global Scoring Model Specializing in the Analysis of Unrated Firms and Low Default Sectors*, July 2018.

Considerations for scenario analysis

To avoid confusion around terms that might be used interchangeably, the following definitions are used for the purposes of this paper.

Scenario analysis is the examination of the outcome of a possible future environment, either at a point in time or over a time period. While scenario analysis can be applied to individual companies, industries, or well defined regions or economies, this paper concentrates on individual companies. In a scenario, usually more than one variable influencing the outcome is changed, taking into account their interrelationships based on a coherent narrative in which the variables move in a consistent and plausible fashion. The energy transition scenarios from The CO-Firm's climateXcellence model are complex, with interactions among many factors over time based on coherent narratives.

Stress tests can be thought of as exercises that could possibly overlap with scenarios, where the outcome of a set of materially adverse conditions, resulting from a change of one or several factors over time, or at a point in time, are examined.

A sensitivity is the effect of alternative, but not necessarily adverse, assumptions being applied compared to a defined base-case state. In other words, an alternative scenario arising as a result of the change of a single or several factors, occurring over a certain period of time. A scenario used for sensitivity testing can possess a relatively small change in factors, but it can also show a range of alternative values of factors.

The TCFD's Technical Supplement on Scenario Analysis has five characteristics mentioned as important for creating scenarios – that they are plausible, distinctive, consistent, relevant, and challenging. When linking energy transition scenario outcomes to potential credit risk implications, Trucost also considered additional principles that are important to analyze the range of potential outcomes for a portfolio of companies. The analysis also needs to be scalable – the resources used should be able to produce results for a larger number of companies and scenarios in an efficient and replicable way.

The data used in modelling

For the purposes of this analysis, Trucost received data points from The CO-Firm based on scenario modelling of asset structure and core financial KPIs of nine European listed companies across the utilities, cement, and steel sectors.

The energy transition scenarios are built bottom-up, based on asset-level data, deriving demand and prices for products and raw materials based on the climate scenarios, as well as production and investment in assets based on alternative adaptive capacity pathways within scenarios.

Table 1: Credit Score Conversion

Credit Score	Numerical Value
aaa	1
aa+	2
aa	3
aa-	4
a+	5
a	6
a-	7
bbb+	8
bbb	9
bbb-	10
bb+	11
bb	12
bb-	13
b+	14
b	15
b-	16
ccc+	17
ccc or lower	18

Source: S&P Global Market Intelligence

Derived financial KPIs pertain to the operating assets of the companies in their core sector of operation only, and modelling and analysis does not cover other operating segments, any additional services provided, or qualitative factors. Given that any secondary segments are excluded from the analysis, this means that the credit analysis is only illustrative of a simplified company structure, covering its primary segment only. The KPIs provided within the project scope are restricted to turnover, earnings, depreciation, and capex. These limitations provide clear scope for a sensitivity analysis in the scenarios based on potential variability across possible ranges for factors with high-explanatory value in credit analysis that are not defined within the scenario dataset.

Given the characteristics of the data inputs provided, Trucost's focus of assessment is on the direction of risk compared to a base case of 2016 results, or a Frozen adaptive capacity (i.e. a 'do nothing' case) and to identify where and why the credit scores are shifting. Since the scenarios are not always detrimental to the companies, and credit quality is affected by a wide range of variables, one would not necessarily expect to see consistently significant change in the ability of companies to service their obligations.

In terms of results, due to the hypothetical nature of the exercise, the standalone risk profile of the companies is the most important outcome, which, for the specific companies under assessment, are the same as the sovereign capped scores due to the companies being domiciled in countries with low sovereign credit risk.

Model methodology

CreditModel™ Corporates 2.6 is trained primarily using S&P Global Ratings' historical SACPs for corporates, prior to any extraordinary support considerations and capped scores based on sovereign risk considerations.

Qualitative endogenous as well as exogenous factors affecting a company's creditworthiness are captured in SACPs that formed the dataset. Industry risk is implicitly captured in the model by training industry-specific sub-models, or adding dummy variables to reflect differences in specific industry sectors. For selecting the most relevant variables predicting credit risk for modeling purposes, more than 100 alternative financial and non-financial factors were calculated. In order to select the final set of inputs and variables, statistical analysis and expert judgement was used based on considerations of availability,⁷⁵ correlation, multi-collinearity,⁷⁶ and relevance.⁷⁷ Variables were selected that would comprise these risk dimensions from a range of categories, including financial information, as well as economic and industry-based risk indicators to ensure a proper balance of microeconomic and macroeconomic factors.

The model was calibrated using a regional and sector segmentation based on similarities of available financials and SACP distributions, as well as taking into account data availability and other macroeconomic considerations. The European sub-model used in Trucost's analysis was calibrated with 10 sub-regions based on the credit ratings distribution, and 19 industry-sector dummy variables.

⁷⁵ All factors included in the model must be widely available on a consistent basis over time for companies in each sector, as some financial KPIs have a high predictive power, but are seldom reported by companies.

⁷⁶ Highly correlated factors do not provide additional insights and could distort model performance.

⁷⁷ Using expert judgement all candidate variables were mapped to their risk dimensions used by S&P Global Ratings for analyzing corporate issuers.

Predictive process

The model employs an advanced generalization of logistic regressions, based on the family of exponential density functions. It uses the prior distribution of all SACPs in the calibration dataset as an “anchor distribution”, and modifies it in proportion to how the financials of a specific company deviate from those of companies used in the anchor distribution. The process of variable selection considers both linear and higher-order terms, and selects the final variables according to the k-fold Greedy Forward Approach, a statistical method that ensures a good fit out-of-sample and out-of-time.

The model uses a number of techniques, including variable transformations, which minimize the impact of extreme values, as well as various constraints, which avoid a risk of model over-fitting without any loss of data and a more accurate estimation of the parameters and final output. It maximizes the maximum likelihood function within a maximum expected utility, adapted to a multi-state case (based on the number of rating categories available), and uses the Akaike Information Criterion (AIC) to limit the maximum number of variables that are included (for model parsimony). This optimization process ensures that the model exhibits greater stability and out-of-time performance, while monotonicity constraints are applied to ensure that the model produces outputs that follow economic intuition. For more details, please refer to the CreditModel™ 2.6 Corporates Technical Reference Guide (2018).

Limitations

The model has a number of limitations given the assumptions that are made, as is common with any model. Because the scoring model is based on historical SACP data, linked default rates, and rating migration, the operating environment and the methodologies applied to derive these SACPs are implicitly assumed to be unchanged in the future during which the scenarios unfold (2020 to 2050 in the climateXcellence model). This is also assumed for the underlying drivers of the model, rating methodology, and the relative perception of credit quality based on a set of financial KPIs. In other words, because the model reflects how companies were rated based on a specific set of historical ratios and modifiers, business and country risk drivers, and their change of ratings and observed defaults within a certain timeframe, the methodology to derive credit scores for the future will imply the same score in the future as in the past for equivalent financial criteria. This may or may not prove to be a reasonable assumption.

Filling the data gaps

A number of key data points were not present in the underlying climateXcellence dataset, and required additional steps to generate results using CreditModel™, including assuming the level of asset turnover and assets, and allowing the model to impute other missing variables.

Table 2: Key variables for credit risk modelling

CreditModel™ Input Variable	Source
Total Assets	Assumed based on on CO-Firm climateXcellence scenario data on Revenue and constant Asset Turnover
Asset Turnover	Assumed to be sector average
Cash from Operations/Interest	Imputed from CreditModel
Debt/(Debt + Equity)	Imputed from CreditModel
Free (Operational) Cash Flow/Debt	Imputed from CreditModel
Operating Income Before Depreciation and Amortization/Revenues or EBITDA Margin	Changing based on CO-Firm climateXcellence scenario data on EBITDA
Operating Income After Depreciation and Amortization/Revenues or EBIT Margin	Changing based on CO-Firm climateXcellence scenario data on EBIT
Long-term Liabilities/Equity or Gearing Ratio	Imputed from CreditModel
EBIT/Total Capital or Return on Capital	Imputed from Credit Model

Additionally, revenue and EBIT were used as absolute inputs, where required by the model. Revenue data was used to calculate the year-on-year sales growth that was an input variable in the model.

Assumptions

Because the modelling framework used for the analysis requires total assets for scoring (being a proxy for company size and business risk), Trucost needed to make assumptions for the total assets of companies. Trucost did this by deriving average asset turnover efficiency ratios from available companies in each company's sector available from the S&P Global Capital IQ platform from 2012 to 2016. Other variables not available for scoring were generated using the imputation technique of the models.

Imputation

The CreditModel™ imputation framework uses advanced mathematical techniques to estimate missing model inputs. It focuses specifically on financial ratios, as the results are less affected by currency conversion effects, and are more statistically robust and less time-intensive than estimating missing raw financial items.

The imputation mechanism can accommodate any number of missing ratios used in the models, provided the user specifies at least one common financial variable.

To select the best imputation approach, two dimensions were considered: (1) how well the imputed financial ratio approximates the actual value (indicated by the mean squared error (MSE) as the primary metric), and (2) how the model performs with the imputed values. Out of the techniques available for imputation, the model uses the k-nearest neighbour (KNN) approach that performed better than alternative approaches. This is consistent with the fact that the model does not score public and private companies using separate sub-models, and the universe of private companies covered is much larger than that of public companies.

Steps in modelling for the core scenarios

Using the above model, assumptions, and imputation technique, the following steps were taken to generate credit scores:

1. Total assets were calculated from revenues and assumed (industry average) asset turnover.
2. Using the model's imputation technique, other significant explanatory variables were derived with the 2016 provided KPIs, thereby arriving at a base-case credit score.
3. 30 scenario-based scores were generated (based on two energy transition scenarios, three adaptive capacity pathways, and the five years for which the KPIs were generated) for future periods for each company by changing the provided KPIs and keeping the imputed KPIs constant for monotonicity.

The need for sensitivities around scenarios

Since not all the input variables used by the credit model are modelled within the underlying scenarios, deriving a comprehensive set of energy transition-based financials for a company can pose a significant challenge.

Many qualitative factors and potential proactive or reactive decisions made by companies within a scenario affecting operational efficiency or capital structure, among others, as well as industry risk, cannot be projected or derived from the energy transition scenarios. This is because the scenarios mainly allow for demand, asset mix development, and high-level assumptions on development of raw material and product prices, utilization rates, or capex per unit of capacity.

Based on future long-term circumstances that are difficult to reliably foresee today, companies will make or be restricted to take specific decisions on their strategic positioning, business models, portfolio mixes, risk tolerance operations, and financing structure. This will, together with other asset level KPIs, determine the approximate credit quality in a specific future scenario and adaptive capacity combination across the years.

For sensitivity analysis, a selection of ratios that have the highest explanatory power in the model can be singled out for closer examination.

INCORPORATING SCENARIOS INTO RISK CREDIT ANALYSIS: KEY FINDINGS

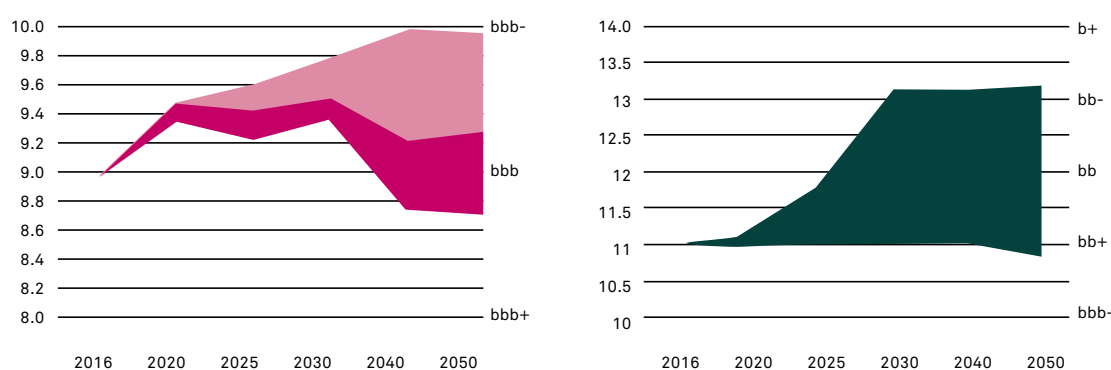
The following section summarizes key insights from the analysis of potential credit quality implications drawn from The CO-Firm's climateXcellence scenarios. The findings focus on trends and findings that apply systematically across the universe of companies assessed, rather than findings for individual companies. The dataset represents potential futures of a sample of actual companies based on their assets today and assumptions of how these assets, company strategy, and financial performance might evolve in the future. However, for the purposes of this report, individual companies have been kept anonymous. Reasons for this include:

- To avoid any undue inferences over future credit quality of actual companies given the inherently high degree of uncertainty over future outcomes, which are only a subset of potential futures, and whose assessments in this report extend long term through to 2050 and require significant assumptions to be made.
- The fact that simplifying assumptions were made to assess only primary high-emitting business segments, meaning that some credit outcomes only represent a subset of any company with multiple business segments (for example, power generating utilities that also have significant activities in natural gas distribution are only assessed on their power generating activities).
- In the results for the cement sector, a further limiting factor is that only six countries of operations were included in the scenario modelling, rather than full global operations.

Visualizing the Results

Results of the credit quality assessments can be visualized in terms of the range of impacts of the modelled scenarios on credit scores over time. In the following two illustrative examples, a dark coloured area represents the range of potential credit quality outcomes across the 2°C ACT and 2.7°C LCT scenarios, under Market and Market EBIT adaptive capacity pathways, from a 2016 base year. The lighter shaded areas represent variability within the Frozen baseline case in 2°C and 2.7°C scenarios, if it extends outside of the range of the above adaptive capacity outcomes. In the graphs, an increase in score represents a weakening of credit quality, and a reduction in score represents an improvement in credit quality.

Figure 5: Visualizing impacts on credit quality



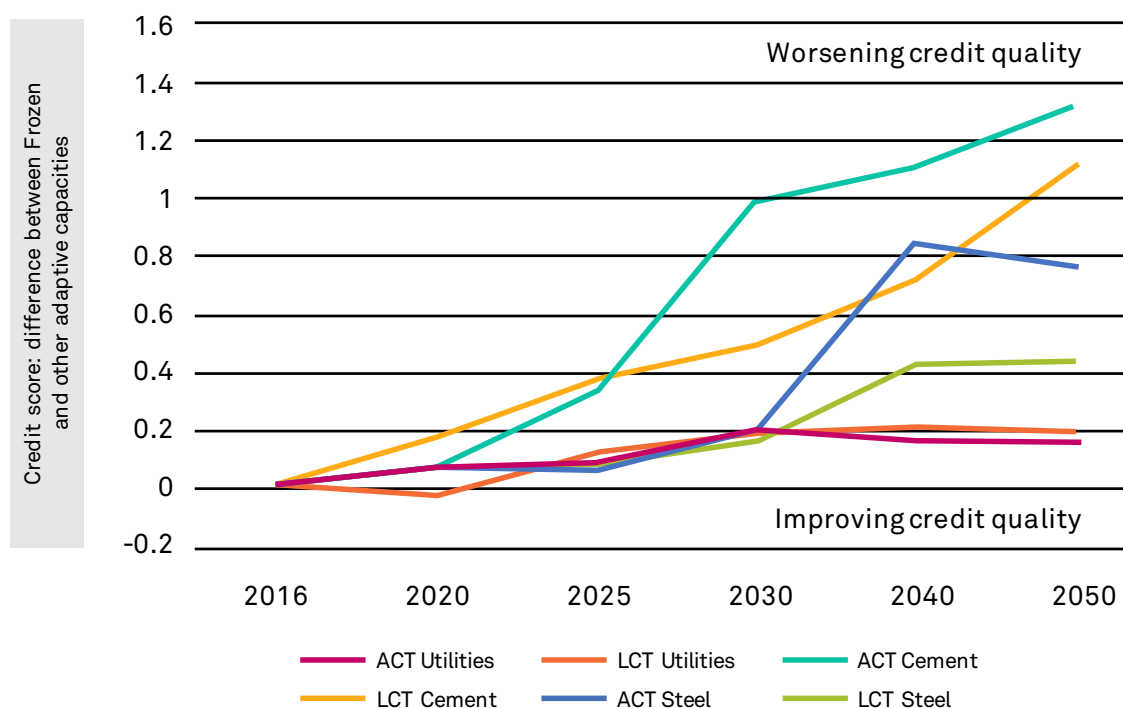
Source: Trucost, The CO-Firm. Figure is for illustrative purposes only.

Key Finding 1: Inaction by companies has consistently negative credit consequences under transition scenarios.

Examining differences in credit quality between Frozen and other adaptive capacity pathways provides a simplified, but illustrative, measure of the potential implications for the creditors of high-emitting companies that disregard potential climate risks and opportunities and do not change their strategies and asset portfolios. When asset portfolios are not adapted, consistently worse credit quality outcomes are evident, with the effect of credit quality worsening over time. The potential credit consequence of inaction is estimated to be most significant for the cement sector and least for utilities. However, it should be noted that the assumptions of this Frozen adaptive capacity pathway are unlikely to unfold, as most companies would almost certainly adapt in some way to address their changing operational environments, even though the specific actions are subject to significant uncertainties.

Figure 6: Negative credit quality impacts of a failure to adapt

Average notch difference in credit score between Frozen and other adaptive capacity pathways



Source: Trucost, The CO-Firm

Key Finding 2: Transition scenarios do not create uniformly negative implications for companies assessed.

Credit quality moves to different degrees and in different directions depending on the company and scenario-adaptive capacity-year combination.

Looking across all sectors and all plausible⁷⁸ scenario-adaptive capacity-year combinations, four companies' credit quality is consistently impacted in a positive manner, albeit to varying degrees, while another four have the potential to either improve or deteriorate over time. One company's change in creditworthiness is consistently negative, but ranges between an insignificant change to a two-notch deterioration.

Overall, however, there are more observations of credit quality improving than worsening. A key implication is that, in at least some cases, a company's ability to grasp transition opportunities and a strategic alignment with energy transition drivers appears to be capable of outweighing the effects of transition risks, and result in improving credit quality.

The following table expresses the changes in potential credit quality by frequency of observations, where each observation is a plausible scenario-adaptive capacity-year combination for one of the nine companies. Results indicate that potential improvements in credit quality dominate across the transition scenarios and sample of companies examined.

Table 3: Credit quality could shift in either direction due to a low-carbon transition

*Cumulative credit score movements relative to 2016 across plausible scenario-adaptive capacity-year combinations**

Credit Score Change	2020	2025	2030	2040	2050
2 notch worsening	0	0	1	1	1
1 notch worsening	0	0	0	0	0
<1 notch change	36	34	31	31	30
1 notch improvement	0	2	4	4	5
2 notch improvement	0	0	0	0	0

* Excludes Frozen adaptive capacity pathway

Source: Trucost, The CO-Firm

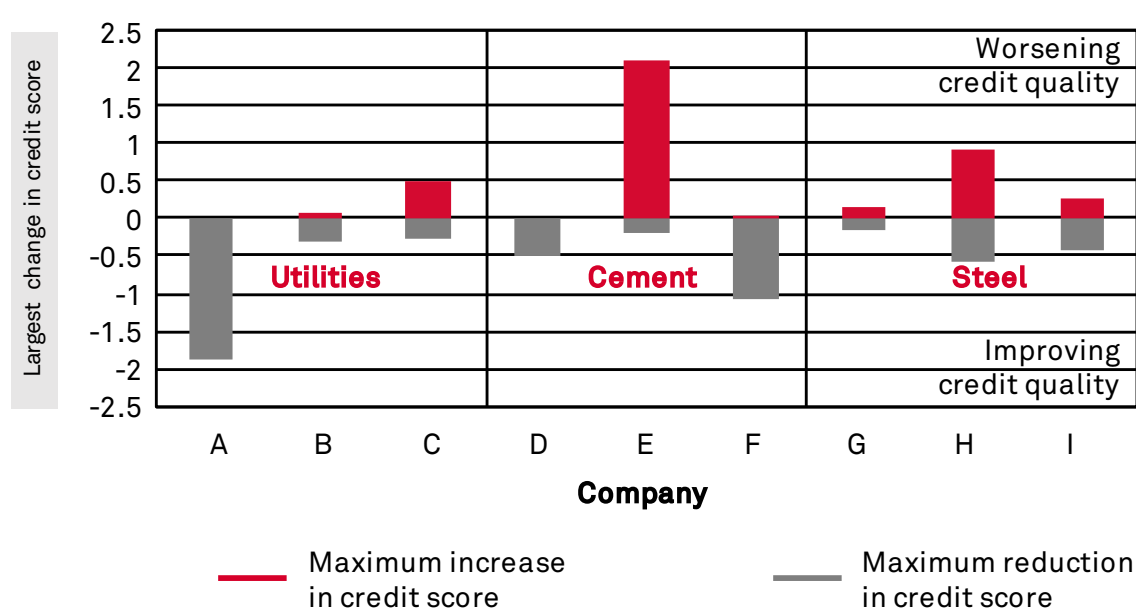
⁷⁸ For this purpose, the Frozen adaptive capacity pathway is excluded from consideration. Under the Frozen pathway, asset portfolios do not change at all beyond 2020 or 2022. It serves as a measure of the effects of inaction in adapting asset portfolios to climate risks and opportunities, but does not reflect a plausible scenario each companies would follow based on observed market, regulatory, technological and other drivers.

Key Finding 3: Only a third of companies assessed are estimated to have material changes in credit quality under the range of scenario outcomes and years examined.

Across the nine companies evaluated, the majority (six companies) were estimated to experience changes in credit quality of less than one credit score notch higher or lower in all scenario-adaptive capacity-year combinations considered plausible. For these six companies, the transition risks and opportunities embedded in the scenario dataset, combined with plausible adaptive capacity pathways (Market or Market EBIT), do not materially change measures of credit quality, though there are slight variations in credit scores within their starting scoring band.

Figure 7: A minority of assessed companies exhibit material changes in credit score

Range of changes in credit score from 2016 baseline*



* Excludes Frozen adaptive capacity pathway

Source: Trucost, The CO-Firm

The number of changes in credit quality equivalent to one or more score notch grows over time, with the first estimated to occur in 2025 for one power utility company. Its credit quality continues to improve and comes close to a two-notch score improvement. The potential improvement in credit quality for this utility is consistent across both the ACT and LCT scenarios, and across Market and Market EBIT adaptive capacity pathways. However, there is no significant expected movement in credit quality for the remaining two power utilities across plausible transition scenarios.

The climateXcellence modelling indicates that power utility industry earnings increase under both the 2°C and 2.7°C scenarios. Growing carbon prices are a driver of higher electricity prices, and there is significant growth in power demand and capacity with growing electrification, population, and GDP – factors that, in turn, result in higher earnings for the industry after 2020, except for coal-fired power assets.

Differences in the outcomes between utilities are driven by complex and intersecting factors. Utility Company A, whose credit quality improves significantly under the climateXcellence scenarios, has a high degree of sensitivity to changes in electricity and fossil fuel prices, and a high share of nuclear power generation assets. Its growth in earnings is supported by capacity payments by regulators for dispatchable power supply that are assumed in the modelling, which complement declines in other dispatchable power supply from fossil fuels and a growing share of generation from variable renewable sources.

The other two power utilities fail to see improvements in credit quality, but see their earnings increase and are able to maintain their current credit quality. Their current strategies and diverse asset portfolios indicate significant opportunities with the growing demand for natural gas and renewable power generation.

Two of the three cement companies also face potential shifts in credit quality within the transition scenarios examined. One company's implied score improves by one notch, while the other's worsens by the equivalent of up to two notches. Changes in credit quality for these cement makers were less consistent across different scenario-adaptive capacity-year combinations than was the case for the utilities.

Companies in the steel sector are less impacted under the transition scenarios. Results indicate that none of the three steel producers examined has a change in credit quality equivalent to as much as one score under any of the examined scenario-adaptive capacity-year combinations through to 2050.

A number of factors contribute to differences in credit quality implications within the cement and steel sectors, influencing the direction and magnitude of change. Companies whose assets comprise a diverse mix of production technologies and countries of operation generally fare better than ones with concentrations within a narrow range of production technologies or countries, including their home markets in Europe.

More specifically, companies that had concentrations of asset types with the highest emissions profiles, whose costs will rise or usage will be curtailed by climate policies, generally suffered. For example, in the case of steel producers, this included companies focused entirely on the more emissions-intensive blast furnace relative to companies that have diversified operations using electric arc furnace and direct reduced iron technologies, which have stronger prospects for growth and profitability under climate transition scenarios. Over the long time period considered, industry dynamics for these different production methods, and production methods available in other industries, can be expected to change substantially in favour of processes with greater carbon efficiency, where new assets are expected to be required to match growing demand or make up for the retirement of facilities using legacy high-emitting technologies at the end of their useful operating lives.

Companies with operations solely or primarily in advanced developed countries that are expected to face earlier and more substantial carbon prices and other complementary climate policy costs, or which have mature markets with lower projected growth in demand, also suffer, as the model assumes that companies do not enter new countries in which they do not currently have operations. Companies could incur losses or lower margins due to higher carbon prices until carbon capture and sequestration becomes a cost-effective option.

By comparison, cement and steel producers operating in developing countries with higher growth rates and lower carbon costs are comparatively well positioned within the climateXcellence results.

One cement maker in the analysis could suffer worsening credit quality equivalent to two notches in credit score driven by its focus on countries expected to have stagnating cement demand together with high carbon prices. However, the effect of these drivers on credit scores is only material for the 2°C ACT Market EBIT adaptation pathway, while its impact in other scenario-adaptive capacity pathways is muted. By contrast, another cement maker could improve its credit score by one notch on the basis of greater exposure to operations in growing emerging markets.

Results assume that companies without current operations in a given country or technology do not make new strategic moves into these areas. Though a simplifying assumption, this provides consistency with companies' existing business strategies and greater relevance for engaging with those companies today, relative to making assumptions about what new regions or technologies a company could expand its operations into.

Key Finding 4: For utilities and steel companies, a 2°C ACT provided consistently better company credit outcomes than a 2.7°C LCT, while for the cement companies the results were consistently opposite.

Credit quality was consistently higher under the ACT 2°C scenario for utility and steel companies. If we compare the ACT and LCT scenarios across multiple equivalent adaptive capacity-year combinations, credit quality was higher under the ACT scenario for 58 scenario-adaptive capacity-year combinations, compared with only two combinations where the ACT scenario entailed lower credit quality. Together with the finding that the only material change in credit quality in these sectors was one utility company, whose implied credit score improved by almost two scores, this suggests that some utilities and steelmakers have viable pathways to maintain or improve credit quality under a range of possible transition outcomes, though it is unclear to what extent these results are specific to the companies assessed, or whether these results could differ across a wider, more diverse group of companies in these industries.

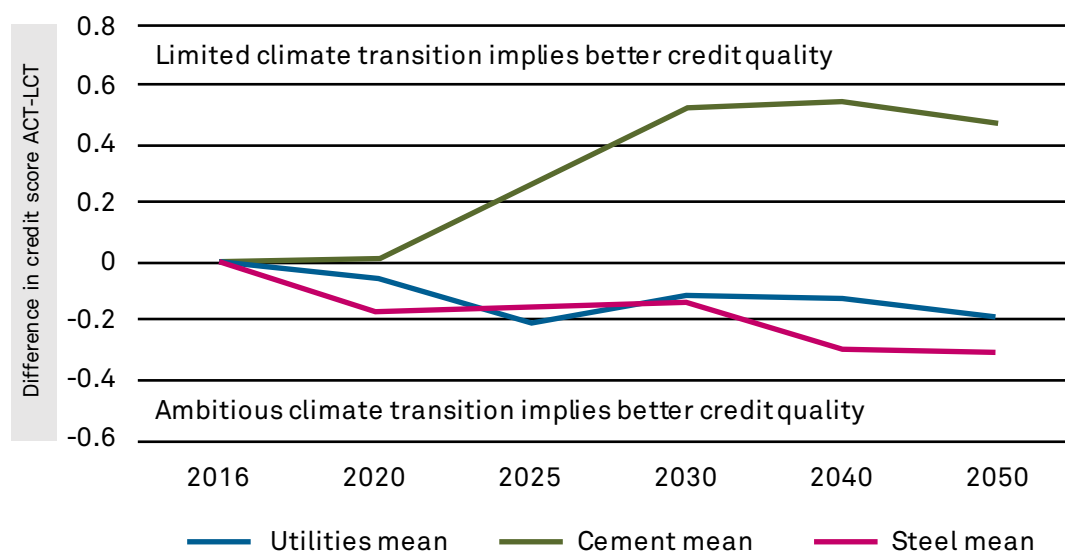
This is in contrast to the three cement companies assessed, where the 2.7°C LCT scenario was more beneficial to credit quality in most plausible scenario-adaptive capacity-year combinations (25 out of 30 unique observations), and this difference was more significant in magnitude.

This suggests a more narrow range of viable pathways for some cement makers to maintain or improve credit quality if more aggressive climate mitigation is to occur, though once again results may not extend to all other cement makers globally. Underlying these results for the three cement companies assessed here, the higher carbon allowance prices in advanced economies associated with a 2°C outcome create a competitive environment with risks of greater clinker imports from countries with low carbon prices, particularly in geographies with proximity to potential clinker transport by ship. This competitive potential limits the ability of producers in developed markets to pass carbon costs through to customers and compresses their profit margins under the 2°C scenario.

However, it is also necessary to subject the cement results to more provisos recognizing that the climateXcellence scenarios modelled only consider cement assets in six countries – Brazil, France, Germany, Italy, Mexico, and the US – rather than providing a full global view, as with the other two sectors.

Figure 8: Credit quality implications of an ACT versus LCT

*Range of changes in credit score from 2016 baseline**



Note: In this graph, each line represents the average of Market and Market EBIT credit outcomes averaged across the three companies examined for each industry.

Source: Trucost, The CO-Firm

Limitations and future areas of research

The results should be considered illustrative and exploratory, rather than definitive. As previously noted, it is important to remember that scenarios represent plausible future pathways under uncertainty. Scenarios are not associated with probabilities, nor do they represent a collectively exhaustive set of potential outcomes or actual forecasts.

Further work needs to be done by investors to embed scenario analysis in credit and other investment analysis. Research that is more widespread is needed to validate these findings across a range of companies and industries, using a variety of credit risk modelling approaches.

Not all financial KPIs with high explanatory value in the CreditModel™ were available in the underlying climateXcellence scenario dataset, so had to be separately assumed or imputed as part of the credit modelling process, and separate from the scenario modelling process. These included important values for assets, debt, and leverage. A scenario modelling process that generates a more complete interrelated set of balance sheet, cash flow, and income statement items would provide greater consistency and, potentially, greater insight when it comes to estimating credit risk.

This issue was partially mitigated through additional assumptions made by Trucost, the ability for imputation of some missing values using the CreditModel™, and sensitivity analysis around variables missing in the underlying scenario dataset.

The credit analysis undertaken in this paper was performed using a quantitative credit risk assessment model, one of several available methods of assessing credit risk. There could also be significant additional value and insight gained by integrating forward-looking results from scenario analysis into a detailed fundamental credit risk assessment that also considers a range of qualitative factors related to climate governance, strategy, and management. Ideally, such an assessment would include multiple dimensions of climate risk, including physical risk. However, doing so for specific company credit risk assessments was outside the scope of this project, in large part due to limitations in the breadth of data available to execute a more comprehensive credit assessment approach.

CONCLUSION & IMPLICATIONS

High-emitting companies, and by extension their lenders and creditors, are increasingly being recognized as facing exposure to material risks and opportunities related to the energy transition. However, key aspects of these future developments are subject to significant uncertainty. One way of grappling with this uncertainty is through the use of scenario analysis. The exploratory findings of the scenario analysis described in this paper indicate that the impacts on creditworthiness from transition risks and opportunities could be negative or positive, and of varying magnitudes, depending on the particular company assessed, even within a given industry and region. This suggests the potential emergence of winners and losers within industries, and an importance for investors and creditors to better understand the implications over medium- and long-time horizons, in addition to the more short-term nature of financial analyses commonly used in debt and equity markets.

The analysis also suggests that the impacts on credit quality of company inaction are consistently negative across companies and scenarios, and that the credit quality of companies in some very high-emitting industries could be stronger under scenarios that limit warming to 2°C relative to 2.7°C. However, it is only in a relatively small subset of scenarios that credit impacts appear likely to be material.

The TCFD recognizes that this type of scenario analysis is at an early stage of development, and capabilities are still evolving, having an expectation that those capabilities will improve over time.⁷⁹ There is still much work to be done, and many investors are just beginning this journey. The PRI reports that only 12% of its signatories undertook climate scenario testing in 2017.⁸⁰ At this early stage in the integration of scenario analysis, there is space and investor demand for experimentation with a range of scenario analysis techniques, tools, and data sources. A range of stakeholders - companies, investors, lenders, their service providers, as well as civil society and academic institutions and other relevant stakeholders - each have the potential to play a valuable part in developing and mainstreaming climate scenario analysis by bringing their diverse competencies and perspectives to bear on the topic. Collaboration and knowledge sharing will be key to enabling faster and more rigorous development of best practices.

Only after a capacity-building phase, including experimentation and trial and error in methods and the investment community gaining comfort with the insights to be had from climate scenario analysis, can it be expected scenario analysis will be utilized substantively in investment decision-making. Investors and lenders can get started today by engaging with others on climate scenario analysis and its results. A number of investors have already been active in requesting disclosures of scenario analysis by companies, and companies are increasingly responding with new publications on scenario analysis. Equity and debt holders have also used less formal or visible means to encourage scenario analysis to be undertaken and disclosed.

Today, there is growing recognition that engagement is not just a viable strategy for equity investments, but that strategic engagement from credit investors can have meaningful impacts on influencing corporate behavior and managing issuer climate and other ESG risks.⁸¹

⁷⁹ TCFD (2017). Technical Supplement: The Use of Scenario Analysis in Disclosure of Climate-Related Risks and Opportunities. June 2017.

⁸⁰ annualreport.unpri.org/data-snapshot.html.

⁸¹ Principles for Responsible Investment (2018), *ESG engagement for fixed income investors: Managing risks, enhancing returns*, <https://www.unpri.org/download?ac=4449>.

This could take the form of direct bilateral engagements, or by contributing to collaborative engagement initiatives, like Climate Action 100+ that is being coordinated by the PRI and regional investor groups on climate change.⁸²

As scenario analysis becomes more widespread and institutionalized, there may also be opportunities for investors to identify and select securities from issuers that have better prospects under likely transition scenarios, or where analysis of plausible scenario outcomes suggests a current mispricing of risk.

Table 4: Incorporating climate scenario analysis in investment strategy

*Cumulative credit score movements relative to 2016 across plausible scenario-adaptive capacity-year combinations**

Build capabilities to undertake and interpret climate scenario analysis, and use this to understand portfolio exposures to climate risks and opportunities	Take engagement and investment actions consistent with risk tolerances, informed by scenario analysis	Monitor and report on progress in integrating scenario analysis to investment decision-making
Encourage scenario analysis and its disclosure from relevant companies	Engage with borrowers or issuers, policymakers, and other stakeholders on findings of scenario analysis	Monitor activities and progress in integrating climate scenario analysis, report in a balanced fashion to internal and external stakeholders, including challenges and limitations
Develop forward-looking scenario data and analysis in-house	Invest with climate risk and opportunity factors integrated into decision-making	Collaborate with industry peers and technical experts to share information and experiences, and build best practices
Encourage development of scenario data and analysis by external providers	Consider thematic investments that grasp opportunities	
Integrate insights into investment research processes and publications	Avoid issuers through exclusion or reducing exposures where risk exposures are not compatible with risk tolerances	

Source: Adapted from the Measure – Act – Review climate change strategy framework in Principles for Responsible Investment. Developing an asset owner climate change strategy: Pilot framework. <https://www.unpri.org/download?ac=1885>

To accelerate progress in climate scenario analysis, investors and lenders may also have to undertake or commission their own independent scenario analyses. Such analyses may provide greater consistency of findings across issuers, and transparency. This paper has provided illustrative results of such an independent climate scenario analysis focused on the needs of debtholders, and is indicative of one potential combination of data sources, models, and methodologies through which analysis could be scaled to a different or larger universe of companies. The findings that demonstrate diverse potential credit quality impacts even across a small sample of companies and industries is suggestive of the potential breadth of credit quality outcomes possible across a wider universe.

Hermes Investment Management (2018), *We can all get along - Part I: Why bondholders and long-term shareholders can jointly engage companies*, <https://www.hermes-investment.com/ukw/wp-content/uploads/sites/80/2018/09/hermes-we-can-all-get-along-bond-and-shareholder-engagement-part-1-q3-2018.pdf>.

⁸² <https://climateaction100.wordpress.com/investors/>.

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