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The Climate Risk Tool Landscape

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Featuring an anthology of implementation case studies from financial institutions

Acknowledgments

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Introduction

The importance of climate risk assessments

Societies, governments, and companies have justifiably recognized the threats climate change poses to the global economy. Physical risks such as droughts, sea level rise, and flooding are likely to increase in the coming years, with consequences for real assets, supply chains, and business operations. While critical, mitigating global warming poses challenges as well. Businesses and countries will experience transition risks in the shift from a fossil fuel-driven economy to a low-carbon one.

The financial sector has a central role to play in managing climate-related risks and providing capital for climate resiliency and the low-carbon transition. As a result, a wide range of stakeholders have shown interest in how financial institutions are preparing to confront climate change.

- Activists and civil society have added public pressure for financial institutions to demonstrate that their activities are contributing to a sustainable future.
- National and local governments that have committed to reducing emissions are looking to the financial sector to catalyse the development and deployment of projects that will help them reach those goals.
- Financial supervisors and policy-makers around the world are aware of how climate change can threaten financial stability and have been increasingly setting climate risk management expectations and mandating climate disclosures, climate transition plans, and climate stress testing.
- Shareholders in financial institutions are eager to understand how firms are preparing to confront both physical and transition risks in their portfolios.
- Internal management within financial institutions want to identify the key risks and opportunities that a changing world presents and ensure that their firm is well-positioned.

In recent years, financial institutions have been exploring data, tools, and analytics that will enable them to meet the needs of these stakeholders. While many institutions are developing in-house climate capabilities, most are also working with outside vendors to obtain the skills, information, and outputs they require. As a result, there is a burgeoning market for climate solution providers for financial institutions to choose from. These providers can range from public data sources from organizations such as the United Nations and the World Bank to paid providers who can create bespoke tools for an institution.

Program and module overview

TCFD program retrospective

The work in this report was carried out as part of UNEP FI's TCFD programme. Since the publication of the FSB's TCFD recommendations in 2017, UNEP FI has run a series of pilot programs to assist members in exploring physical and transition risks and developing practical approaches for evaluating these risks using climate scenario analyses. Over 100 financial institutions (banks, investors, and insurers) from all around the world have participated in these pilots. Participating institutions have been supported by over a dozen technical partners including climate modelers and climate risk experts.

The latest TCFD programme (beginning in March 2021) involved forty-eight global banks and investors. The program contained two parallel components. The first was a climate risk roadmap to empower participants at all stages of their climate disclosure journey. The roadmap featured dozens of interactive discussions with regulators, climate modelers, climate scientists, as well as peer presentations. The second component was a series of "modules" where participants could dive deeply into specific aspects of climate risk. These modules explored topics from the economic impacts of climate change to conducting a climate stress test.

Detail on the Landscape Review Module

The case studies and recommendations for tool providers that comprise this paper were completed as the primary output of the module titled: "Landscape Review of Climate Risk Assessment Methodologies" or the "Landscape Assessment" module. The Landscape Assessment module offered participants hands-on opportunities to learn about and demo the latest physical and transition risk assessment tools. The module allowed participants to explore the range of climate risk tools and determine their strengths, limitations, and areas for potential enhancement. Over a dozen tool and data providers gave presentations to the group about their methodologies and analytics. The module was also supported by expert guidance and insights from the Centre for Economic Research at ETH Zurich.

The module contained three phases:

1. **First phase—background and context**

In the first phase of the module the lead authors of UNEP FI's Climate Risk Landscape report (UNEP FI 2021) discussed the report's key messages and conclusions with participants. The participants then compared methodologies for transition risk assessment based on ETH Zurich's paper: Taming the Green Swan (ETH, 2020). The ETH sessions allowed participants to consider multiple dimensions of existing tools as shown below.

Figure 1: Areas of assessment in ETH tool analysis

I.	**Accountability**
1	**Public transparency**
a	Model modules, code public
b	Study questionnaire completed*
2	**Emission data strategy**
a	Data sources reported
b	Third party verified
c	Missing data strategy explained
3	**Science-based approach**
a	Scientific references
b	Peer-reviewed
II.	**Depth of risk analysis**
4	**Hazard (shock/smooth trnsition)**
a	1.5/<2°C scenario
b	Country=differentited
c	Sector-differentiated
5	**Exposure**
a	Current GHG emissions
b	Expected GHG emissions
6	**Vulnerability & resilince**
a	Profits to cover costs
b	Peers performance. competition
c	Cost pass through

7	**Adaptability**
a	Input substitution
b	Climate strategy, climatee-ligned R&D or future CAPEX plans
8	**Economic Impact**
a	Economic losse and gains
b	Macroeconomic development
9	**Risk amplification**
a	Mutual risj amplification
b	Financial market amplification
III.	**Usability**
10	**Output interpretability**
a	Model structure, scanarios and assump-tions reported
b	Assumptions-based output communica-tion
11	**Uncertainty**
a	Baseline adaptable
b	Scenario-neutal (various risk realistions)
c	Profitability distribution input (timing)
d	Profitability distribution output (values)

Following these background sessions, participants worked with UNEP FI to define a set of criteria for producing a structured case study on the tools they would pilot in the second phase. The agreed-upon structure is referenced in the case study section of this report.

2. Second phase—tool presentations and demos

Figure 2: Tool and data providers which feature in the case studies in this paper

In the second phase of module UNEP FI invited around fifteen tool providers to provide a demonstration of their latest climate risk assessment tools to the participants. In these interactive sessions, participants were able to ask providers about tool methodologies, coverage, and functionality. At the end of these demonstrations tool providers gave details on the potential piloting of their tool (e.g., how many participants could pilot, how many assets would be assessed, what outputs may look like).

Following these demonstrations, module participants decided which tools would be most appropriate for their institution to pilot. UNEP FI then matched up participants with tool providers and held an introductory session to provide the parameters of the pilot and to kick off the collaboration between providers and participants. During the course of the pilot, providers and participants met bilaterally to discuss topics such as data required and interpretation of outputs.

3. Third phase—review and case studies

The third phase of the module allowed participants the opportunity to discuss the piloted tools with the wider group. These post-pilot discussion sessions enabled participants to compare their experiences in the pilot and discuss the strengths and limitations of the tools they had seen. These feedback sessions facilitated the drafting of the case studies found within the report.

Objectives of this report

Given the expanding use cases for climate risk analyses in the financial sector and the growing number of tool providers, over the past few years, UNEP FI has worked to inform financial institutions about the structure, coverage, and methodologies of commonly used tools. This research has encouraged firms to integrate climate risk analyses into their operations and ensure they are informed consumers of climate tools and data.

In 2019, UNEP FI published Changing Course, as an output of the TCFD pilot for investors (UNEP FI, 2019). This report covered the climate risk assessment methodology developed as part of the pilot (in coordination with Carbon Delta), but also explored a selection of other methodologies that analytical tools have deployed to assess climate risks.

Since the release of Changing Course, climate risk analysis has gone mainstream. Demands of regulators and other stakeholders has driven financial institutions to improve their capabilities for conducting physical and transition risk analyses. Financial institutions have also identified new needs such as improved geographic coverage for physical hazards and 1.5°C-aligned scenarios for assessing transition risk. Tool providers have responded by increasing their offerings and developing new approaches to generate decision-useful and actionable outputs for their clients. A number of new providers have entered the market while others have partnered or been acquired in order to enhance their capabilities.

Due to the rapidity of change around climate risk tools, in early 2021, UNEP FI released The Climate Risk Landscape, a report that mapped climate-related financial risk assessment methodologies. The landscape review summarized key developments across third party climate risk assessment providers since the publication of Changing Course, including new and updated scenarios, methodological tools, as well as an overview of the changing regulatory landscape and potential future developments. The report explored almost 40 providers, split between physical and transition risks. These providers completed a detailed survey to inform key conclusions about the state of third party tools. A summary of the assessments is shown below. For physical risk tools, the report built on work within UNEP FI and Acclimatise's 2020 paper, Charting a New Climate (UNEP FI and Acclimatise, 2020). For transition risk tools, the report benefitted from the analyses included in ETH's 2020, Taming the Green Swan, which provided deep methodological assessment of existing transition risk tool providers (ETH, 2020).

Figure 3: Summary table of physical risk tools from The Climate Risk Landscape, 2021

			Provider																		
			427 (1)	427 (2)	ACC	ACC-WTW	C4 (1)	C4 (2)	CFIN	CW	MSCI	OF (1)	OF (2)	RhG	RMS	SP (1)	SP (2)	TCS	VE-PL	VR	XDI
Scenarios	<2.0°C (RCP 2.6)				✓	✓			✓		(✓)[i]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Scenarios	2.0°C (RCP 4.5)		(✓)[i]		✓	✓	✓	✓	✓	✓	(✓)[i]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Scenarios	3.0°C (RCP 6.0)				✓	✓	✓		✓		(✓)[i]	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Scenarios	>4.0°C (RCP 8.5)		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Time horizons	Baseline/historical				✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Time horizons	Near term (2025–2040)		✓	✓	✓	✓			✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Time horizons	Medium term (2050)		(✓)[i]		✓	✓	✓	✓	✓	✓[ii]		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Time horizons	Long-term (2100)		(✓)[i]				✓	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Physical Hazards	Chronic		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Physical Hazards	Acute		✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Risk analysis	Level of analysis	Asset	✓	✓	✓	✓	✓	✓		✓			✓	✓	✓		✓	✓	✓	✓	✓
Risk analysis	Level of analysis	Firm	✓	✓	✓	✓	✓	✓	✓					✓	✓	✓	✓	✓	✓	✓	✓
Risk analysis	Level of analysis	Sector	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓			✓	✓	✓	✓
Risk analysis	Level of analysis	Country	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓			✓	✓	✓	✓
Risk analysis	Level of analysis	Portfolio	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓		✓	✓	✓	✓	✓
Risk analysis	Impact Channel	Macroenvironment		✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	
Risk analysis	Impact Channel	Supply chain		✓	✓	✓	✓		✓			✓	✓		✓	✓	✓	✓	✓	✓	✓
Risk analysis	Impact Channel	Operations and assets	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Risk analysis	Impact Channel	Markets and customers		✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
Risk analysis	Method	Physical Exposure	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Risk analysis	Method	Vulnerability indicators		✓	✓		✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓
Risk analysis	Method	Physical impact modeling	✓	✓		✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Risk analysis	Method	Financial modeling	✓	✓		✓			✓			✓	✓	✓	✓		✓	✓	✓	✓	✓
Physical Hazard Type	Flood, coast		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
Physical Hazard Type	Flood, inland		✓	✓	✓	✓	✓	✓	✓	✓	(✓)[i]	✓	✓		✓		✓	✓	✓	✓	✓
Physical Hazard Type	Extreme weather		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
Physical Hazard Type	Extreme heat		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓			✓	✓	✓	✓	✓
Physical Hazard Type	Extreme precipitation		✓	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓		✓	✓	✓	✓	✓
Physical Hazard Type	Landslide				✓	✓	✓	✓				✓	✓						✓	✓	✓
Physical Hazard Type	Drought		✓	✓	✓	✓	✓	✓			(✓)[i]	✓	✓		✓		✓	✓	✓	✓	✓
Physical Hazard Type	Water scarcity		✓	✓	✓	✓	✓	✓									✓	✓	✓	✓	
Physical Hazard Type	Wildfire		✓	✓	✓	✓	✓	✓	✓		(✓)[i]	✓	✓		✓		✓	✓	✓	✓	✓

This current report aims to extend the work of The Climate Risk Landscape in a new way. Rather than expanding the number of providers explored (a topic for the next edition of the landscape paper), this report seeks to catalogue the actual experiences that financial users had while piloting different tools. The detailed case studies include insights into the process, challenges, outputs, and learnings related to using selected climate risk tools. These case studies should be seen as a companion to the categorizations provided within The Climate Risk Landscape. Together, the two reports begin the process of providing financial users with a resource for understanding both the theoretical attributes of different tools as well as how they function in practice.

In addition, the case studies were designed to inform tool providers on specific topics and aspects where their tools and services could benefit from additional components, and where they could be enhanced or complemented with further information and features. Finally, the case studies were designed to inform supervisory authorities and regulators about the status quo of tool applicability, possible existing gaps and ways forward in the near future.

Through this piloting process, participants gained deep familiarity with the tools they used and provided feedback and reflections on their experiences. The following section discusses some of the major trends related to climate risk tools observed by UNEP FI and participants as well as areas for further tool development. Given the emerging trends towards better comparability and baseline climate risk metrics in climate risk disclosures, this report could also inform about the status quo of tools coverage and performance, and possible issues to be solved by regulatory guidance in the near term.

Key takeaways on climate risk tools

Major trends to note

- **Tool creators are partnering and larger players are bolstering their capabilities through acquisitions**

With growing demand for climate risk tools and data, mergers & acquisitions are becoming ever more common. These partnerships can be between tool developers and data providers, such as between Oliver Wyman and S&P Global Market Intelligence to launch their Climate Credit Analytics platform. They can also include acquisition of climate expertise into a larger professional services firm. Examples of this include Willis Towers Watson's acquisition of Acclimatise, Moody's Analytics acquisition of Vigeo-Eiris, and McKinsey's acquisition of Vivid Economics. Whether through partnership, joint venture, or acquisition, the moves towards collaboration and consolidation may expand the resources in standard financial service providers capabilities devoted to climate risk tool development. This trend is a signal of growing investment in provider capabilities.

- **Transition and physical risk methodologies are being combined**

In the past, many tools focused exclusively on physical risks or transition risks. However, as financial institutions and supervisors look to assess overall climate strategies and exposure to climate-related risks, a more integrated approach has been required. This has been very much driven by the physical-transition risk-combined reference scenarios of the NGFS. Rather than assessing physical risks and transition risks under different scenarios, some tool providers have sought to provide a holistic view of a firm's climate-related risks under different scenarios. Providers such as ISS-ESG and Moody's Analytics offer combined assessments for both risk types, while other providers calculate risks separately and then aggregate them. While the consideration of interaction effects between transition policies and physical risks is complex, the first steps are being taken in this direction. For example, in the NGFS's latest climate scenarios, the trade-off of impacts between transition and physical risks were incorporated into the reference scenarios.

- **Development of tools to meet regulatory expectations**

In 2021, a handful of jurisdictions announced mandatory climate risk disclosures (often based on the TCFD framework), climate risk management expectations, and climate stress tests. These increased demands represent a growing appreciation of the risks that climate changes poses to the financial system and a desire to understand the nature and magnitude of those risks. Two of the most comprehensive stress tests have been developed by the Bank of England/Prudential Regulatory Authority and the European Central Bank. Their exams require financial institutions to modify existing stress testing models and create new ones. Third party tool providers have closely observed the expectations of these leading central banks in developing offerings to meet the needs of financial users. Data providers have also been focusing on providing detailed information on counterparties, regions, and industries necessary to generate stress testing outputs.

- **New physical risk data sources and improved granularity**

One of the major challenges tool providers seek to address is converting physical and transition risk data into financial impacts. Doing this effectively demands reasonably granular data that captures elements of financial relevance. Given that many of the original forecasts of climate-related physical risks were developed for scientific purposes, a recent focus of data providers has been on the needs of corporate and financial users. Initiatives such as ClimINVEST are developing open source access to physical risk data as is the EU's Copernicus Climate Change Service (E3CS). Alongside E3CS, through the Linux Foundation, Open Source Climate (OS-Climate) aims to be a clearinghouse for climate data needed by financial actors. In addition to these initiatives, there are also emerging collaborations between tool and data providers to enhance the resolution and coverage of physical hazard data.

Improved physical risk data allows financial institutions to assess their exposures against physical risks in various regions. The proliferation of data also means that tool providers and financial institutions have shown a greater interest in understanding asset-level physical risks, which are highly location dependent. The ability to evaluate asset-level risks is also enhanced by the increasing frequency and detail of corporate climate-related risk disclosures.

- **Growing interest in machine learning, AI, and remote sensing data sources**

Big data has been key to improved climate model projections for many years. Typical simulations of climatological phenomena are highly computationally intensive. As computing power has grown and new statistical techniques have developed, climate risk tools providers are also looking to leverage advanced data collection and analysis techniques. For physical risks, remote sensing technologies can provide early warnings of a hazard or can offer a more detailed picture in previously data-scarce regions. For transition risks, new technologies can detect methane leaks and other sources of emissions to refine estimates of financed emissions.

Machine learning and artificial intelligence have been increasingly used to pour through climate-related datasets and derive new insights. For physical hazards, advanced data analyses have led to the identification of drivers of extreme event severity and the potential for business and supply-chain disruptions. New data sources and AI have also helped tool providers to refine forecasts in real time. An example is Jupiter Intelligence, which has developed a physical risk model up to 2100 that is constantly updated through satellite and sensor data. Also, AI could help to extract firm-level communications of their own climate targets and strategies, which are by some tool providers included in their risk analyses.

- **New transition risk scenarios and a focus on net zero**

Earlier transition risk assessments focused on comparisons between current policy scenarios and Paris-aligned transition scenarios (below 2˚C). However, in the past few years there has been a growing focus on 1.5˚C scenarios and increased nuance in the design of transition pathways.

First, there has been a widespread recognition of the need to incorporate 1.5˚C scenarios into tools. The global focus on 1.5˚C followed the publication of the IPCC's Special Report on 1.5˚C in 2018 that showed significantly greater harms experienced by a 2˚C warmer world than a 1.5˚C one (IPCC, 2018). That report spurred financial actors to call for the development of 1.5˚C scenarios from leading modelers such as the IEA, which obliged with its net-zero 2050 scenario (IEA, 2021). Climate science indicates that the 1.5˚C threshold requires reaching net-zero CO_2 emissions by 2050, which has become a central goal of policymakers and financial institutions alike. Following COP 26, over 90% of the world's governments had made preliminary net-zero commitments, and they were joined by over 450 financial institutions (GFANZ, 2021). The global consensus on the need for net-zero 2050 and the goal of 1.5˚C have made it imperative that tools enable financial institutions to assess their performance under these objectives.

In addition, there has been a growing appreciation that while more ambitious temperature targets can increase transition risks, the nature of the transition itself (orderly vs. disorderly) can have a major impact on the level of transition risk experienced. In UNEP FI's paper Decarbonisation and Disruption, the effects of a disorderly transition were explored for various economic sectors (UNEP FI, 2021). Likewise, the latest NGFS scenarios have developed scenario narratives that explore both orderly and disorderly transitions as well as the implications of delayed action and regional policy differences (NGFS, 2021). These NGFS scenarios provide a more detailed picture of the risks that may result from different transition pathways, and tool providers and financial institutions have been eager to determine the impacts of these new scenarios on financial portfolios.

- **Rising expectations of tool capabilities from FIs**

As more financial institutions use climate risk assessment tools and are faced with growing pressure to disclose and act on their climate risks, tool providers have sought to improve their offerings. Broadly, financial institutions look for tools to be: decision-useful, disclosure-useful, and commitment-useful.

Decision-useful tools enable senior leadership and those in the business to act on the outputs produced by the tool. Such outputs can inform overall climate strategy, improve client engagement, and spur the development of new policies. Decision-useful outputs should be clear and able to answer the questions posed by users.

Disclosure-useful tools are developed to meet regulatory or other external disclosure requirements. They can be used for climate stress testing, TCFD reporting, or other sustainability disclosures. Multiple tool providers have worked to develop approaches that allow a financial user to easily translate the outputs of the tool into commonly used reporting frameworks. In a sense, these tools work backward from the reporting expectations in order to produce outputs that are likely to align to reporting standards.

Commitment-useful tools recognize the large number of financial institutions that have made commitments to green-financing and net zero in recent months. These tools enable appropriate target-setting and can also help financial institutions to monitor progress against specific targets. For commitment-useful tools, the methodology used in the assessment is particularly important as it may need to align with the methodology permitted under specific target-setting protocols.

Tools can serve more than one of these functions and often do.

Recommendations for future tool enhancement

As the trends above suggest, tools are constantly improving as providers look to meet the needs of their financial services clients. However, through the piloting exercise and group discussions, UNEP FI and the participating financial institutions identified several areas for future tool enhancement. These recommendations are geared towards tool providers (both third party and within institutions) in hopes of spurring the further development of approaches and methodologies required by financial institutions. They are grouped into specific areas for ease of reference.

Input data coverage

Although new data sources continue to be developed and many tool providers are working with more data than ever before, financial institutions still identify room for improvement. A common concern for financial users is how appropriate a tool's data is for their portfolio. This can include coverage of different asset classes, economic sectors, and geographic areas. While proxies and extrapolations may be required, there is a strong desire to ensure that their application is both intuitive and transparent. Through the piloting exercise, feedback regarding input data coverage pertained to three areas: physical risk data, transition risk data, and emissions data.

Physical risk data

Regional data coverage

While new sources of data are helping to address gaps in certain regions, much work remains to be done. Pilot participants with holdings in Africa, Southeast Asia, and South America all raised concerns about the degree of granularity offered by climate risk tools. Where data is unavailable, proxies and regional averages are sometimes used. However, there is no replacement for good data, and emerging economies continue to experience data gaps for physical hazards, transition risks, and emissions data.

Physical asset level data

A number of climate stress tests have required financial institutions to conduct counterparty level analyses on potential climate risks. Effective counterparty assessment requires data on the exposures of major assets to physical risks. That in turn demands highly granular data. As noted above, this data is most often lacking in emerging economies, but in some instances even when available only certain hazards are covered.

With a growing interest in asset-level assessments, many tool providers are working to improve their level of coverage and granularity.

Additional physical hazard scenarios
Pilot participants noted that physical risk scenarios typically considered representative concentration pathways (RCPs) associated with IPCC reports. Participants considered the strong mitigation (RCP 2.6) and the no action (RCP 8.5) scenarios to be most relevant in assessing the range of physical risk outcomes. However, within each of the RCPs are a variety of different potential pathways for the development of hazards. These pathways vary based on the underlying climate model used but can demonstrate that even for a given RCP the speed and severity of certain hazards can vary significantly. Participating financial institutions expressed interest in seeing a greater diversity of physical hazard scenarios for given RCPs, something that can be integrated into future tool design.

Transition risk data

Private company transition plans
In late 2021, the TCFD provided new guidance about the importance of disclosing climate transition plans as part of its recommended disclosures (TCFD, 2021). Additionally, certain jurisdictions (such as the UK), have mandated the disclosure of climate transition plans. These plans can provide a wealth of information about a company's preparedness and resiliency during a low-carbon transition. Financial institutions are looking at ways to integrate insights from corporate transition plans into their company-level assessments. Third party tool providers should also consider how this new information can be effectively incorporated into company assessments.

Sectoral assumptions
The transition to a low-carbon economy will affect nearly every sector in unprecedented ways. Assumptions around how different sectors will respond and which industries will be winners and losers of the transition have major implications for tool outputs. When exploring transition risk tools, pilot participants were eager to understand the key sectoral assumptions made by the tools. Participating financial institutions wanted more guidance around sectoral assumptions both to understand their effect on outputs and also to compare them to their own analyses of sector and industry outlooks. Tool providers can offer greater detail on the narratives in their scenarios and the implications of those scenarios for major emitting sectors such as energy, transportation, buildings, and industrials. They can also continue to add nuance to how carbon budgets for these sectors and their associated decarbonisation pathways vary across countries.

Additional transition scenarios

As noted in the trends section, many tool providers have increased the number of transition scenarios available to financial users. The added focus on net-zero pathways and scenarios reflecting current and potential climate policies has been a positive development. However, tool providers can go further in adding nuance to different scenarios, especially for disorderly transition scenarios. While the comparison of an orderly and disorderly transition is useful, a disorderly transition can proceed in many ways. Tool providers can work with economic modelers to consider the implications of different transition pathways on specific sectors and the global economy overall.

Emissions data

Emissions data has become increasingly important for financial institutions to define and track their decarbonisation commitments and to assess the transition risk of their exposures. While initiatives like CDP have done valuable work in collecting and providing self-disclosed data on corporate emissions, coverage is largely limited to public companies. For financial institutions that lend to or invest in small and medium enterprises, a number of assumptions are needed to address reporting gaps. These extrapolation methodologies may have major impacts on a portfolio's financed emissions or its transition risk, and so should be clear, transparent, and aligned with commonly accepted approaches for calculating emissions. Third-party verification of data is also important to validate and improve the quality of self-reported information. Tool providers will need to continue developing methodologies that cover these data gaps in greater detail in order to ensure that outputs generated for alignment and risk assessments are considered credible.

Risk types included

As financial actors and supervisors acknowledge the systemic risk of climate-related developments for financial stability, it has become imperative to gain a comprehensive view of a firm's climate risks. Such a holistic view demands tools that capture potential impacts from a wide range of climate-related phenomena. Pilot participants desired tools to capture the broad set of physical hazards they might be exposed to, common policy-driven transition risks, and emergent literation risks, interactions between risks, and financial system contagion.

Physical risks

Additional hazards

The physical risk tools profiled in the case studies of this report contain a variety of different physical hazards. However, as pilot participants noted, the most prominent hazards may vary significantly by region, and these prominent hazards may require additional detail. An example can be the hazard of flooding, which depending on location may be predominantly driven by coastal inundation (coastal), river overflow (riverine), or rainfall (pluvial) or some combination of these. Some tools already separate hazards into different types, but for those that do not, this additional nuance is welcomed.

Another area of interest involves indirect hazards of climate change. Pilot participants noted that few tools explored topics such as disease burden, water desalinization costs, and biodiversity loss. A full picture of climate risks requires consideration of the range of negative outcomes associated with a warming world. Additional work is needed to determine the financial and economic consequences of some of these more indirect effects of climate change.

Extreme event severities

For physical risks, many tools provide estimates that include both changes in incremental risks and changes in the frequency and severity of extreme events. While the likelihood and nature of extreme events may be moderated by changing baseline conditions (incremental risks), risk managers within financial institutions are highly concerned with the effects of extreme events. However, given different forecasting models there is a large degree of variation in the frequency and severity of these extreme events. Pilot participants sought to consider a larger set of extreme event frequencies and severities in assessing the performance of their portfolios. One way for tool providers to offer this is to show losses under different tail risk events and their associated probabilities (a topic discussed in the methodology points raised below).

Transition risks

Policy risks

During discussions with UNEP FI, pilot participants spoke about their interest in better understanding the implications of various policies on their portfolios. While net-zero commitments have been made by nations around the world, the implementation of this major economic change often remains vague. Different transition scenarios within climate risk tools offer financial institutions the opportunity to consider the effects of various policies and decarbonization strategies. However, among pilot participants, there was a strong recommendation that tool providers include more policy-driven scenarios in their tools and provide clear narratives for how the policies are likely to influence different sectors.

Carbon pricing

While carbon pricing can be considered a policy decision, it also reflects the development of global carbon markets and the use of internal carbon prices by different firms. Pilot participants considered the carbon price one of the clearest ways to evaluate the performance of portfolios and particular counterparties across a transition scenario. Tools that allow users to change the carbon price or compare different carbon prices and their effects were particularly desirable to participants.

Litigation risks

One area of risk rarely, or only indirectly captured by most tools is climate litigation risk. 'Climate litigation risk' in this context refers to the financial risks from any cause of action, regulatory investigation, or any dispute, that has a physical or transition risk catalyst. Customer and counterparty actions that could, for example, give rise to climate litigation include: failures to: mitigate emissions, consider climate change impacts, manage or disclose material climate risks, make accurate representations about climate risks/green credentials, or to comply with regulatory adjacencies.

Climate litigation risks function like other traditional risks in that they can reduce asset values or pose credit risks by creating additional costs that corporates must pay. And whilst it may be challenging to incorporate such risks into tools, the recent growth in litigation in this area means that their consideration is necessary to both fully and adequately assess climate risks.

Additional time horizons

After data granularity and risk coverage, time horizons were frequently brought up by pilot participants as an area for future tool enhancement. Some tools designed for regulatory purposes adhere to the time horizons requested by the supervisory exams, while others align to the time horizons of the publicly available scenarios they take as inputs. These decisions are sensible, but as pilot participants noted in their discussions, financial institutions need to assess climate risks over a variety of time horizons. This can prove challenging given the progressive emergence of physical risks or the time needed to adapt the global economy to a low-carbon operating model. However, greater consideration of short-term shocks can allow financial decision-makers to understand the low-probability high-severity consequences of climate change or the low-carbon transition on today's portfolios. In addition, shorter term risk assessments can be more easily integrated into strategic planning and turned into actionable policies by business lines.

Output application/interpretation

While many providers consider their products as multi-solution tools, pilot participants were eager to better understand the implications and applicability of tool outputs. In order to effectively use the results, participants put a premium on transparency and clarity of assumptions. Relatedly, there was a strong desire to understand the range of uncertainty around different results. Many tools produce a single answer for a portfolio, but according to participants, a range of output values might be as useful if not more so in interpreting the results. Participants also requested additional guidance on how to use tool outputs in reporting and a desire to see illustrative examples to confirm the sensibility of the outputs generated.

Greater transparency

Participants within the UNEP FI pilot program often serve as critical communicators of climate risk insights to the rest of their organization. As a result, these individuals need to understand the outputs and the key assumptions of the tools they are using particularly well. The pilot exercise with tool providers received positive feedback from participants in terms of the transparency and openness shown by the tool providers about their methodologies and outputs. However, that transparency was made possible by direct meetings between the participants and tool providers. It would be valuable for all tool providers to provide accessible documentation that supports a greater understanding of their tools and the associated output among financial users. While this information should not compromise intellectual property, it should enable financial institutions to act as informed consumers of the various tools they may consider using.

Uncertainty around results

All tools based on future projections are subject to uncertainty, a fact widely acknowledged by the pilot participants. More details on the range of that uncertainty in outputs was considered a high priority by program participants. The IPCC itself uses various certainty measures (e.g., highly likely, likely) to connote probabilities of different outcomes in the climate projections it uses. Tool providers could also add more clarity around which results are more likely and which are more highly uncertain. Uncertainty may depend on data considerations, time horizons, and the measures being forecast. However, the inclusion of a form of "error bars" would aid in the communication of tool results and greater confidence in how to act on the information they provide. In addition, users should understand the probabilities associated with different outcomes and where those outcomes fall in a distribution, for example, does an output represent a mean estimate of losses or a 95th percentile? The topic of probabilistic estimates is explored further below.

Clarity in how outputs can be used to meet needs

During the individual tool piloting phase, participants were asked to consider how the tool outputs could be used throughout their organization. Many participants requested that tool providers offered additional guidance for how to interpret results and where the outputs might be most relevant. In the case of regulatory tools, use cases may be clear, but for many outputs, there are a range of potential applications. Tool providers can consider how their outputs might be used and also structure those outputs to fit the needs of these use cases. An example provided by a participant was the challenge in transforming the outputs from the tool into a format that could be incorporated in a TCFD report. Another question regarding tools involves how to effectively use outputs for internal decision-making.

Methodological assumptions

As outputs of climate risk tools are reported in public disclosures, regulatory exams, and internal analyses, methodological considerations around these tools are critical. Through discussions with UNEP FI, the pilot participants identified multiple areas where enhancements in tool methodologies could increase the realism of results. In most of these instances, participants expressed a concern that existing tools and analyses resulted in an underestimate of potential climate risks. The fuller incorporation of different hazards, tipping points, and tail risk events might present an opportunity to capture the potential consequences of climate-related financial impacts more fully.

Additional complexity/realism

Integration of physical and transition risks

As noted previously, some tool providers have begun integrating physical and transition risks into their models. However, even for tools that consider both physical and transition risks, internal consistency may be limited. Rather than applying a single scenario that covers both physical and transition risks, a tool may consider the risks separately and link them based on RCPs or temperatures, meaning that the underlying assumptions between the physical hazards and the transition pathway can come from different models. Beyond just using the same underlying models, tool providers should consider the interaction effects of both risk types on individual assets and portfolios overall. Examples include how coastal real estate may be hit by tropical storms due to climate change and also face higher electricity and rebuilding costs due to the low-carbon transition. On the other hand, a positive synergy might be resiliency measures that also increase energy-efficiency.

Interaction effects between hazards

For physical hazards, interaction effects are critical to understanding the full extent of the climate-related risks. A storm that strikes in a location that has suffered from coastal erosion and sea level rise will be more damaging than its windspeed and flood heights would indicate. There are often correlations between different hazards that also amplify potential damages, such as warmer and drier conditions that make wildfires more likely and severe. While these interaction effects may not be directly modelled by a climate risk tool, tool providers should move away from considering individual hazards in isolation where possible and look for underlying models that consider the relationships between hazards.

Incorporation of tipping points

Climate tipping points have become an area of growing concern due to scientific research indicating that many of them may be activated at even modest levels of warming. Fundamentally, tipping points are non-linearities in a system, which when exceeded change that system from one state to another. They can be physical in nature, such as melting ice sheets, or economic, such as the collapse of confidence in global credit markets in 2008, but regardless of where they manifest, they are critical to gaining an accurate view of climate risks. Few tools explicitly capture tipping points as they relate to physical risks, such as marine ecosystem collapses, or as they relate to transition risks, such as the collapse of coal power in OECD economies. Given that these non-linearities are where outsized climate risks may be experienced, it is imperative that tool providers consider how they can be both integrated into their models and used to inform the outputs generated. These tipping points also demand a paradigm shift for financial institutions from risk-return management to resilience management.

Inclusion of second and third order effects

Climate risk tools often focus on a set of hazards when assessing their financial impact on a portfolio or individual counterparty. These hazards (both physical and transition) are often the direct effects of climate change or of the transition. Examples for physical hazards include damages from flooding or wildfire, examples for transition risks include carbon taxes or rising energy costs. However, many climate-related impacts are not the direct result of the initial event, but rather the secondary and tertiary effects. The case of

Hurricane Katrina is illustrative on this point. While the damage from the storm itself and the attendant flooding were estimated at over $100 BN, the New Orleans economy felt additional shocks. Businesses that remained closed for months or longer lost revenues and customers, the city lost tax revenues, and investments in new projects were repurposed to rebuild the damage. Furthermore, over 100,000 residents who left New Orleans did not return, leading to a smaller city with lower output than before the storm. Assessing the true costs of climate change requires evaluating the long term consequences of different events and policies.

Probabilistic estimates of losses

Many climate risk tools provide specific output values for a given portfolio and timeframe. However, the uncertainties inherent within climate modelling mean that climate risk is a fundamentally probabilistic challenge. Unfortunately, in some cases, users and providers may confuse a scenario with a severity. For physical risks, this may mean considering RCP 8.5 to be the "severe" scenario or for transition risk, it might be considering 1.5˚C to indicate "severe" transition risks. However, each scenario is merely a single potential pathway and the results of a tool are a point estimate of losses or impacts on that pathway.

However, RCP 8.5 may have widely varying implications for different physical hazards. This is easier to see given the proliferation of climate models that are run for RCP 8.5 that may show different levels of flooding, storms, wildfires and other hazards. To look at the most severe outcomes, a probabilistic method should be considered which looks at these different underlying models and considers hazard severity. As such, the 95^{th} percentile of flooding for an RCP 8.5 scenario should be in the top 5% of the worst flooding as indicated by different models. For transition risk, this approach is slightly different, but relies on macroeconomic probabilities of key variables like growth rates and trade balances. It may be more challenging to assign numerical probabilities to different transition scenarios, but certainly for a given 1.5˚C scenario, optimistic, base, and pessimistic cases of economic performance can be considered. The modelling community has explored some of these different futures through the creation of shared-socioeconomic pathways (SSPs).

While these challenges may require the involvement of climate modelers and scenario developers, their implications should be contemplated by thoughtful tool providers. Looking at the tail risks of different scenarios can provide a better view of downside risks that financial institutions must prepare for, and avoid the mistaken assumption that if a portfolio performs well in a certain RCP 8.5 or 1.5˚C scenario than it faces limited climate risk.

Strategic guidance

According to the pilot participants, climate risk tools are already being used to guide decisions. However, in addition to the enhancements noted above regarding coverage, hazards, outputs, and methodologies, participants want tools to provide guidance as well. Specifically, participants are looking for tools that can identify potential climate-related opportunities, improve client engagement, and develop new climate strategies. These desires represent a step forward for many climate risk tools that have been developed to produce a loss estimate or meet a reporting need. The application of forward-looking analytics to opportunities and strategies can allow firms not only to manage their risks but to take advantage and thrive in a changing world.

Opportunity identification

While recent years have seen a large number of tools marketed to help manage climate risk or report on climate alignment, fewer tools appear to focus on the tremendous opportunities presented by climate change through mitigation and adaptation solutions. In the UNEP FI pilot program, many participants indicated awareness of potential climate-related opportunities, but few mentioned that they were using tools to evaluate them. Given the widespread economic shifts that climate change and net zero will bring globally, financial institutions have the opportunity to support the creation of a resilient, just, and sustainable future and profit while doing so. Forecasts from the IEA and NGFS for reaching net zero require trillions in annual funding for the development and deployment of clean technologies. Pilot participants expressed an eagerness to see tools that helped them identify opportunities most suitable to them and determine how best to capitalize on them.

Client engagement

When asked about how they planned to use the outputs of the pilot analyses, participants frequently mentioned client engagement. Information about climate risks and individual counterparties can help financial institutions decide on the relationship the firm would like to have with those counterparties in the future. However, there was a desire for tools to be developed that even more explicitly focused on client engagement, and specifically in helping clients to transition to net zero. A number of participants have made public commitments about supporting client transitions and would welcome the creation of tools that allow them to assess transition plans and more effectively communicate with clients on how they can advance their progress towards net zero.

Strategy-setting

In addition to client engagement, participants also mentioned that pilot outputs could be used in determining climate strategy. Many tools provide outputs that are helpful in developing high-level climate strategies. Yet, for specific businesses, the desire for actionable guidance on climate policies demands more granular outputs. Part of the challenge involves getting the business line familiar with the outputs of climate tools and confident in their usefulness for developing a forward-looking strategy. Beyond that, tools geared towards specific businesses, sectors, or asset classes can provide information that can be integrated into processes such as underwriting and origination.

Case studies

Case study structure

The case study structure was developed in consultation with experts at ETH Zurich and covers the major areas noted below to promote comparability of the tools and the usability of the case studies as a resource for the financial sector. In the case studies that follow, the detail and nature of the criteria below may vary at the discretion of the pilot participant.

Figure 2: Criteria included within case study assessments

Introduction
- Overview of the piloting exercise
- Key findings or conclusions

Process
- The process followed in using the tool, step-by-step
- Main challenges encountered

Data and coverage
- Data needed to conduct the analysis
  - Internal
  - External
- Portfolio coverage
  - What geographies and sectors can the tool assess?
  - What was actually assessed in the demo?
  - Percentage of portfolio, geography, sector, total exposure?
  - Number of counterparties?

Risk factors and scenarios
- Key risk factors explored during the demo (e.g., hazard types)
- Temperature pathway(s) analyzed
- Scenarios used (NGFS, IEA, etc.)

Outputs and insights
- What outputs were generated?
- What learnings came from using the tool?
- What are use cases for this type of analysis or for the full tool?
- Any future plans to extend the analysis or conduct similar analysis internally?

Suggested enhancements for providers
- How easy was the tool to use?
- Are there any modifications or suggestions you have that would enhance your analysis?
- What are areas that you'd like to see the providers explore in the future?

Detail on tool providers and tools

As mentioned in the acknowledgements, UNEP FI and the pilot participants would like to thank the providers for allowing the piloting of their tools. The table below provides a high-level overview of the participating providers and the tools that were piloted.

Provider	Description	Featured tool overview	Risk types covered by tool
Entelligent	Entelligent is a climate risk analytics platform that measures and manages investment exposure to climate risk.	Entelligent has built technology — the first to be patented — that leverages macroeconomic and forward-looking climate-scenario models. This allows Entelligent's platforms to help institutional investors managing equity and corporate bond portfolios to maximize both financial performance and carbon-emissions reductions, while minimizing climate change transition risk.	Transition Risk
ISS-ESG	ISS ESG solutions enable investors to develop and integrate responsible investing policies and practices, engage on responsible investment issues, and monitor portfolio company practices through screening solutions.	ISS ESG provides climate data, analytics, and advisory services to help financial market participants understand, measure, and act on climate-related risks across all asset classes. In addition, ESG solutions cover corporate and country ESG research and ratings enabling its clients to identify material social and environmental risks and opportunities.	Physical & Transition Risk
Moody's Analytics	Moody's Analytics provides financial risk intelligence and analytical tools supporting our clients' growth, efficiency, and risk management objectives. The combination of our unparalleled expertise in risk, expansive information resources, and innovative application of technology helps today's business leaders confidently navigate an evolving marketplace.	Moody's Climate Solution suite offers a complete framework that spans across the overall risk management framework covering climate change analytics across both physical and transition risks, a comprehensive climate scenario analysis framework and stress testing, integration to credit risk modelling and financial metrics and tools to support Climate-related financial disclosures. Note that these studies were conducted pre-acquisition of RMS by Moody's, therefore, can be enriched to bring the breadth and depth of climate-related financial risk analysis that joint firms can today bring.	Physical & Transition Risk

RMS, A Moody's Analytics Company	RMS, a Risk Management Company at the Forefront of Risk Intelligence At RMS, Risk Management Solutions is their name and what they've been building over 30 years: industry-leading risk management solutions for insurers, reinsurers, financial services organizations, and the public sector. Their science, technology, and 300+ catastrophe risk models help (re)insurers and other organizations evaluate and manage the risks of natural and man-made disasters.	RMS has over 200 peril models in nearly 100 countries enabling insurers, reinsurers and other organizations to quantify the potential magnitude and probability of economic loss from catastrophe events.	Physical Risk
Oliver Wyman and S&P Global Market Intelligence	Oliver Wyman is a global leader in management consulting. With offices in 60 cities across 29 countries, Oliver Wyman combines deep industry knowledge with specialized expertise in strategy, operations, risk management, and organization transformation. Oliver Wyman is a business of Marsh McLennan [NYSE: MMC]. S&P Global Market Intelligence is a division of S&P Global (NYSE: SPGI), the world's foremost provider of credit ratings, benchmarks and analytics in the global capital and commodity markets, offering ESG solutions, deep data and insights on critical business factors.	Climate Credit Analytics—S&P Global Market Intelligence and Oliver Wyman developed Climate Credit Analytics, a climate scenario analysis and credit analytics model suite. These tools combine S&P Global Market Intelligence's proprietary data resources and credit analytics capabilities with Oliver Wyman's industry-leading climate scenario and stress-testing expertise. This solution provides a comprehensive, tailored approach to assess credit risk on counterparties, investments, and portfolios under multiple climate scenarios, including those published by the NGFS Phase II framework. Coverage includes more than 1.6 million public and private companies globally.	Transition Risk
TCS	The Climate Service is backed by an Advisory Board including 4 IPCC Nobel Prize winning scientists, and strategic partners including Aon, IBM, the AICPA, and LMI Consulting. Their goal is to help investors, companies and communities to understand their risks from the changing climate, and the opportunities from the transition to a low-carbon economy. Their mission is to embed climate risk data into every decision on the planet, and facilitate the world's transition to a lower carbon economy.	Subscription to the Climanomics® platform enables climate risk reporting and disclosure aligned with the Task Force on Climate-Related Financial Disclosures (TCFD) framework. Subscribers use the outputs to measure and report their transition and physical risks and opportunities in financial terms under different climate scenarios.	Physical & Transition Risk

Willis Towers Watson	At WTW, they provide data-driven, insight-led solutions in the areas of people, risk and capital. Leveraging the global view and local expertise of our colleagues serving 140 countries and markets, we help you sharpen your strategy, enhance organizational resilience, motivate your workforce and maximize performance.	Climate Diagnostic—It can be difficult to conceptualize climate change as a specific risk to your organization—2100 or even 2050 can feel far off, talk of sea levels rising by inches can sound insignificant, and the global effects are broad and complex. This tool shows changes in acute hazards such as extreme wind and flood as well as chronic stress factors like sea level rise and heat stress under multiple combinations of climate scenarios and timelines. It shows how those changes could affect your specific properties. Climate Diagnostic can advance your journey to effective climate risk management. Climate Quantified (CQ) is WTW's suite of models, tools, datasets and services to support organizations to identify, assess, and respond to physical and transition risk—for example through climate stress testing of investment portfolios, assessing compliance with legislative requirements or identifying opportunities to invest in the transition. Combined with learning and knowledge-sharing opportunities, CQ supports implementation of strategic responses to climate change.	Physical Risk
JBA Risk Management	They are JBA Risk Management, otherwise known as The Flood People. They are the one of the global leaders in flood risk science, helping the insurance and property industries, governments and financial institutions to understand and manage global flood risk.	They help the insurance and property industries, governments, and financial institutions understand and manage global flood risk across a wide range of flood sources, including river, surface water and coastal. Our probabilistic (CAT) models and flood maps cover 190+ countries in the World.	Physical Risk
right. based on science	The pioneering˚C data provider: right. based on science GmbH (right.) provides transparency on the climate impact of economic activities—plain & simple in˚C. Their aim is that climate-related decisions are guided by the best available science. Specialized and high-quality data for various key stakeholders: Their software and metrics enable actors from the real economy, finance, and real estate to plot pathways to 1.5°C alignment.	X-Degree Compatibility (XDC) Model—We developed the X-Degree Compatibility (XDC) Model to calculate the climate impact of e.g. companies, buildings, and financial portfolios (private & listed equity, bonds, sovereign bonds). The central question: How much global warming would occur by 2050 if the whole world performed as the entity in question? Results are expressed as tangible degree Celsius values, allowing a direct benchmarking against the Paris Agreement goal of keeping global warming to 1.5°C or, at least, well below 2°C.	Transition Risk

Baringa	Baringa have set out to build the most trusted consulting firm in the world. They team up with their clients to tackle their toughest business challenges. ▪ Their work spans the big picture—vision, strategy, future direction—and the nuts and bolts of the delivery. ▪ They work on challenges like helping clients define their net strategy, deliver complex change, spot the right commercial opportunities, make the move to digital, manage Climate risk, or bring their purpose and sustainability goals to life. They work with everyone from FTSE 100 names to bright new start-ups, in every sector. They have hubs in Europe, the US, Asia and Australia, and they can work all around the world.	Climate advisory We advise clients across financial services, government, regulatory bodies and wider sectors on climate risk and net-zero strategy through; ▪ Leading climate scenario and transition modelling capabilities ▪ Deep sectoral expertise in transition to net zero	Physical and Transition Risk
BlackRock	BlackRock's purpose is to help more and more people experience financial well-being. As a fiduciary to investors and a leading provider of financial technology, they help millions of people build savings that serve them throughout their lives by making investing easier and more affordable.	Aladdin Climate: Central to understanding—and ultimately acting upon—the effects of climate change on investments is a need to quantify the financial impact of climate-related risks. Aladdin Climate was built to quantify climate risks and opportunities in financial terms—bridging climate science, policy scenarios, asset data, and financial models to arrive at climate-adjusted valuations and risk metrics.	Physical and Transition Risk
Pricewater-houseCoopers	PwC's Sustainability practice helps organisations plan, source, deliver, finance and measure the wider impact of products and services. They help to future-proof businesses by making them more resilient, agile and sustainable. They provide guidance on a wide variety of issues, working with clients from the corporate, private equity and public sector. They are specialists in how organisations can spot the risks and harness the opportunities.	PwC's "Climate Excellence" tool for climate scenario analyses supports investors and companies in making their portfolios fit for the risks and opportunities of climate change. This enables them to realize increases in value, adequately manage risks, and set up a long-term sustainability strategy and compliant reporting.	Physical and Transition Risk

Participant:

Sustainable Leaders Capital

Provider:

Entelligent

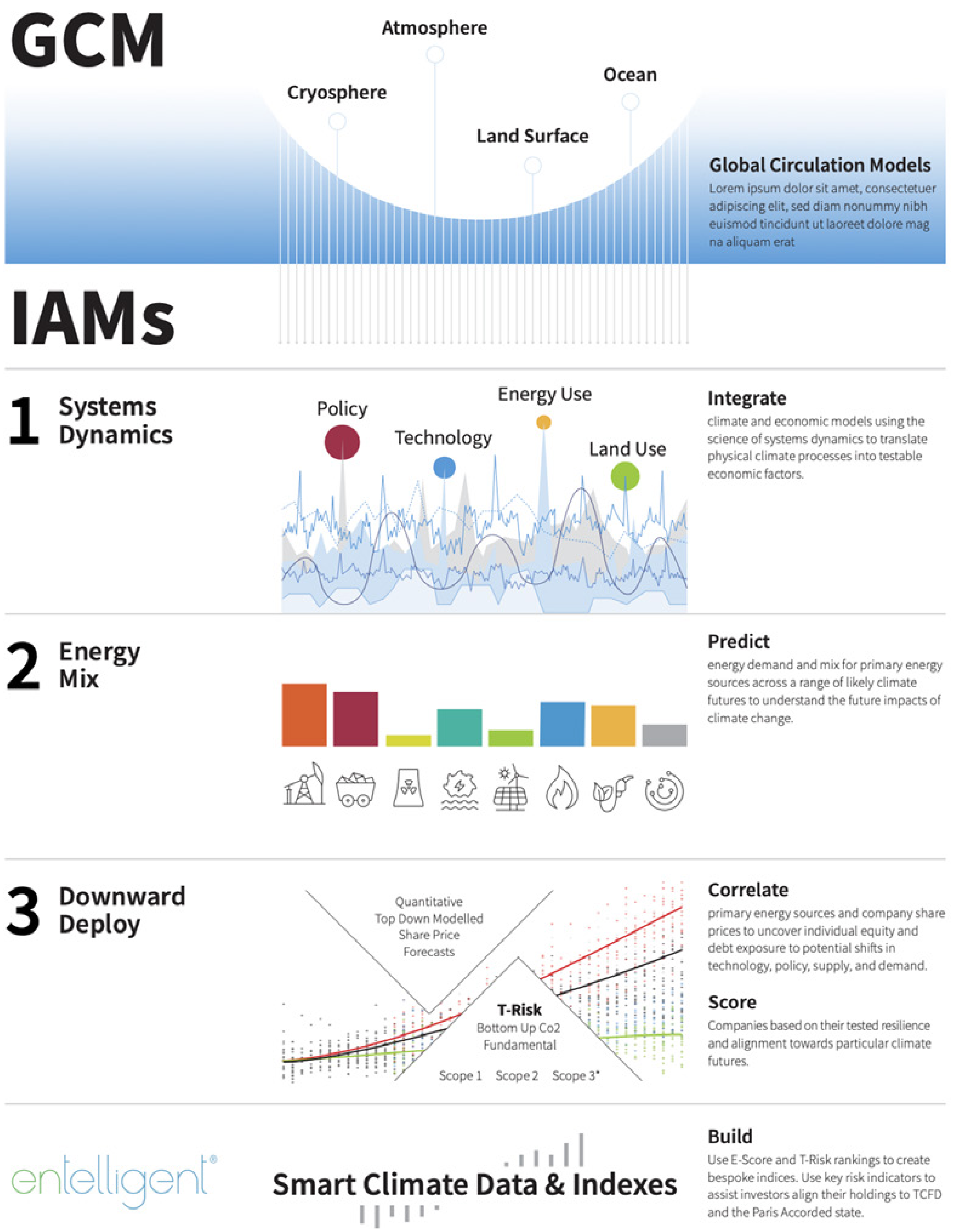
Risk types covered by tool:

Transition risk

Introduction

Sustainable Leaders is a private, employee-owned institutional investment boutique offering actively managed thematic and rules-based ESG investment strategies addressing environmental and social themes. We aim to deliver sustainable, first-class investment performance, and to make a material and positive difference for our clients and society.

Entelligent is a data analytics platform that leverages the capital markets to make a positive impact on climate change mitigation and adaptation. Entelligent's climate scenario analysis and climate risk approach—which are patented—use sophisticated climate models and systems dynamics approaches to project scenarios for the future energy mix as the world aligns with the Paris Accord and net-zero commitments. Entelligent's SmartClimate technology scores companies based on climate resiliency, providing data that can underpin stock selection for funds and indexes.



Bringing together the experienced investment team at Sustainable Leaders and the climate science and machine-learning teams at Entelligent, we have built two Paris-Aligned net-zero strategies (U.S. and Global) that are optimized to maximize financial returns and environmental out performance. These case studies demonstrate a breakthrough in terms of enabling investors to better track investments alongside the transition to a low-carbon economy and lower the carbon in their portfolios, therefore reducing climate-related transition risks.

Process

Promethos Capital (now branded Sustainable Leaders for the Entelligent Index and other passive index-tracking, rule-based smart beta strategies) and Entelligent partnered to build two climate change-focused investment strategies: 1) Paris Aligned Net-zero US Large Cap and 2) Paris Aligned Net-zero Global Large Cap. The strategies are designed to build investment portfolios that feature inclusive climate transitions toward Paris goals. The portfolios are optimized to be climate resilient, have neutral representation across sectors and regions relative to the benchmark, and are focused on reducing carbon exposure.

SmartClimate is used by asset and fund managers in a joint product development effort. Sustainable Leaders selects the global index benchmarks, and Sustainable Leaders integrates ESG and mission-oriented strategies with Entelligent's climate science-based transition risk scores[1] to build portfolios that seek to create superior financial performance and environmental outcomes based on TCFD recommended metrics. The steps in the process are summarized below:

- Select global benchmark (Sustainable Leaders)
- Design ESG and mission-based strategies (Sustainable Leaders)
- Select climate scenarios (Sustainable Leaders & Entelligent)
- Project share price returns on the benchmark constituents for the selected scenarios (Entelligent)
- Compute climate risk exposures by estimating share price sensitivity to the range of energy transitions, including energy price and demand (Entelligent)
- Set screening and optimization thresholds for climate resiliency and ESG criteria (Sustainable Leaders & Entelligent)
- Run portfolio strategies and climate optimization (Entelligent)
- Deliver weights/allocations to Sustainable Leaders (Entelligent)
- Build financial products/set trades and provide investable universe to financial leaders (Sustainable Leaders)

Data

For climate modeling and inputs, we use data from MIT's En-ROADS climate and energy simulator. En-ROADs, which incorporates systems dynamics, was first used by Donella Meadows in her Limits to Growth report, published by the Club of Rome.[2] The model uses data from the Internal Energy Agency (IEA), NASA's Goddard Institute for Space Studies (GISS), the Carbon Dioxide Information Analysis Center (CDIAC), the National Climatic Data Center (NCDC), the National Ocean Atmospheric Administration (NOAA), the multisector, multiregional, computable general equilibrium model of the world economy (MIT EPPA). The financial data is from MSCI, S&P and FactSet. The carbon data on Scope-1 and 2 emissions, used to validate findings, is provided by ISS. The model is validated by a third party WSP. The model inputs and outputs are in the confidence

1 More information on Entelligent methodology and score computation is provided here: A demo version of the model is available here: https://en-roads.climateinteractive.org/scenario.html?v=2.7.29

2 A demo version of the model is available here: https://en-roads.climateinteractive.org/scenario.html?v=2.7.29

interval of forecasts from EMF 27 suite, WEO, BP and EIA. The ESG data and company-level exclusions were provided by Sustainable Leaders.

Coverage

The selection universe for the Paris Aligned Net-zero US Large Cap strategy is a U.S. large cap index tracking 500 major companies. The Paris Aligned Net-zero Global Large Cap selects from MSCI world large-cap and mid-cap equity universe.

The data produced (E-scores) is forward-looking, action based and does not hedge on a particular scenario. The model estimates the deviation of share price forecasts two years into the future to estimate climate transition risk. The difference in return forecasts under different climate scenarios is taken as a measure of transition risk. The focus of the methodology is entirely on the climate scenario resilience of share price estimates. Securities with higher area dispersion are more exposed to future policy, technology and energy shocks related to climate change mitigation and adaptation.

There are no bottom-up sustainability factors in our computation. But ISS Scope I and Scope 2 data are used to validate the efficacy of resultant risk-adjusted portfolios. Carbon reductions are an outcome (value-add) of E-score application to portfolio construction for climate-risk minimization, and not inputs to the model. The companies that show more resiliency toward climate and energy shocks tend to be more sustainable compared to their peers in the same sector and region. The process of score computation is fully standardized. It is same for BP, Walmart or Tesla.

The database is updated every quarter to make sure the latest data, price movements and corporate actions are captured. The unit of output is area estimates of dispersion. More specifically, the raw units are a two-year summation of absolute deviation over expected returns under a max and min carbon scenario.

Risk Sources & Scenarios

The sources of risks are climate transitions such as carbon tax, electrification, changes in energy efficiency, technical breakthroughs and other socio economic and energy factors. Each of these factors contributes to a shift in the supply, demand and price of energy. This approach considers climate transition risk and chronic physical risk factors such as temperature rise, atmospheric concentrations and sea-level rise. The visuals and scenario outputs are provided in more detail below.

Entelligent Climate Scenarios

We use four different scenarios to answer a pressing question:
What will the world look like in the year 2100?

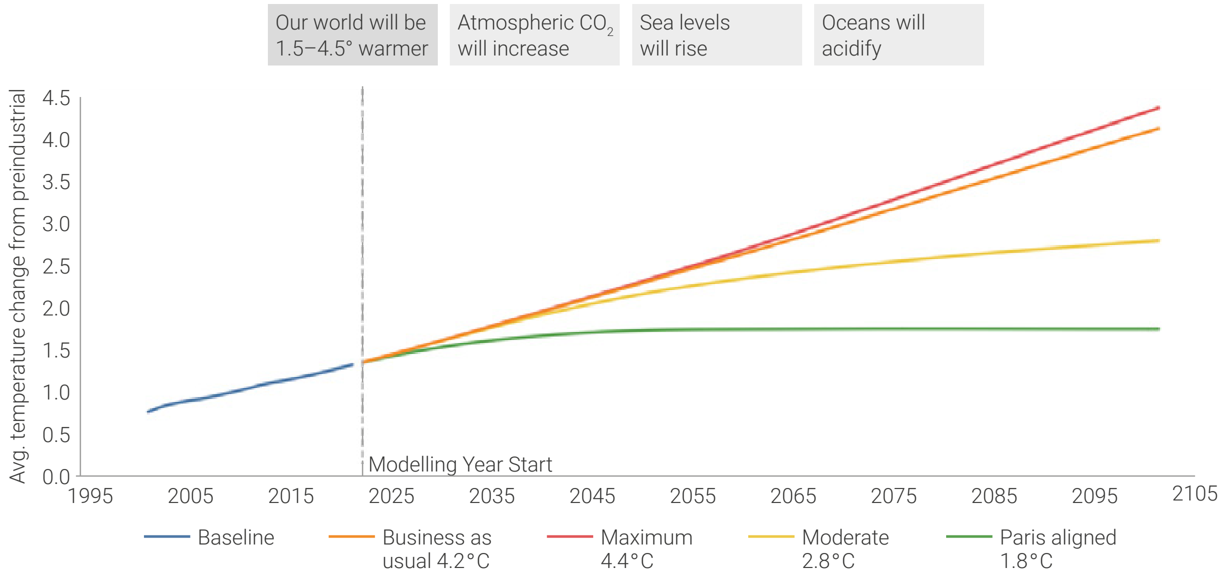


Table 1: E-Score Dataset: Default Min & Max Scenario Settings- Environmental & Energy Impact (2100)

Time of Departure 2018			
BAU		**Min Scenario**	**Max Scenario**
Global population in billions	11.18	11.18	11.18
Global GDP per capita	59,473.60	59,473.60	66,671.30
Average total final energy intensity of GDP	1.52	0.62	1.41
Carbon intensity of final energy	105.01	34.82	103.94
CO_2 emissions from energy	106.03	14.48	109.25
Total Final Energy Demand	1009.65	415.86	1051.06
Atmospheric concentration CO_2	893.84	536.62	948.51
Equivalent CO_2	904.404	627.95	957.69
Temperature change from preindustrial	4.24586	2.86	4.45
Fuel price of oil per barrel	181.77	233.89	201.02
Market price of electricity in KWh	0.11	0.16	0.15
Sea level rise (from 2000)	1282.81	1054.27	1305.48
Delta pH levels (from 2000)	-0.32	-0.12	-0.25

Output

Entelligent's SmartClimate platform minimizes portfolio exposure to climate transition risk subject to diversification principles such as min/max holding size, regional exposure, sector allocation and constituent turnover.

This strategy yields U.S. and global equity portfolios with decreased exposure to climate change risk and greater opportunity for resilient business activities. Hypothetical financial and environmental performance over a four-year backtest for the global portfolio is presented below.

The chart above shows the performance of the Global Paris Aligned Net-zero index versus an all-cap world index. The goal of the index, comprised of about 300 companies in 23 developed markets and 27 emerging markets, is to reallocate capital toward a low-carbon and climate-resilient economy. Index components are developed by screening out certain weapons, tobacco, coal and fossil fuel companies. Additionally, companies that are non-compliant with international ESG standards such as the United Nations Global Compact Principles are removed. The companies included are projected to have the greatest potential for both environmental and valuation impact.

The tables below show comparative environmental out-performance of the index based on TCFD-recommended metrics. Entelligent projects the Sustainability Leaders can achieve an 80% improvement on carbon intensity, a 400% increase in revenues per tons of carbon invested and a 257% improvement in carbon footprint.

Carbon Impact Results	Portfolio	Benchmark	% Better
Carbon intensity	119	597	80%
Carbon revenue/ton	8,373	1,675	400%
Carbon growth percentage	-3.4%	-3.1%	10%
Average carbon footprint	13.6	35.0	257%
Total carbon emissions/MM	15.5	26.7	172%
Exposure carbon related assets/MM	1.7	13.6	800%
Exposure carbon related assets/%	1%	6%	600%

Annualized return	1 Yr	3 Yr	Inception
Global Paris Aligned Net Zero	54.7%	18.7%	19.4%
ACWI	50.9%	13.4%	13.7%
+/- Benchmark	3.8%	5.3%	5.7%

Global Paris Aligned Net-Zero Characteristics		
Benchmark	MSCI ACWI	
Position Size	5% Maximum	
Holdings	200	
Sector	+/-3%	
Region	+/-3%	
Top 10 Holdings	43%	
Market Cap	Large	
Tracking Error	4.63%	
Beta	0.96	
Style	Core	
E-Score	4.95	5.0

Insights gained

It is possible to maximize financial returns and environmental performance via a climate transition strategy. Science-based strategies (such as this) are both effective and scalable. The strategies outlined above demonstrate that, when science meets business, we can find opportunities that are win-win for both investors and the environment.

Working with Entelligent, Sustainable Leaders streamlines the TCFD six-step process for applying scenario analysis to climate-related risks and opportunities and into investment decision-making processes:

Governance	**Risk Management**
▪ Board oversight of climate-related risks and opportunities ▪ Management's role in assessing and managing climate-related risks and opportunities	▪ Organisation's processes for identifying and assessing climate-related risks ▪ Organisation's processes for managing climate-related risks ▪ Integration of the above processes into overall risk management structure
Strategy	**Metrics and Targets**
▪ Climate-related risks and opportunities over the short, medium and long term ▪ Climate-related risks and opportunities on the organisation's businesses, strategy, and financial planning ▪ Resilience of the organisation's strategy, considering various climate-related scenarios, including a 2 °C or lower scenario	▪ Metrics used by the organisation to assess climate-related risks and opportunities in line with its strategy and risk management process ▪ Scope 1, 2, and Scope 3 greenhouse gas emissions, and related risks ▪ Targets used to manage climate-related risks and opportunities and performance against targets

i. Sustainable Leaders' board and management have been directly involved in the definition and adoption of climate-related risks and opportunity KPIs for investment decision and monitoring. This aligns with the Step 1 governance of TCFD recommendations.

ii. Entelligent's approach helped Sustainable Leaders' board and management learn how to determine the present-value of the medium- to long-term material impacts of climate change—technology, policy and market shocks—to near-term outlooks. This involves setting up processes and functions for risk management, per TCFD Step 2.

iii. Through a series of climate scenarios (from Paris alignment to 4+ hot world) relevant to Sustainable Leaders investment strategies, selecting climate scenarios and investment benchmarks are very close to TCFD's Step 3 recommendation.

iv. The computed climate risk exposure (Step 4) establishes the important of setting up screening and optimization thresholds to ensure long-term financial and environmental performance in line with Sustainable Leaders' fiduciary duty.

This case study helped us identify key processes and KPIs that should be communicated to relevant parties to ensure full transparency and accountability. Establishing climate targets, metrics and quarterly measuring standards ensure portfolios remain aligned with Paris goals. This aligns with the final TCFD recommended metrics and targets.

TCFD states that this exercise can be a useful additional factor in determining how to prioritize risk management activities and where to consider making additional allocations.[3]

Usability

Sustainable Leaders and Entelligent Paris Aligned Indices are available to asset managers and asset owners to capitalize their financial and sustainability goals. These applications are highly customizable and can be integrated to multiple investment visions, missions, themes and philosophies. We understand the diversity in investment practices, and we want to use the power of diversity and inclusion to build Paris and net-zero aligned climate solutions.

Suggested enhancements for the tool providers

Sustainable Leaders suggests Entelligent include bottom-up data such as carbon emissions, biodiversity, water and physical risk packaged with the existing top-down transition risk approach. That way, the analysis will be more complete and persuasive. The development of a 360-degree view on climate risk and opportunity, which may require collaborating across multiple climate scoring systems, would be beneficial. Entelligent uses Scope 1 and Scope 2 emissions data in the validation of its E-Scores. The next iteration of its scoring methodology, known as T-risk, will add Scope 1 and Scope 2 emissions as inputs into the ranking.

3 https://www.tcfdhub.org/scenario-analysis/

Participant:

TD Asset Management

Provider:
ISS ESG

Risk types covered by tool:
Physical and transition risk

Introduction

TD Asset Management Inc. (TDAM, a wholly-owned subsidiary of The Toronto-Dominion Bank) considers climate change a systemic risk affecting economies, companies, and investors. Our approach to climate change is aligned with our overall philosophy of integrating all sources of risk and return in our investment processes.

As an investment manager of diversified asset classes, we consider climate change as an important area of research to fulfill our fiduciary responsibility on behalf of our clients. We actively engage with companies as well as our partners, and leverage our asset ownership positions to encourage improvements in company disclosures on climate-related risks and opportunities facing their businesses. In addition, we participate in numerous industry collaborations including Climate Action 100+, Carbon Disclosure Project, and the United Nations Environment Programme Finance Initiative (UNEP FI) TCFD investor pilots, with the first two furthering our company engagement efforts, and the latter developing a better understanding of climate-related investment risks. Our approach continues to evolve to help position our portfolios to capitalize on investment opportunities arising from an accelerated transition to a low carbon economy and manage undue climate-related physical and transition risks.

As part of the UNEP FI landscape review module, TD Asset Management Inc. was tasked to evaluate a third-party tool used to measure the climate risks of an investment portfolio. We were matched with Institutional Shareholder Services (ISS) ESG (Climate Solutions), a source of corporate governance and responsible investment solutions. We were provided with login credentials (usernames and passwords) to access ISS' proprietary DataDesk platform (the "platform") as well as a brief tour and walk through of the platform to ensure that we would be able to maximize our 4-week trial period.

For our analysis, we turned our attention to the portfolio analysis section of the platform which let us generate a PDF report emphasising the key climate risk exposures of the portfolio. Notably, all data used to create the report could be conveniently downloaded as a CSV file for added flexibility and further examination.

Data and Coverage

For this exercise, we uploaded the holdings (as of December 31, 2020) of a long-only global equity portfolio benchmarked to the MSCI All Country World Index. The portfolio held 195 securities from over 30 countries across both developed and emerging markets, and leaned toward mid-sized, dividend-paying and low volatility securities from defensive sectors such as Utilities and Consumer Staples.

Uploading the portfolio to the platform was straightforward. We simply had to provide the platform with a CSV file comprising the following information: portfolio name, client identifier type (e.g., ISIN), client identifier (i.e., the ISIN values), modeling currency (in our case, CAD) and weight in percentage. Every security of the portfolio was successfully mapped onto the platform. Moreover, all dual-class shares and ADRs were correctly mapped to their underlying issuers.

The platform contained data for 99.83% of the portfolio (by weight), or 194 out of the 195 securities. It is worth noting that all missing data, as with that of the non-covered security, was suitably labelled as either “not applicable”, “not collected” or “not disclosed”, to avoid confusion with available but zero or null-valued data points.

Risk Sources and Scenarios

ISS ESG’s offering can be split into four categories: emission analysis, climate scenario alignment analysis, transition risk analysis and physical risk analysis.

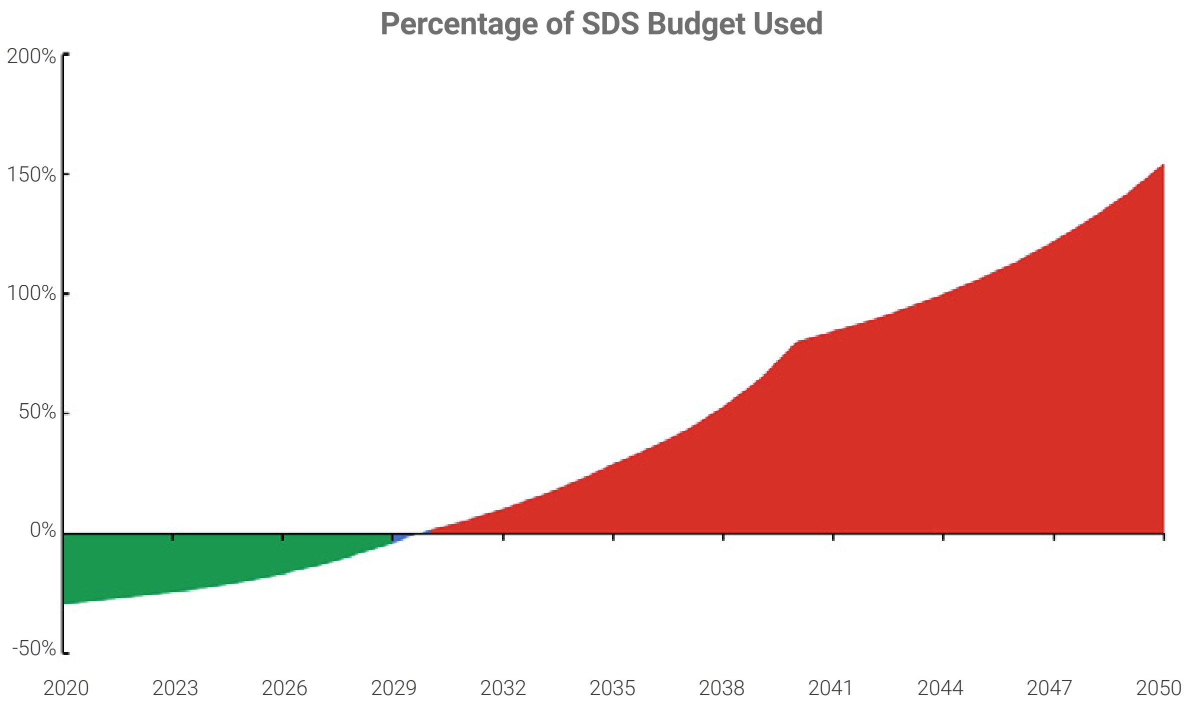
The first category, emission analysis, comprises common carbon metrics, where applicable aligned with the TCFD Recommendations and the PCAF Global Standard, such as the share of disclosing holdings, carbon emissions (including scope 3 emissions) and carbon intensity. An interesting feature of the platform is the emissions “trust” rating. This metric estimates the extent to which we can trust a company’s reported carbon emissions numbers. For instance, emissions that have been externally audited would be rated higher than emissions that have only been estimated. The second category, climate scenario alignment analysis, compares current and future portfolio greenhouse gas emissions with the carbon budgets from the International Energy Agency (IEA) Sustainable Development Scenario (SDS), Stated Policies Scenario (STEPS) and Announced Pledges Scenario (APS). The third category, transition risk analysis, focuses on green energy generation and fossil fuel reserves (i.e., oil, gas and coal). The fourth and last category, physical risk analysis, gauges the impact of the six most costly physical climate change risks such as floods, droughts or storms on the current and future overall value of the portfolio.

Outputs and Insights

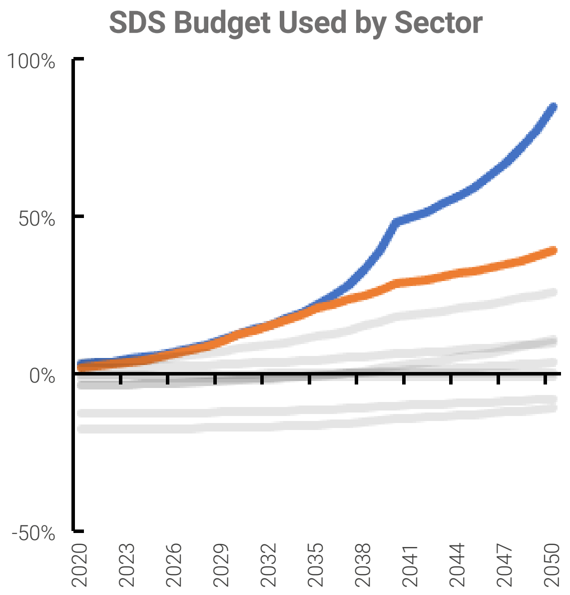
For the sake of brevity, we chose to focus solely on the last three categories, namely climate scenario alignment analysis, transition risk analysis and physical risk analysis, and only on the data that we deemed most interesting to us, as specified below.

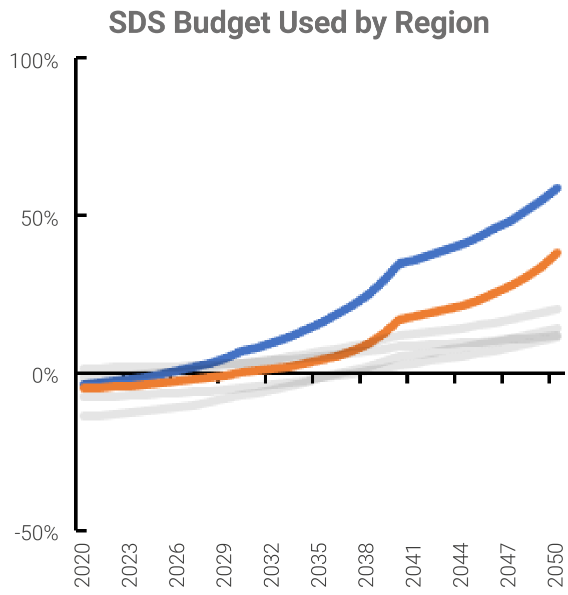
Climate Scenario Alignment Analysis

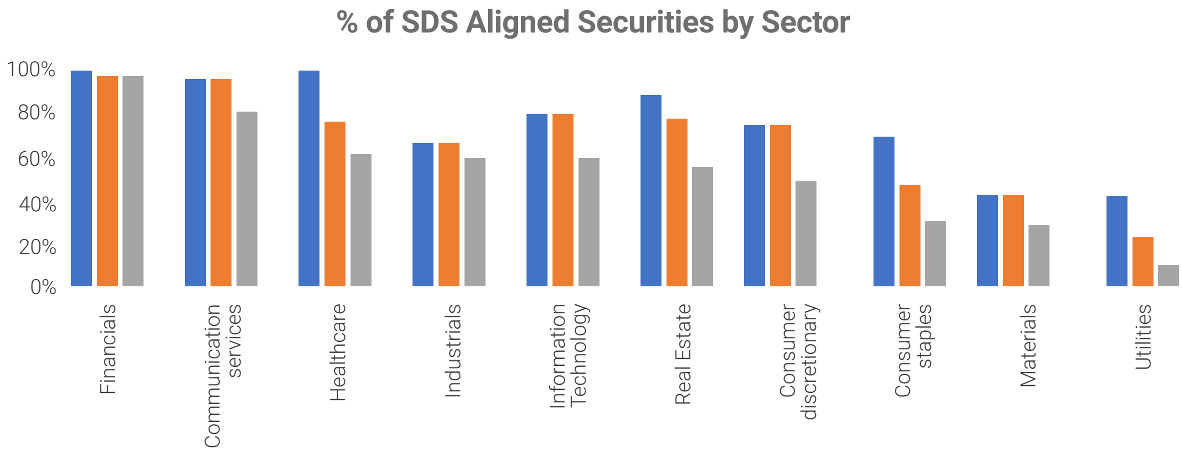
For the climate scenario alignment analysis, we concentrated on the IEA's Sustainable Development Scenario (SDS) pathway as it boasted the most comprehensive and intuitive data. The SDS charts a GHG emission pathway in line with the Paris Agreement of holding warming to well below 2˚C by the end of the century. The following chart plots the portfolio's emission pathway as a percentage of its SDS budget. As it stands, the portfolio is misaligned with the SDS scenario by 2050 and is on course to exceed its SDS budget by 2030. By 2050, it is expected to overshoot its SDS budget by nearly 150%, corresponding with a potential temperature increase of nearly 2˚C by 2050.



The PDF report generated by the platform highlights the key sectors contributing to the misalignment of the portfolio. Having the data readily available outside of the platform allowed us to perform additional analysis on the portfolio. For example, we could easily single out the sectors, regions or even securities which used most of the SDS budget of the portfolio. Namely, we found that most of the SDS budget is used by securities in the utilities sector. In particular, we found that a small portion of the portfolio, representing roughly half a dozen securities, was responsible for using most of allocated SDS portfolio budget.





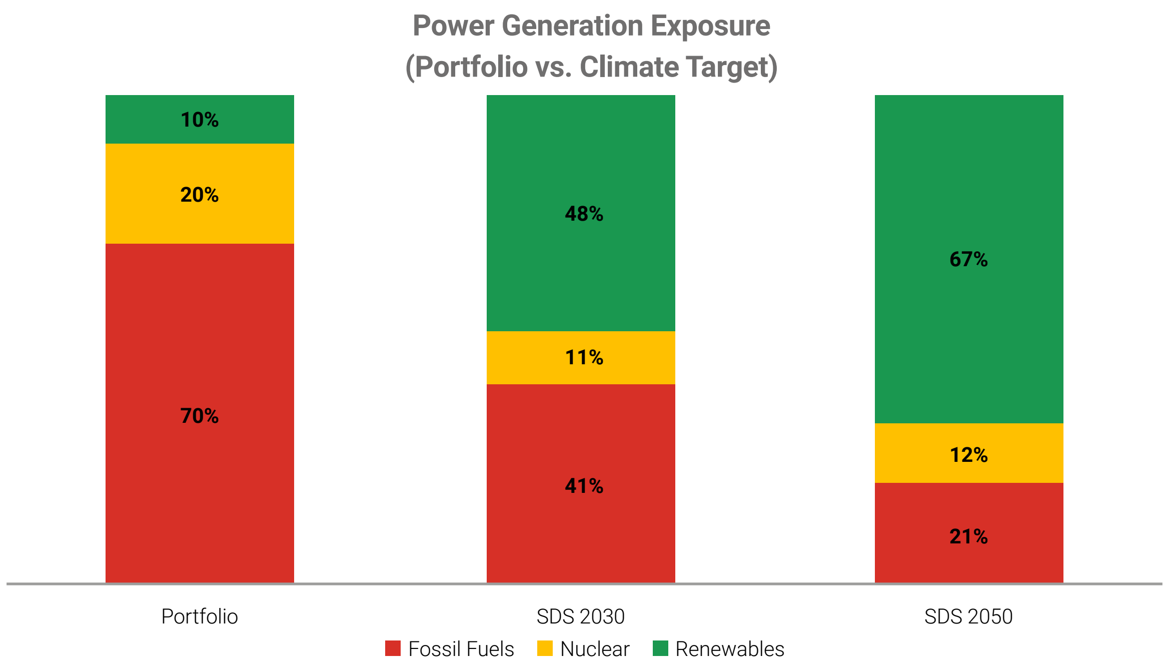


This information is important because it alerts us to the fact that the portfolio could be more closely aligned with the SDS pathway with only minimal changes to the portfolio's holdings. This information also reveals which sectors and/or securities we should target our carbon risk reduction efforts on.

Transition Risk Analysis

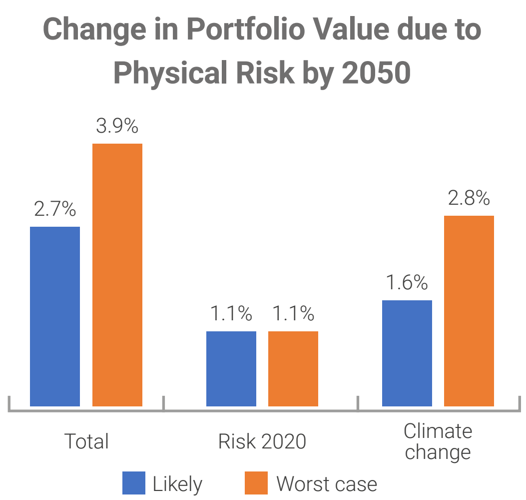
The transition risk analysis module of the platform emphasizes both power generation (demand side) and fossil fuel reserves (supply side) as key to transitioning to a greener, decarbonized economy. The rationale is that exposure to "brown" (i.e., non-renewable) electricity generation or fossil fuel reserves may eventually lead to higher reputational risks, policy and/or regulatory risks as well as stranded asset risks.

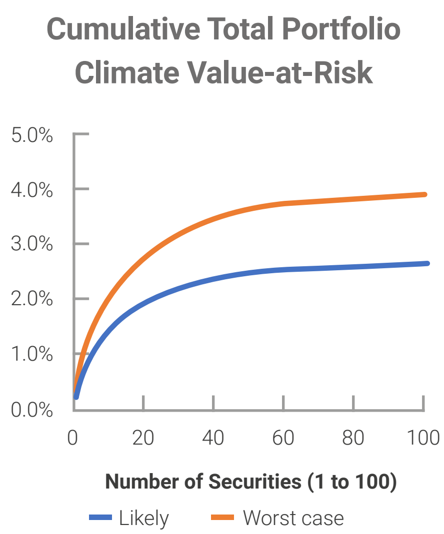
The portfolio used in this exercise holds no energy companies and therefore has minimal exposure to fossil fuel reserves. However, it is strongly exposed to traditional utilities companies, and consequently, to "brown" electricity generation. The graph below compares the energy generation mix of the portfolio against the SDS target mix for 2030 and 2050.



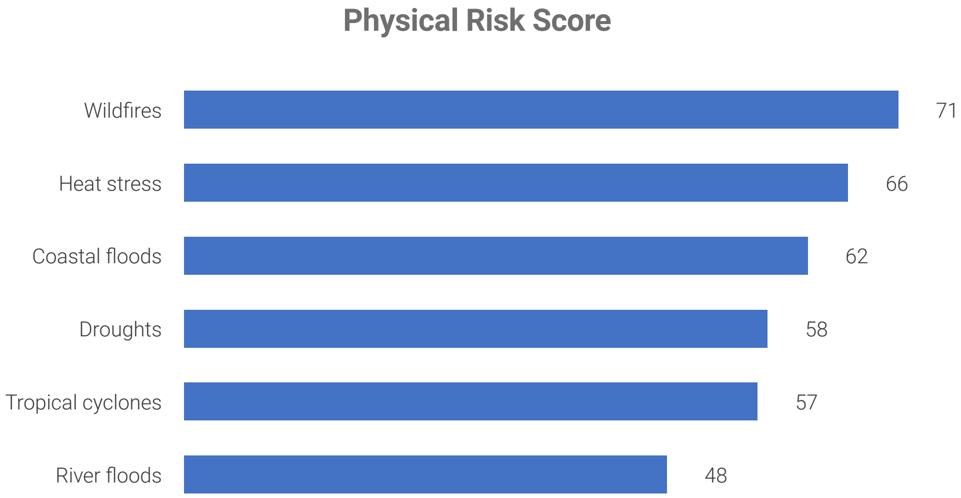
Physical Risk Analysis

The platform's physical risk analysis measures the potential financial impact of the six most costly natural climate hazards such as floods, droughts or wildfires on the value of the portfolio. The first metric used to assess physical risk is a portfolio-level climate value-at-risk. The chart below on the left highlights the potential impact on overall portfolio value in 2050 based on 2020 risk levels (Risk 2020) and hazards due to climate change (Climate Change) for two climate warming scenarios of the Intergovernmental Panel on Climate Change (IPCC) (most likely and worst-case scenarios), while the chart below on the right highlights the cumulative portfolio value-at-risk for the first 100 riskiest securities (based on climate value-at-risk). A striking observation from these two charts is that nearly 80% of the climate value-at-risk of the portfolio can be attributed to just 30 securities.





The other metric used to quantify physical risk is a physical risk score. This physical risk score is impacted by the projected change in financial risk due to individual hazards in a likely warming scenario. A low (high) score implies a large (small) projected increase in physical risks. The figure below charts the weighted-average physical risk score for the six main natural hazards.



It should be noted that physical risk scores were unavailable for close to a quarter of the securities in the portfolio, most of which were in the utilities sector, since the underlying asset-level data base is still being scaled up.

Uses Cases

The platform offers a broad and deep look into potential climate risks, encompassing emissions analysis, alignment analysis, transition risk analysis and physical risk analysis. This information can be used in security selection, to get a better understanding of the climate risks faced by companies under consideration, as well as for portfolio construction, to lower or cap the portfolio's overall exposure to climate related risks. It can also be a useful tool for reporting purposes.

Conclusion and Suggestions

The platform was approachable, and the web interface was intuitive which made navigation straightforward. The platform included a data dictionary carefully describing the various data series which helped along with our exploration of the data at hand. Having the ability to download the data in spreadsheet-form was also extremely useful to further our understanding of the data and expand our analysis beyond the bounds of the platform. We did encounter minor online formatting issues and glitches that may have been due to browser compatibility. For example, highlighting a data column would occasionally display the wrong data definition. However, none of these issues prevented us from successfully using the platform.

In a future iteration of the platform, it would be interesting to see more ambitious climate alignment scenarios, such as such as net-zero emissions by 2050 (NZE2050). According to ISS ESG, this scenario is already on their product roadmap and should be available on the platform by the end of 2021. Lastly, many well-know indices and benchmarks are available in the screener portfolio of the platform, but without weights. Therefore, they cannot be use for portfolio benchmarking in the portfolio analysis section of the platform. ISS ESG acknowledged this limitation and advised that it will be discussed internally as to whether weighted indices will be included on the platform going forward.

Author:
Jean-Francois Fortin, Vice-President, TD Asset Management Inc.

Participant:

DNB Asset Management

Provider:
ISS ESG

Risk types covered by tool:
Physical and transition risk

Introduction

As part of this UNEP FI-TCFD pilot project, DNB Asset Management (DNB AM) selected ISS ESG to conduct a trial of the ESG Carbon and Climate Impact solutions tool. The tool is intended to help investors to understand, measure, and act on climate-related risks across all asset classes by providing detailed analyses of Scope 1, 2 and 3 emissions, transition and physical risks, and climate scenario analysis. The trial was conducted on 10 of DNB AM's equity portfolios, all of which implement the DNB Standard for Responsible Investments. This is our investment policy which is intended to ensure that DNB does not contribute to the infringement of human or labour rights, corruption, serious environmental harm or other actions that could be regarded as unethical. It shall also ensure that assessments of risks and opportunities related to ESG (Environment, Social and Governance) factors are integrated in the investment management process. Several of the funds implement additional exclusion criteria, others have an additional sectoral focus, including those which focus on selecting companies providing solutions to climate and environmental issues faced throughout the world.

The tool contains the following components:

Data	Portfolio Analytics	Ratings
▪ Carbon and Climate Data ▪ Potential Avoided Emissions Data	▪ Carbon Footprint Report ▪ Climate Impact Report	▪ Carbon Risk Rating ▪ Fund Rating

While the trial provided access to all components of the ISS' solution, we chose to focus on the Portfolio Climate Impact Report and the accompanying dataset to explore physical and transition risks, as well as the Climate Scenario Alignment across the selected DNB equity portfolios used in the trial.

Sectoral and geographical coverage

The tool allows for the assessment of both transitional risk and physical risk for the uploaded portfolios—with the production of a range of outputs in a single report. As part of the transitional risk assessment, the tool considers fossil fuel reserves and renewable energy assets contained within the portfolio. As part of the physical risk assessment, the tool provides an assessment of the potential financial implications of a range of climate hazards on the portfolio value. The analysis uses the median impact of the ensemble of models forced with the RCP 4.5 and RCP 8.5 scenarios. The RCP 4.5 is a "middle of the road" emission scenario (likely) while the RCP 8.5 is a high emission scenario (worst-case). The analysis is done for baseline year 2050 (median of 2025 through 2075). Several metrics are provided to offer insights on the physical risk exposure of individual issuers and the portfolio, namely Financial Risk metrics, Value at Risk, a Physical Risk Score and a Physical Risk Management Score.

Given we are based in Norway, as are many of our customers, we chose to analyze a number of our Norwegian and Nordic funds, to understand the potential transitional and physical risks faced. We also chose to assess several our fund products which focus on selecting companies providing solutions to climate and environmental issues faced throughout the world. These funds assessed include both actively and passively managed funds. Coverage of data for the funds assessed ranged between 76–100% of constituents.

Assessment process

The tool was straightforward to use, and available through the ISS DataDesk platform. After logging in, the following steps were undertaken to conduct the assessment:

1. Upload fund holdings into platform. For each of the holdings, the tool required information regarding the holding identifier, weight, and values of the holding.
2. Ran 'Climate impact assessment' for the funds in question.
3. Reviewed PDF report and the excel file of data factors produced by the tool.
4. Also possible to assess the results in the online tool using the DataDesk screening function to deep dive into issuer level analysis of companies. This provided greater detail regarding the companies' commitments and performance relative to targets under different scenarios.

It was possible to undertake analysis using equity, fixed income or mixed portfolios, however for the purpose of the case study we only assessed equity portfolios.

Outputs and potential use case

As part of the Portfolio Climate Impact report, two outputs of the data are produced:

Climate Impact Assessment Report

This is intended to provide users with a straightforward overview of the information produced by the tool. The report includes a range of analyses and metrics across carbon emissions, transition risk, and physical risk (by risk type, sector, and company)—a few select elements of the report are outlined below. Broadly the report provides an overall assessment of the potential performance of the fund with regards to climate, while also highlighting companies most at risk—this information could be fed into a company engagement process, and feature as part of investment decision making.

Alignment analysis

The report includes an analysis of the funds' alignment with the IEA Sustainable Development Scenario (SDS), Stated Policies Scenario (STEPS) and the Announced Pledges Scenario (APS), based on current and projected future emissions. Comparison is indicated as the percentage of assigned budget used by the portfolio and benchmark, as well as an indication in which year the fund will, based on the modelling, exceed the SDS budget along with the corresponding potential temperature increase associated with the fund (see table in graphic below). The results from this analysis across the funds assessed were within our expectations. For the example in the graphic below, given the focus of that fund on climate and environmental solutions, we would expect to see the fund not exceeding the SDS budget in 2040 or 2050. We anticipate that as more companies within the fund begin to set science-based emission reduction targets and begin to reduce emissions in line with these targets, that the budget overshoot will be lessened. At the same time, our experience with other approaches is that for companies providing products and services which lead to emission reductions, these reductions can be difficult to quantify and as a result are not sufficiently captured. This could also be a consideration here.

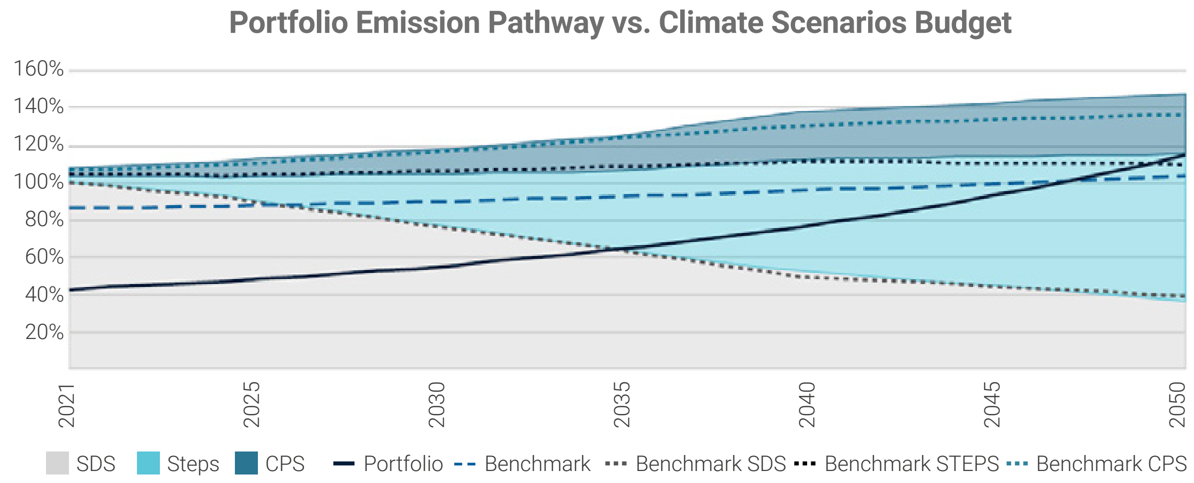
Portfolio and Benchmark Comparison to SDS Budget (Red=Overshoot)

	2021	2030	2040	2050
Portfolio	-57.45%	-31.36%	-45.70%	+213.91%
Benchmark	-14.41%	+15.05%	+92.74%	+166.23%

2036 The portfolio exceeds its SDS budget in 2036

2.7°C The portfolio is associated with a potential temperature increase of 2.7°C by 2050.

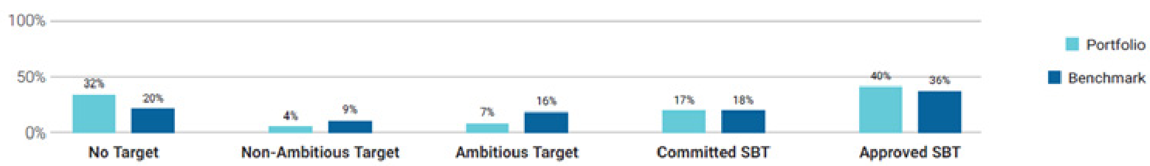
As part of this assessment, there is also a visualization of the Portfolio emissions pathway compared with the carbon budgets of the selected climate scenarios, this could be utilized as part of regular assessment of funds' holdings and climate related risks (both physical and transitional). This visual (and the underlying data) may prove useful with fund clients interested in the understanding the alignment/misalignment of their funds with different climate scenarios—and may be particularly relevant for fund managers with public commitments for net-zero or other science-based emission reduction targets. The assessment of the alignment could also be a KPI of interest to management/board, as it may provide an indication regarding the potential direction of travel for specific funds, different classes of funds, or all holdings. For the example below, the assessed fund in its current state is misaligned with the SDS scenario in 2050, while the fund's benchmark is also misaligned.



Climate Targets Assessment

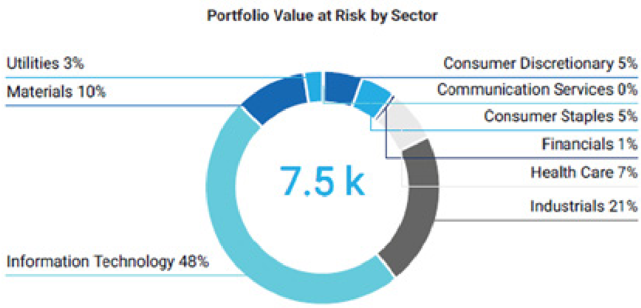
To reach the global climate goal set out by the Paris Agreement—to limit global warming to well below 2, preferably to 1.5 degrees Celsius—companies are widely being called upon to set public GHG emission reduction targets to ensure they are part of the solution. These targets should be public to ensure transparency and accountability of the companies' actions. A challenge faced as an investor when assessing companies' emission reduction targets relates to the comparability of and quality of the targets set. As we continue to focus on how companies position themselves and manage climate related risks, having insight into the targets being set is important.

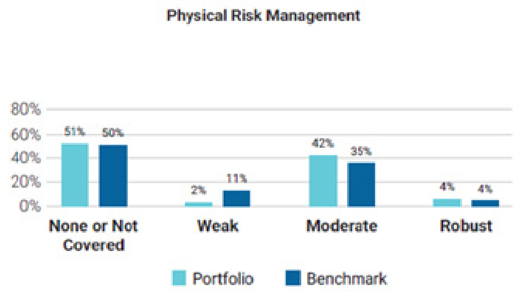
The Climate Targets Assessment provides a fund level overview on the targets companies within the fund are setting. The targets are placed in 5 categories: Approved SBT (Science-based target), Committed SBT, Ambitious Target, Non-Ambitious Target, and No Target—the chart below is then produced based on the weights of companies in the fund and can be compared with the benchmark (see below). This information is also available on the company level as part of the data file. As with the above analysis, the assessment of the targets could be a KPI of interest to management/board and may be particularly relevant for fund managers monitoring emission reduction targets of companies within their funds. This will likely be of increasing importance with increasing commitments to net zero, as well as from increasing disclosure requirements in the European Union including the Sustainable Finance Disclosure Regulation (SFDR).



Physical Climate Risk Analysis

The assessment of the physical climate risk is comprised of four elements, providing insight into the physical risks the fund is potentially exposed to, as well as an assessment into how the company is managing these risks. One output is included below, with the left chart providing a quantification of the value at risk by sector (under the RCP4.5 scenario), with Information Technology contributing 48% of the risk. The chart on the right provides a breakdown of the strength of the physical risk management approaches of companies within the fund. We found these charts used together provides a clear overview of where the potential risks exist within the selected fund from a sectoral perspective, while also indicating the portion of companies in the fund managing these risks.





Underlying data via excel, API, FTP or data desk.

The underlying data for the companies included in the analysis is provided for the companies in the portfolio. The company specific data can be analyzed in the excel spreadsheet or on ISS' Data Desk, and it is also possible for the data to be delivered by API or FTP.

The data output allows direct integration into internal databases for further internal integration into the active ownership and investment processes, particularly when comparing companies to peers and the fund relative to the benchmark. Access to granular data provides the opportunity to deep dive into the potential performance of the companies under different scenarios. The metrics indicating a company's percentage of the carbon budget utilized under three climate scenarios presents an opportunity to assess a company's emissions trajectory and assess scenario alignment at a given point in time. The scenarios included are the Sustainable Development Scenario (SDS), the Stated Policy Scenario (STEPS), and the Announced Pledges Scenario (APS). When combined with other data points regarding targets provides a picture of a company's commitment to decarbonization, and the likelihood of achieving this. This could also be utilized as part of TCFD reporting regarding climate scenario analysis.

Overview and Future plans for tool

The opportunity to demo the tool provided some new and useful insights into the potential climate risk and impact of the selected funds. The tool was straightforward to use and produced the desired reports and data files without issue. The results from the analysis were broadly in line with our expectations. We observed for the funds where we place a greater emphasis on climate and the environment, were associated with temperature increases closer to 1.5 degrees and also lower potential exposure to physical risks, while funds with greater exposure to sectors or geographies with high emitting companies or sectors, were associated with higher temperatures.

The assessment of the carbon reduction targets for the companies in the fund and categorization of targets into SBT-committed/approved, and ambitious and non-ambitious targets, is greatly welcomed. This aspect of the analysis presented some unexpected results particularly when compared to benchmarks, namely that some funds were without. With the increasing focus on net zero both for companies and for investors, insights like this can help to provide focus for engagement and impact the selection decisions.

We provided feedback on suggested enhancements to the company directly, and ISS flagged several future developments expected in late 2021/early 2022. Including:

- Introduction of metrics related to the IEA's NZE2050 scenario as part of the development of their net-zero product. This will utilise the ISS climate data, as well as ISS' voting and engagement services.
- A transition Value at Risk will be launched which will reflect carbon pricing and sector growth risks.
- Update its current estimation approach on Scope 3 data and add reported and quality checked Scope 3 data to the existing dataset.
- Provide derived data in excel file for further use by asset managers in integration of the data in internal systems.
- Continued expansion of physical risk assessment, increasing the number of risks covered.

Participant:

TD Bank

Provider:
Moody's Analytics

Risk types covered by tool:
Physical and transition risk

Introduction

TD Bank Group (the "Bank") and Moody's Analytics worked together in a pilot project in March 2021 to explore an approach to quantifying climate change impacts on actual Bank borrowers and exposures held by the Bank. Moody's Analytics used its internally developed tools to evaluate the climate-related risks for a sample of the Bank's publicly traded Commercial & Industrial (C&I) and U.S. Commercial Real Estate (CRE) obligors under three representative Network for Greening the Financial System[4] (NGFS) scenarios.

Overall, the Moody's Analytics models provided meaningful insights into how the Bank could approach incorporating climate risk into its credit assessments. It also highlighted the significant challenges associated with trying to quantify the impacts of a multi-dimensional scenario over a long-time horizon, including sensitivity to assumptions and model validation challenges. TD feels confident it can use the information from the pilot project to help the Bank move forward on its climate risk quantification and management journey.

Process and Data

The initial base for all scenario analysis for both the C&I and CRE models was a set of Moody's Analytics' proprietary macroeconomic scenarios that align with the NGFS scenarios. These scenarios reflect many of the chronic physical and transition risk impacts with variables including productivity metrics, energy demand, commodity, and carbon prices, as well as classic macroeconomic measures like government spending, employment by industry, incomes, and output.

C&I Credit Analysis

The C&I analysis estimated the individual and combined impacts of physical and transition risk on each individual borrower's propensity to default. Both physical and transition risks were estimated using Integrated Assessment Models (IAMs), which predict economic and climate outcomes for the underlying scenarios. For transition risk, the IAM was augmented to incorporate an oligopoly-based model of firm competition

4 A global group of 90 (as of April 2021) central banks and supervisors helping the financial sector address the risks of climate change and support the transition to a resilient economy: https://www.ngfs.net/en/page-sommaire/governance.

and price setting. These were then extrapolated into equity, asset volatility and liability impacts, customized by individual firm's carbon emission intensity and energy emission intensity to determine a Climate-adjusted Expected Default Frequency (EDF) and associated change to Borrower Risk Ratings (compared to the non-climate-adjusted model).

The model automatically sources the required data from either public source (i.e., corporate financials) or proprietary databases (i.e., firm-level physical climate risk scores[5] and total carbon emissions). Where the required degree of granularity is not available, including for private entities[6], proxies can be used. For TD's sample of 13 firms, one firm lacked a firm-specific physical climate risk score and a sovereign average was automatically used as a proxy. Similarly, two firms lacked carbon emissions data and industry averages were used.

CRE Credit Analysis

The CRE Climate-adjusted EDF model also sources proprietary physical climate risk data automatically, at very precise spatial granularity, focusing only on wildfire and flooding impacts for the TD CRE footprint. Those physical risk impacts are calibrated to historical losses for similar building types and locations. The remaining inputs are typical of any CRE credit model, principally including loan origination and maturity dates, loan rate and outstanding balance, property type, address, value, and net operating income.

Coverage

The intent of the pilot was to improve TD's understanding of the capabilities of Moody's Analytics climate risk models, as opposed to a sampling analysis of TD's entire credit portfolio.

The 13 public firm C&I borrowers evaluated in this pilot represented a very small fraction of TD's customers, but the sampled firms did span eight industries with headquarters in two countries (U.S. and Australia). The CRE sample of 55 properties represented less than 10% of the value of TD's global CRE portfolio, although they spanned 12 metropolitan areas in the U.S., five property types[7], and had varying loan maturities, including some exceeding 10 years.

At the time of the pilot, the C&I Climate-adjusted EDF model accommodated only public firms, which could be located anywhere in the world, subject to the availability of appropriate macroeconomic scenarios. Climate-adjusted scenarios were then available only for the U.S., Canada, UK, and Western Europe.

5 These scores include acute and chronic physicals risks (wildfire, cyclone, inland flooding, heat stress, water stress, sea level rise) to all corporate facilities and operations, as well as to the firm's supply chain and markets.

6 Functionality also supports the inclusion user-supplied firm characteristics in order to enhance the analytical output for non-public entities.

7 Multifamily, Office, Retail, Industrial and Hotel.

The climate risk impact data used by the CRE Climate-adjusted EDF model are translations of specific physical risk (e.g., inland flooding) scores for each Metropolitan Statistical Area, and climate transition risk macroeconomic scenarios. When the pilot project was undertaken, coverage was limited to the U.S. data coverage for both the CRE and C&I EDF modeling approaches has since expanded significantly.[8]

Risk sources and scenarios

This pilot project examined the impact of climate risk on the EDFs of a sample of C&I borrowers and CRE loans. The key sources of risk included acute physical climate risks (wildfire, cyclone, flooding), chronic climate risks (sea level rise, heat stress and water stress), and transition risks stemming from political, economic, and technological drivers, with firm sensitivities driven by industrial subsector and current carbon emissions. For TD's specific CRE portfolio, only wildfire and inland flooding were considered since none of the properties were subject to cyclone risk.

The physical risk quantifications were provided by Moody's ESG Solutions, and reflect future potential temperatures based on Representative Concentration Pathway (RCP) 8.5. Transition risks were introduced through a consistent set of local macroeconomic scenarios that were fully aligned with the NGFS definitions of Orderly, Disorderly, and Hot House World scenarios.

While a great many parameters in these models can be specified or manipulated, this pilot project focused more on the differences within the loans and borrowers, and across the three primary NGFS scenarios.

Output

Both models produce term structures of EDFs, with annual granularity extending forward 10 years for the CRE loans and 30 years for the C&I borrowers. One such EDF term structure is produced for every loan or borrower, for each of the three NGFS scenarios. In addition, EDF term structures are also provided showing the pre-climate adjustment EDFs, and a "worst case" EDF (based on the 95th percentile highest temperature pathway). Expected loss figures are also produced for the CRE loans, where outstanding balances are available.

One summary view of the climate risk impacts is the overall change in implied ratings at a future point in time, and an example of this is shown in Exhibit 1 for TD's C&I portfolio. The physical climate risks to all these obligors produced implied rating deteriorations, while the transition impacts produced both risks and opportunities for various obligors. In only one case was the upside (transition) risks greater than the physical risk impacts, resulting in an overall projected implied rating improvement.

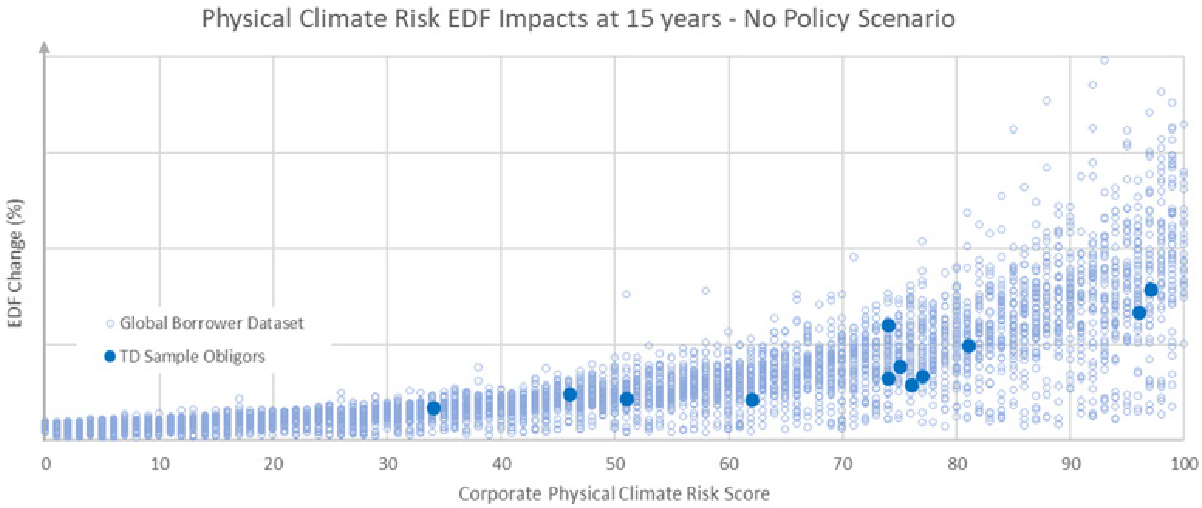
8 As of September 2021, physical climate risks scores and macroeconomic scenarios were available globally, and CRE translations were available for US, Canada, the UK and Western Europe. The C&I model coverage had also expanded to include private firms, globally.

Exhibit 1: Change in 10 Year Annualized EDF-Implied Rating for C&I Sample Set

Risk	Scenario	2 Notch Improvement	1 Notch Improvement	No Change	1 Notch Deterioration	2 Notch Deterioration	3+ Notch Deterioration
Combined	Early Policy		8%	23%	38%	15%	15%
	Late Policy			8%	54%	31%	8%
	No Policy			23%	46%	15%	15%
Physical	Early Policy				85%	15%	
	Late Policy				69%	31%	
	No Policy				77%	23%	
Transition	Early Policy		8%	54%	23%	8%	8%
	Late Policy		8%	77%	8%		8%
	No Policy	8%	15%	54%	8%		15%

While all the output is provided as digital flat files, a variety of automated sorting, filtering, aggregating and mapping functions were also used to better understand the C&I exposures. In addition, physical risk output can be compared to a much larger universe of borrowers to provide some perspective and relative sense of impact, as shown below in Exhibit 2.

Exhibit 2: TD Borrower Sample vs Global Dataset[9]



9 The graph plots TD's sample of 13 public firm C&I borrowers against the global dataset; only 12 points are shown in the graph due to an overlap of two of the TD Sample Obligors.

Insights gained

The relatively small fraction of TD's total portfolio that was analysed precludes drawing any conclusions about aggregate impacts to the Bank, but it did highlight the range of scenarios and parameters available, and the outputs and metrics that might be useful in the future. TD has made several observations about its exposure to various borrowers and loans during this pilot project, including:

- Many of the credit risk impacts, under all scenarios, were relatively small for both the CRE and C&I books, but some EDFs were projected to increase dramatically even looking forward only 7–10 years. This may indicate both the difficulty of using a top-down evaluation approach, and the opportunity to pinpoint individual loans and borrowers that have much higher exposures to climate risk.
- Where credit deterioration was projected for CRE loans, it was almost exclusively due to acute physical risks. In contrast, the impacts to the C&I portfolio being more mixed, with physical risk deteriorating credit quality somewhat broadly but transition risk causing significant EDF erosion for a subset of borrowers.
- In some cases, borrowers were projected to benefit from the anticipated economic transition, driving credit quality improvement. While this was broadly a function of the industry sector, it was also observed for firms whose earnings were derived from several industrial sub-sectors, highlighting the value of detailed earnings attributions. The clear articulation of winners and losers within industries and regions show the potential advantages of a more fulsome credit analysis, incorporating climate risk.
- The transition risk impacts become evident at the date of a policy announcement, driven by the resolution of the uncertainty in investor expectations. For some borrowers those dates markedly increased or decreased creditworthiness which pointed to the potential value of exploring alternative policy development timelines or expectations.
- More broadly, these insights may be useful in the future for portfolio risk analysis and stress testing, as well as individual borrower credit underwriting and loan structuring.

Usability

As TD continues to strategically build capabilities in climate risk analysis, understanding the nature, content and detail of the analytical results will be critical in developing that roadmap. This pilot provided good transparency into the current methodology and process and was a foundational step in the Bank's journey.

This pilot revealed that the differences across loans could be sufficiently large, at some date in the future, to warrant further attention, review or action. Quantification of such risks is growing increasingly important for several use cases, including pricing reviews, portfolio allocation, the potential for stress tests and disclosure requirements at some point. The Moody's Analytics models sourced the required data automatically, and were thus straightforward in terms of execution, though a more fulsome integration into existing credit applications has not yet been explored. Model outputs provided the detail necessary to "drill-down" and explore the drivers of individual results.

Ultimately TD's climate risk management process could provide key metrics for the executive team, and further enable the Bank to examine and guide the loan portfolios relative to the Bank's risk appetite. A key function of usability will be considerations regarding how to establish validation techniques beyond traditional credit risk models, noting TD has historically validated credit risk models against past performance metrics that may not be appropriate given the forward-looking nature of the analysis.

Suggested enhancements

Given the nascent nature of the industry, both Moody's Analytics and TD have identified areas to continue to enhance both the capabilities and the usability of the models.

Capability Considerations

- Expansion of CRE Physical Risk Model and translation data to global geographies, to fully cover the Bank's CRE portfolio.
- Inclusion of forecasted forward-looking physical frequency and damage assessments. The CRE model uses hypothetical scenarios at the user's discretion, however including expected changes would provide a meaningful baseline scenario.
- More granularity in key industries or data availability for private firms. Lending to publicly traded entities is a small subset of TD's overall commercial lending exposures; additional granularity is required (e.g., sub-industry emissions averages) to more meaningfully differentiate across borrowers within a given industry.
- Better flexibility regarding input scenarios. The fundamental basis of the Moody's Analytics' models is the NGSF scenarios and IAMs; the ability to alter assumptions would be useful, primarily to better isolate the impacts of individual assumptions.

Usability Considerations

- Model "validation" guidance—recognizing that traditional approaches to validating this credit model may not be effective, additional detail regarding how we can assess the appropriateness of the model is necessary to be comfortable the Bank is not introducing significant model risk.
- Integration with other internal or third-party platforms to minimize duplication of work efforts by credit analysts.
- TD worked directly with Moody's Analytics to generate the outputs, therefore there was limited ability to assess the user interface. However, further data exploration tools would be useful, including the ability to view portfolio wide metrics and impacts.
- Further documentation and training materials, recognizing that this would need to be used by individuals at the Bank that are not heavily involved in ESG or climate risk matters.

Participant:

A European Bank

Provider:
Moody's Analytics

Risk types covered by tool:
Physical and transition risk

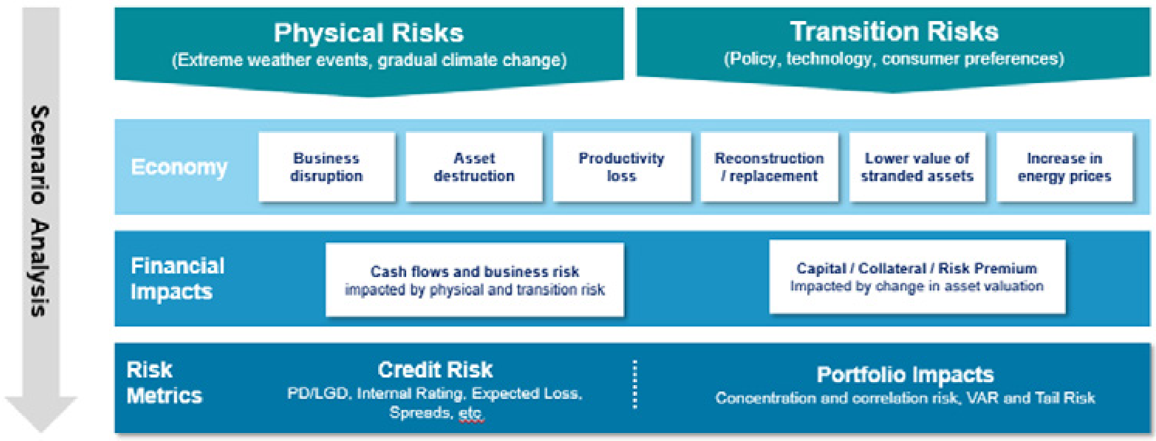
Introduction

Banks can be impacted by climate change in different business lines, overlapping opportunities and risks. Our Group is a global commercial financial institution with positions in Europe and South America. Our engagement in this pilot aimed at investigating leading practices on tools covering the physical and transition impacts of climate risk applied to some of our portfolios. This pilot provided us with a comprehensive view into how Moody's tool could be used to assess physical and transition risks and opportunities.

Process

Moody's tool offers a complete framework that spans across the overall risk management framework covering climate data analytics across both physical and transition risks, climate scenario analysis and stress testing, integration to credit risk modelling, and financial metrics and tools to support Climate-related financial disclosures.

Moody's conceptual framework



Moody's structural approach combined with ESG, transition risk, physical risk and macroeconomic analysis allows to:

1. define appropriate climate scenarios
2. link the climate scenarios to the climate risk impact channels
3. translate risk into financial and economic scenarios
4. estimate the climate adjusted risk metrics.

It can also leverage reference climate scenarios (such as the NGFS) as well as support the bank's vision based on the level of desired complexity, granularity in scenario analysis through its tailored approach.

Data inputs/Coverage

Moody's pilot analysis started with the assessment of a representative portfolio of our Group:

1. Retail & Wholesale Real estate Collaterals in several geographies in Europe and South American countries: location specification
2. Corporate (listed) in Spain and Mexico: ISINs were sufficient to perform the complete climate credit risk analysis on the entities.
3. Fixed Income & Equities Global (listed): ISINs were sufficient to perform the complete climate credit risk analysis on the entities.
4. SME (Spain) and Corporate (private firms): Moody's assessed physical risk exposure based on location-specific inputs through its Climate on Demand real asset application. Bank also provided sector-level (granular NACE classification), baseline rating (PD) to analyse the climate adjusted credit risk metrics and financial analysis.

In summary, 6.870 ISINs of more than 3,000 listed entities were analysed in the sample. Moody's also conducted a full analysis on climate physical risks across 1 million collaterals in Spain, and in two South American geographies.

Risk factors and scenarios

The methodology assesses policy, market upstream, market downstream and technology risks associated with climate transition scenarios and includes physical risk exposure scores for listed entities with detailed analytics for six climate hazards (extreme rainfall and inland flooding, heat stress, water stress, hurricanes & typhoons, sea-level rise and wildfires) as well as an overall score and benchmark measures of supply chain risk and market risk.

The physical risk methodology leverages highly granular raw climate data from global climate models and applies them to a broad range of asset classes for listed companies, private equity, real estate, sovereigns, and sub-sovereigns.

On transition risk, Moody's provides emission profiles and energy transition risk scores for counterparties. The score provides an opinion on the quality of the company's management of risks and opportunities related to the transition to a low carbon economy and its capacity to reduce its future carbon footprint. These risks and opportunities are specific to each sector and the company's operations.

Moody's collects issuer's emissions data following the GHG protocol for all scopes. When emissions data is not publicly disclosed, Moody's estimates Scope 1 and Scope 2 emissions using its own proprietary models.

At the firm level, physical and transition risks are modelled by linking the climate scenarios to the key drivers of a Merton style structural model framework. Thus, each firm's

Earnings and Asset Values are considered to be affected by each scenario through information obtained by carbon footprint and transition risk assessment, as well as by the physical risk exposure scores.

Scenarios

Moody's tool can support Climate Change Scenario Analysis in line with reference practices, including and not limited to:

- **Orderly**/Immediate 2C with CDR (Carbon Dioxide Removal), Emission peak year as 2025, net-zero-year 2050 CO_2 only
- **Disorderly/**Delayed 2°C with limited CDR, Emission peak year as 2030, net-zero year 2060 CO_2 only
- **Hot House**/No additional policy, Emissions continue to rise till 2100
- **Alternative scenarios** on physical risk via 1.5°C (with 66% probability)—NGFS Immediate 1.5 with CDR, IPCC RCP2.6, 4.5, 6 and 8.5.

In addition, physical risk scenarios can be provided by either **directly specifying a path of global expected economic damage from physical risk or specifying an emissions path from an IAM or other assumptions.**

Moody's is committed to updating reference scenarios (like NGFS) in its solutions as they become available.

Time horizons: 30-year time horizon considered whilst there is full flexibility to change it, such as nearer-term or longer-term to 2100.

Outputs and Insights

The analysis results were provided at firm/asset level (output for the retail portfolio is based on mortgage collateral location and SME production site location) and the bottom-up methodology captures firm/asset specific factors to differentiate across sectors, countries, specific location of facilities/supply chains/market context and emission profiles (Scope 1+2 and forward-looking) of counterparties. The same methodology is applied for the SME and private firm universe, depending on the data inputs provided.

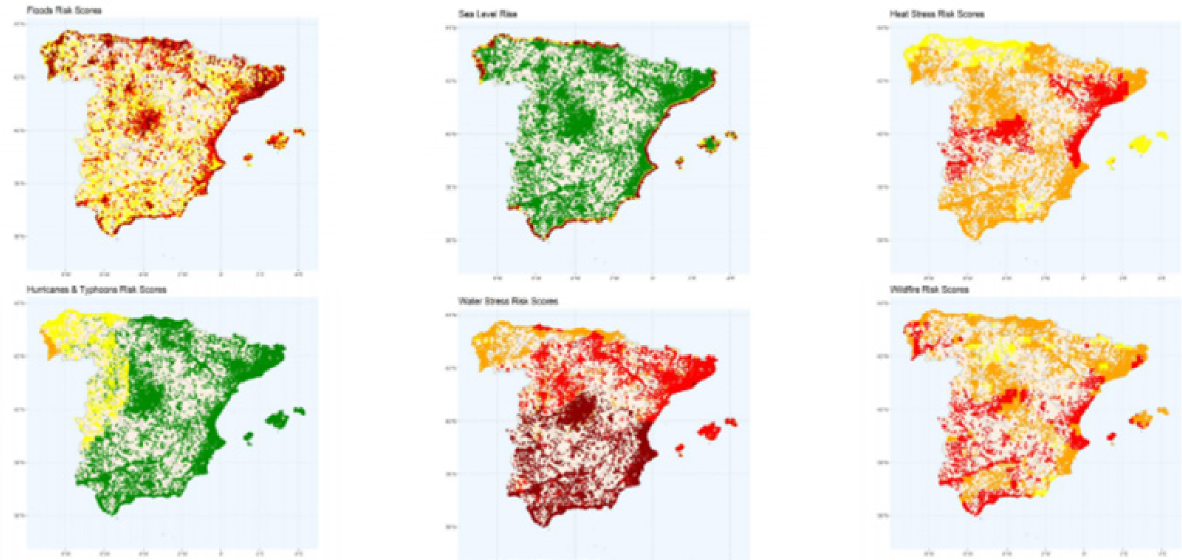
A short summary of outputs that were provided for the bank Fixed Income, Corporate & Private Firm portfolios, where possible:

- Probability of Default (EDFTM)—Expected Default Frequency- change (due to climate risk), Probability of Default (climate risk-adjusted)
- Credit Rating change (due to climate risk), Credit Rating (climate risk-adjusted)
- EBITDA change (due to climate risk) where Moody's use Free Cash Flow to the Firm as a measure of earnings, EBITDA (climate risk-adjusted)
- Expected value (e.g. mean estimate—high probability, estimated impact)
- Extreme value (e.g. tail estimates—low probability, high impact)

Moody's provided a set of climate risk assessments for physical risk and transition risk and trial access to its Climate on Demand application for real assets where our Group was able to analyse at granularity the physical risk exposure against key hazards. In addition, Moody's also conducted a full analysis on climate physical risks across more than 1 million collaterals in Spain, and some thousands in South American geographies during the pilot and provided results.

Insights:

Collaterals (retail & wholesale): 2040 physical risks results based on the RCP 8.5 scenario for 1 million collaterals in Spain by climate hazard:



A similar analysis was conducted in some South American countries (where the largest mortgage exposure is concentrated). The climate hazards exposure differs in each region. For example, hurricane and typhoon risk is not relevant in Spain, but it is significant in some countries of South America.

Suggested enhancements for the provider

Overall, our Group was satisfied with Moody's tool and Moody's team. The demo was effective at demonstrating the climate risk analysis capabilities of Moody's tool for several asset types. The tool is easy to understand, and the methodology document and overview provided were very helpful.

We have developed a wish list of enhancements related to data, scenarios and methodology that could be advisable:

- The physical risk scoring model is limited to the 2040 time-period and the RCP8.5 scenario. It would be useful to be able to compare results with the baseline and other time periods, as well as other IPCC warming scenarios in the long term.
- While there are some sensitivity/mitigating factors implemented for some types of assets, there is room for improvements to be able to customize other adjustment factors in the physical risk scoring.
    - The methodology used for the assessment of wildfire risk by Moody's tool is very much designed for large rural areas (low resolution 25x25 km), extrapolating the

most common type of vegetation to all the area, and does not take into account other factors such as urban infrastructure and vulnerability by sector. These limitations should be taken into account when assessing the results (which could be overestimated in some cases).
    - Sensitivity factors based on the asset types or industry activity of the asset (such as collaterals) or clients (such as corporates or SMEs) are not taken into account, aside from some sensitivity adjustments based on activity for real assets. It does not consider the resilience/sensitivity of clients based on their production activity (not only sector), supply chain characteristics, and initiatives aimed at mitigating physical risks.
- Regarding how transition and physical risk impact the risk parameters such as PD and LGD for the mortgage portfolio, there was a limitation of local historical data in certain geographies. In addition to the NGFS scenarios and existing methodologies, extensive preparation is needed to develop tailored models for each geography (such as the ones created for the USA and UK). This effort was left out of the scope of this pilot.

In general, we also believe transparency when accessing internal parameterisation and scoring rules should be a priority for future developments, for Moody's tool and for any other platform.

Due to time constraints, our Group did not access the broader suite of Moody's solutions, and there are some aspects of the tool that couldn't be tested, such as the Moody's ESG Score predictor which expands climate profiling coverage to the uncovered universe, e.g. SME credit, on-demand scoring to address further any geocoding issues (transforming postal addresses to coordinates), the outcome visualization within the tool (heatmaps, geographical distributions, PD impacts, etc), or the potential data connection required to connect internal financial data with the results.

Note that these studies were conducted pre-acquisition of RMS by Moody's Analytics, which expands the depth and breadth of physical risk capabilities (direct/indirect risk (cost) factors, scenario sets and time spans and impact analysis across broader asset classes) that joint firms can today provide.

Participant:

Intesa Sanpaolo

Provider:
Risk Management Solutions, Inc. (RMS)

Risk types covered by tool:
Physical risk

Introduction

As part of the UNEP-FI TCFD pilot program, Intesa Sanpaolo selected Risk Management Solutions, Inc. (RMS®) as the supplier to participate in the case study.

The RMS climate condititoned catastrophe risk models were used in order to quantify the flood risk related to a small sample of the Intesa Sanpaolo Italian mortgage portfolio.[10] In particular, the RMS climate change Europe Inland Flood HD Models were used in this case study considering the Region interested and the type of risk.

The results of the analysis show losses at sample portfolio level comparing today's risk to 2040 using RCP 6.0 and RCP 8.5 scenarios and related province level estimates.[11]

Differences in the "climate-adjusted" Probability of Default (PD) and Loss Given Default (LGD) are also provided with different return period losses.

Flood risk methodological framework

The RMS modelling framework consists of five key modules, which are detailed below:

- **Stochastic:** the stochastic module contains thousands of simulated events for a given peril. For example, the Europe Inland Flood HD Models' stochastic event set stem from a continuous simulation of precipitation and all subsequent hydrological processes over a period of 50,000 years. These events have been created to represent the full range of possible flood extents and severities, both from pluvial and fluvial flooding, that can impact Europe;

10 The RMS methodology is commonly used by governments, financial institutions and their corporate clients to manage their exposure to extreme events and has over 200 peril models in nearly 100 countries enabling organizations to quantify the potential magnitude and probability of economic loss from catastrophe events (from earthquakes and hurricanes to flood and wildfire). A combination of science, technology, engineering knowledge, and statistical data is used to simulate the impacts of natural and man-made perils in terms of damage and loss.

11 Province level coincides with the NUTS 3 classification (Nomenclature of statistical territorial units of the EU).

- **Hazard:** the hazard module determines the flood extent and severity for each event in the stochastic set. It simulates each precipitation event and determines how these are translated into flooding in space and time considering all relevant processes, such as topography, hydrology, built-up areas, antecedent conditions, to just name a few. Flood hazard is expressed by the extent and flood depths of each flood event;
- **Exposure:** exposure is information about the assets at risk in a given study area. This information is captured in an exposure database. The exposure database contains information on the type, location, value and additional characteristics of each property asset. During the modeling process, the locations of exposed assets are overlaid with the hazard footprint of each stochastic event to determine the severity of the hazard each asset is subjected to;
- **Vulnerability:** vulnerability is the relationship between hazard (e.g. flood height) and damage (e.g. 30% of a building structure damaged). The vulnerability of an asset is dependent on its physical attributes, and can vary by peril (e.g., flood, extreme winds). The models store vulnerability information for thousands of asset types in the form of vulnerability curves, which link hazard values to damages;
- **Financial:** the hazard experienced at an asset location is linked to damage to that asset in the vulnerability module. The financial loss from this damage is then calculated (for each stochastic event and for each asset) using the financial module. Losses are then aggregated across all assets included in the analysis, taking into account any applicable protections (physical or financial) which may be in place or under consideration.

It follows that catastrophe models can be used to deliver insights into how frequently a location is to be impacted by different hazard levels. For example, they can be used to determine how frequently a given location can be expected to be impacted by flooding in excess of 6ft, or other thresholds of interest. These insights can then be used to inform decisions such as top elevations for new seawalls, or road elevation standards for new infrastructure developments.

When used in combination with the exposure, vulnerability and financial module, the model can additionally assess the frequency and severity of the economic impact caused by a specific peril, such as flooding.

This impact is quantified by subjecting the location, its associated vulnerability and financial value of exposed assets to the corresponding hazard severity for each simulated event. This economic impact analysis is particularly useful to objectively compare levels of potential loss to financial assets at different levels of likelihood.[12]

12 As mentioned, the RMS Europe Inland Flood HD Climate Change Models were utilized to quantify the impacts of climate change under different potential future states. This climate change model framework allows a selection between four different Representative Concentration Pathways (RCPs), as defined by the IPCC (https://www.ipcc.ch/), at five-year intervals until the year 2100 to understand the physical risk of climate change in the portfolio.

Data and coverage

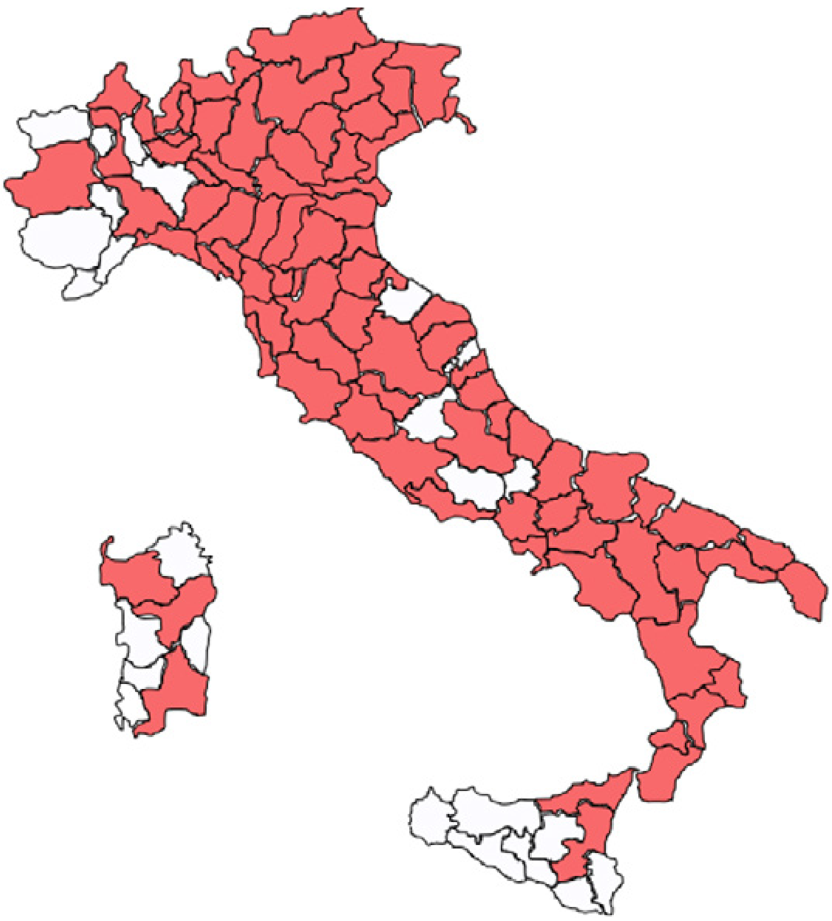
The case study was made on a limited sample of the Intesa Sanpaolo mortgage portfolio in Italian locations with the aim to estimate the related flood risk.

A sample consisting of 1,200 positions within the Intesa Sanpaolo mortgage portfolio (0.27% of the mortgage portfolio) was selected for this case study. The total value of the collateral to which these positions refer, is equal to a total of € 680 Mn (0.15% of the collateralized portfolio) and 85 out of 110 Italian provinces (NUTS 3 level classification) are represented. The key information of the sample is represented below.

Risk drivers' composition of the selected sample (sorted by Probability of Defaults)

Positions sorted by PDs	Average PD	Average LGD
PD <= 0.1%	0.04%	4.98%
0.1% < PD <= 0.5%	0.24%	10.50%
0.5% < PD <= 1%	0.68%	10.56%
1% < PD <= 3%	1.75%	10.67%
PD > 3%	6.25%	12.86%

Italian provinces included in the sample (in red)

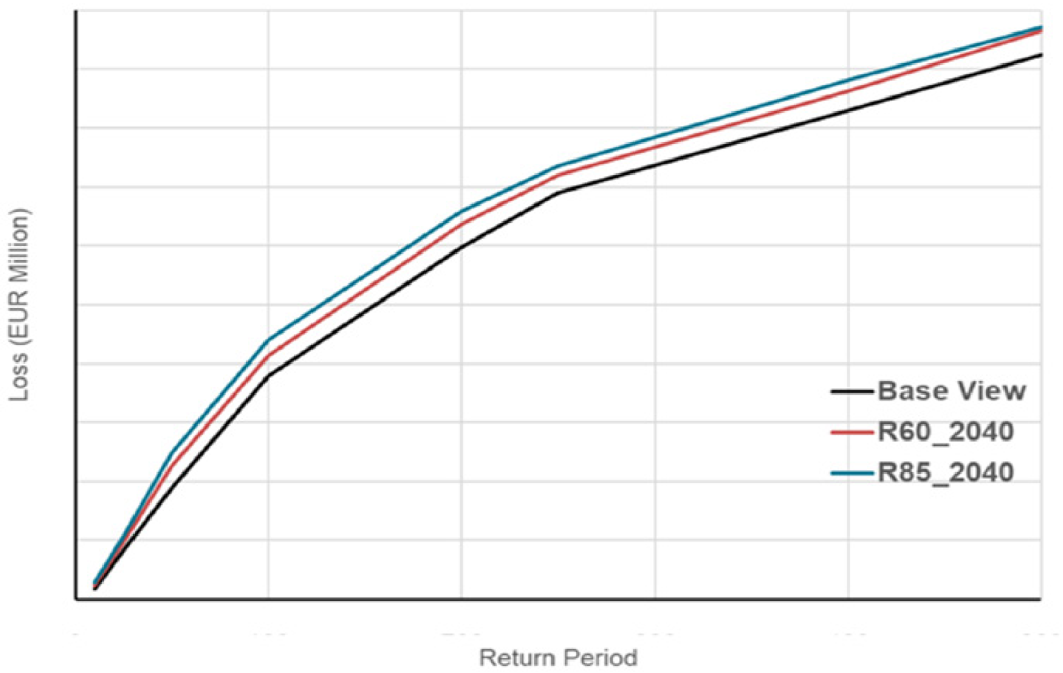


Risk factors, scenarios and outputs

The RMS model was applied to both the RCP 6.0 and the RCP 8.5 scenarios, considering 2040 as the reference year for the projections. The application of the model resulted in the definition of a haircut on the value of the collateral with a proportional increase in the expected LGD. The graphs and tables below show the effect of the model assumptions in relation to an inertial baseline view and two commonly used climate projections (RCP 6.0 and RCP 8.5) considered in terms of impact on:

1. the probability curves related to the gross value loss caused by the event damages and in relation to different return periods;
2. the average return period annual losses, reported in percentage changes with respect to the baseline view, in the most important Italian provinces.

Portfolio Probability Curves (Sample Portfolio Gross Losses)



Average Return Period Annual Losses (most populated Provinces)

Province	Average Annual Loss (% vs Baseline) Change R85_2040
Rome	**Over 50%**
Milan	**Under 20%**
Naples	**Over 50%**
Turin	**Under 20%**

Based on the analysis, Intesa Sanpaolo calculated the impact on Loss Given Default (LGD) and the effect on the Probability of Default (PD) was deduced by exploiting the relationship between PDs and LGDs (following the approach proposed by J. Frye and M. Jacobs Jr., 2012 [1]).

The underlying general premise behind the Frye-Jacobs model is that LGD is an increasing function of default rate, and consequently of the PD, which essentially means that if the default rate increases, the LGD also increases approximately in a similar proportion and vice versa.

Once all steps were performed, the LGDs and PDs implied in the different stress scenarios were estimated for all counterparties of the given sample. The following table summarizes the results taking into account the initial risk drivers' composition of the borrowers, in terms of PDs, and a return period equals to 1 on 500 years losses (for 2040 under RCP 8.5) as a worst scenario. The impacts on PDs and LGDs are substantial and vary from 4% to 39% with respect to the initial values.

Main impacts of scenarios analysis on the mortgage sample selected (sorted by Probability of Defaults)

Positions sorted by PDs	Initial Average PD	Stressed PD	Initial Average LGD	Stressed LGD	Stressed PD (x-times)	Stressed LGD (x-times)
PD <= 0.1%	0.04%	0.05%	4.98%	5.63%	1.19x	1.13x
0.1% < PD <= 0.5%	0.24%	0.30%	10.50%	14.64%	1.23x	1.39x
0.5% < PD <= 1%	0.68%	0.85%	10.56%	12.22%	1.25x	1.16x
1% < PD <= 3%	1.75%	1.92%	10.67%	11.54%	1.09x	1.08x
PD > 3%	6.25%	6.53%	12.86%	14.09%	1.04x	1.10x

Final considerations and suggested enhancements

Regarding the relationship between climate scenarios and credit methodologies, it is certainly true that this tool represents a useful opportunity for understanding the impact of flood risk (especially after the recent ECB Guide on climate and environmental risks, 2020 [2]).

Nevertheless, there is a potential for further enhancements for assessing the risks related to the mortgage portfolio.[13] Below some key points and general considerations:

1. a sample of the mortgage portfolio deemed sufficiently significant in terms of territorial diffusion, collateral values, duration of the loan to provide an acceptable output for the application of the model was chosen. The results appear to be quite satisfactory, despite the need to verify their consistency by expanding the scope of application;

13 RMS is working on methodologies to integrate damage and loss output from RMS cat models with Moody's credit models

2. although collateral properties are identified by the physical address of the building, it has not always been easy to bring them back to NUT 3 level;
3. the choice of the correct time horizon for the risk models used should be consistent with the long term strategies of the institution and in line with the reallocation portfolio decisions;
4. in this preliminary phase, the most direct way to define a correlation between the results of the model and the credit parameters was to evaluate the impact in terms of LGD and, through the relationship between PD and LGD (Frye-Jacobs approach), obtain an impact also in terms of PD. Although the results showed a good level of rationality, further refinements should be developed;
5. this case study primarily focused on acute physical risk from climate change. The analysis should be enhanced by considering other issues such as the energy efficiency certificates (EPC) that characterize every single collateral and the related impact on PD, the possible macroeconomic effects deriving from an indirect effect of a natural catastrophe (e.g., the unemployment rate) and the possible mitigation effects deriving from the presence of specific insurance policies at each counterparty level.

The proposed approach should therefore be considered as an attempt to assess the potential impact on the mortgage portfolios of the flood risk in Italy from the point of view of the financial system, to be refined time by time with the new methodologies and enrichment of data that will gradually become available.

References

[1] J. Frye, M. Jacobs Jr., Credit loss and systematic loss given default, The Journal of Credit Risk Vol 8, 1–32, Spring 2012

[2] European Central Bank, Guide on climate-related and environmental risks—Supervisory expectations relating to risk management and disclosure, November 2020

RMS is a trademark of Risk Management Solutions, Inc.

Participant:

Banorte Financial Group

Provider:
Risk Management Solutions (RMS)

Risk types covered by tool:
Physical Risk

Introduction

Banorte is participating in the third phase of the TCFD-UNEP FI 2021 program for banks, in which we involved various business areas (including risk, credit, specialized areas, sustainability, insurance, and innovation) in developing capabilities to identify, manage, and disclose climate-related risks and opportunities. To better understand and assess climate and physical risks to our portfolios, Banorte began by focusing on our loan portfolio. This was an introductory study to establish a baseline view of risk. The intent of the study was to explore using RMS models to better understand Banorte's exposure to climate and environmental risks. RMS models have the ability to show the baseline risk and climate change risk from hurricane, and as a next step, we will explore opportunities to examine future climate change risk against our baseline. We chose RMS™ from amongst several suppliers to participate in a demo that focused on the physical risk of real assets from our clients across all territories in which Banorte has provided a credit.

RMS is a very well-known provider of physical risk evaluation solutions. The company has performed several assessments for the insurance and reinsurance industry in Mexico. In fact, one of the reasons we chose RMS is because the company has been evaluating our region for more than 20 years. The RMS demo focused on sectors such as metal and mineral processing, business services, agriculture, and manufacturing of cement, lime, and plaster. The demo covered our Commercial Bank Loan book, which represents 10% of our portfolio.

Because we did not have the exact location and detailed characteristics of the facilities and assets included in the exercise, we gave RMS only the ZIP code, city, and state as an approximation to the location, the asset amount, and the sector. RMS performed its analysis based on this data.

Process

RMS consulting ran all of the model and communicated to us how their model would work. Once we had agreed on the data that RMS required to run the Banorte portfolio, we worked internally to team up with different areas of our loan department.

Our loan department and our insurance subsidiary helped us find the information we needed. We realized that our insurance subsidiary had the exact location of the clients we chose for the analysis, because all loans must be protected by an insurance policy. This significantly expedited data collection. The greatest challenge we had been facing was related to overcoming internal legal requirements so that we could share information with providers' and customers' exact geolocation.

Data and coverage

During the analysis, RMS requested data from our clients to load into their platform. Our clients provided this data via a spreadsheet that shared their sector, location, and total assets. To increase the granularity of the analysis, our clients also provided their ZIP codes.

Table 1: Data showed by RMS using their platform.

Top 10 locations by Asset Value					
Loc num	**State**	**City**	**Postode**	**Occupancy**	**TIV**
57842	Guanajuato	El Liano	36390	Metal & Minerals processing	2,587,000,000
57853	Jalisco	Marina Vallarta	48335	Business Services	2,504,000,000
57844	Distrito Federal	Polanco II Sección	11530	Metal & Minerals processing	2,177,000,000
57846	Distrito Federal	Moctezuma Segunda Sección	15530	Business Services	1,697,000,000
57835	Tamaulipas	Roma	89350	Metal & Minerals processing	1,371,000,000
57856	Quintana Roo	Tulum	77760	Agriculture	1,230,000,000
57840	Sinaloa	Bachigualato	80130	Agriculture	1,060,000,000
57855	Nuevo León	Pedregal de Escobedo	66061	Agriculture	700,000,000
57847	Distrito Federal	Sector Naval	2080	Business Services	631,000,000
57839	Puebla	Guadalupe	74126	Metal & Minerals processing	509,000,000

Table 2: Example of information provided on Banorte's behalf.

State & Sector	Zip Code	Total Assets USD*
Baja California Sur		
Hotels and similar accommodation	23403	140
Nuevo Laredo		
Hospital activities	87120	302
Manufacture of cement, lime and plaster	89350	1371
Mining and quarrying n.e.c.	89606	12
Rental and operating of own or leased real estate	89000	64
Waste collection	87080	303

	RMS
Internal	1. Sector 2. Location 3. Total assets

Because Banorte only has operations in Mexico, our assessment focused on specific locations within the country. We shared data of 25 clients representing 10 percent of our portfolio and have commercial activities in the following sectors:

1. Hotels and similar accommodation
2. Hospital activities
3. Cement manufacturing
4. Lime and plaster
5. Mining and quarrying.
6. Rental and operation of own or leased real estate
7. Waste collection
8. Growing of perennial crops
9. Structural metal manufacturing
10. Motor vehicle manufacturing
11. Electric motor manufacturing
12. Generators
13. Electricity distribution and control
14. Monetary intermediation
15. Office administrative and support
16. Real estate activities on a fee or contract basis
17. Architecture and engineering
18. Office administrative and support
19. Meat processing and preserving.

Number of companies: 25
Total: $1.6 billions

Coverage Mexican territory

Risk factors and scenarios

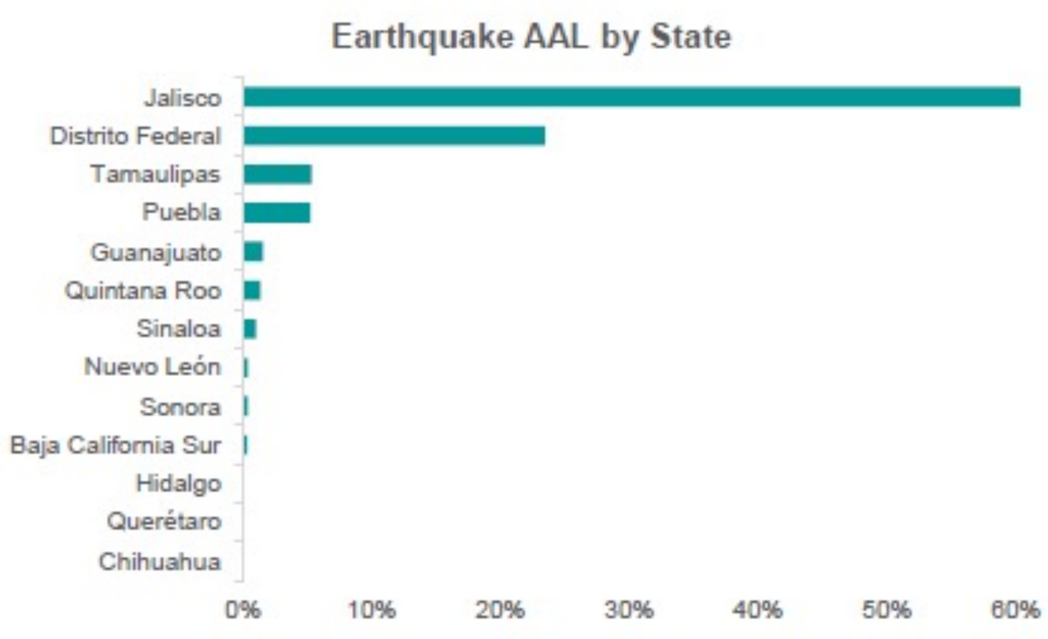
RMS provided us with an analysis that focused on physical hazards such as windstorms and earthquakes. This analysis used the following assumptions:

- Asset value is building only.
- Construction class, year built, and number of stories: unknown (based on inventory database in the model).
- RMS has construction assumptions included in their model data.
- Temperature pathway(s) analyzed: none. It was an exercise with current climate conditions.
- Scenarios used (NGFS, IEA, etc.)
  Because this was an exercise with current climate conditions, the scenarios were based on three situations:

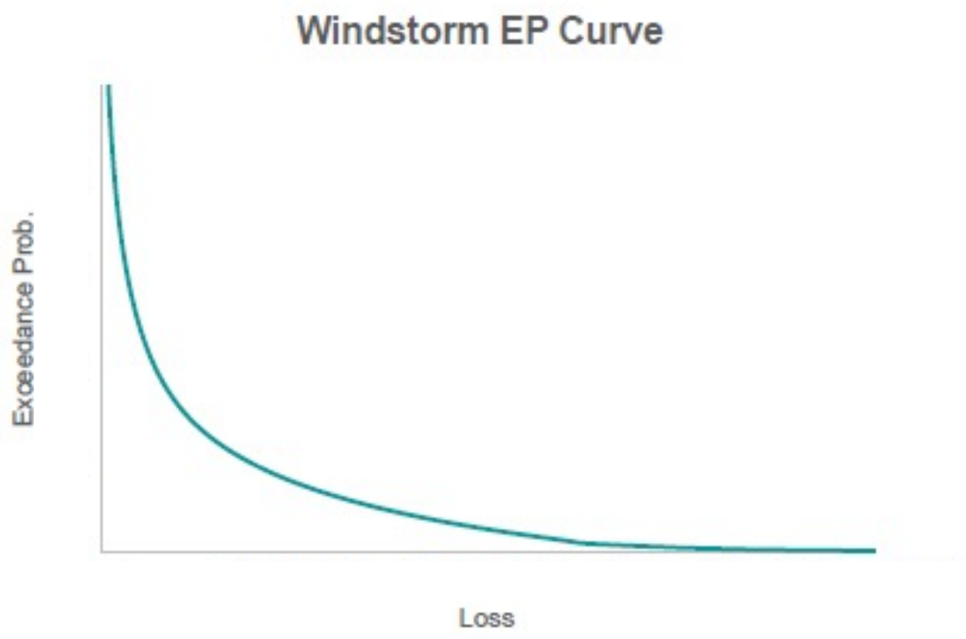
  1. Baseline current physical building risks (what is used today for insurance)
     - Earthquake and windstorm
     - 25 locations

Earthquake results:

Loss By Geography



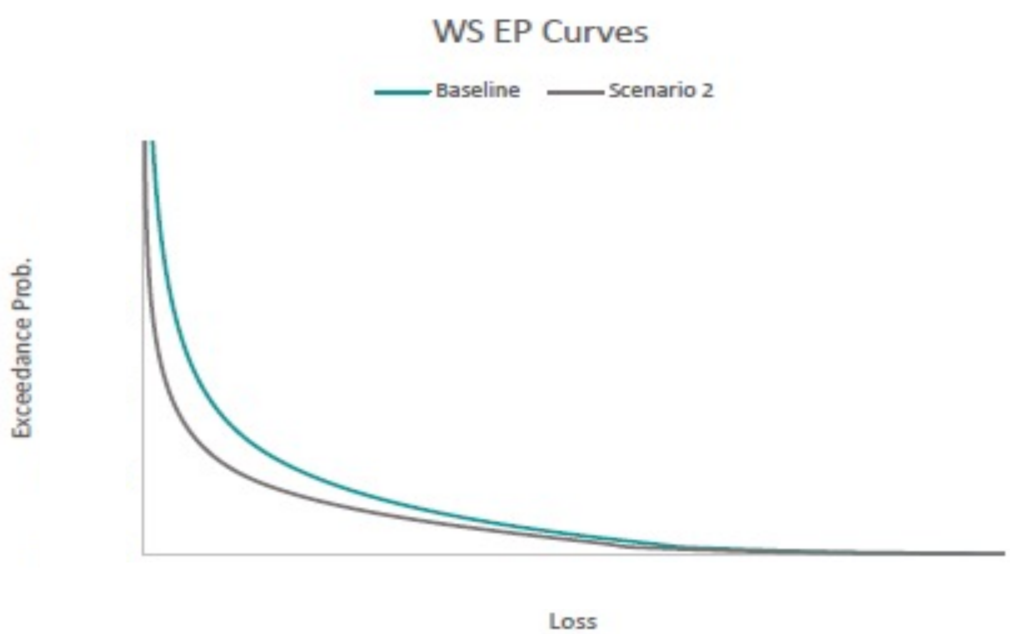
Windstorm



2. Borrow equity captures exposed risk to bank
   - Made assumption to show how one could model LTV
   - Used a 10% LTV assumption
   - Shows loss amounts after 10% borrower equity is considered

Results:

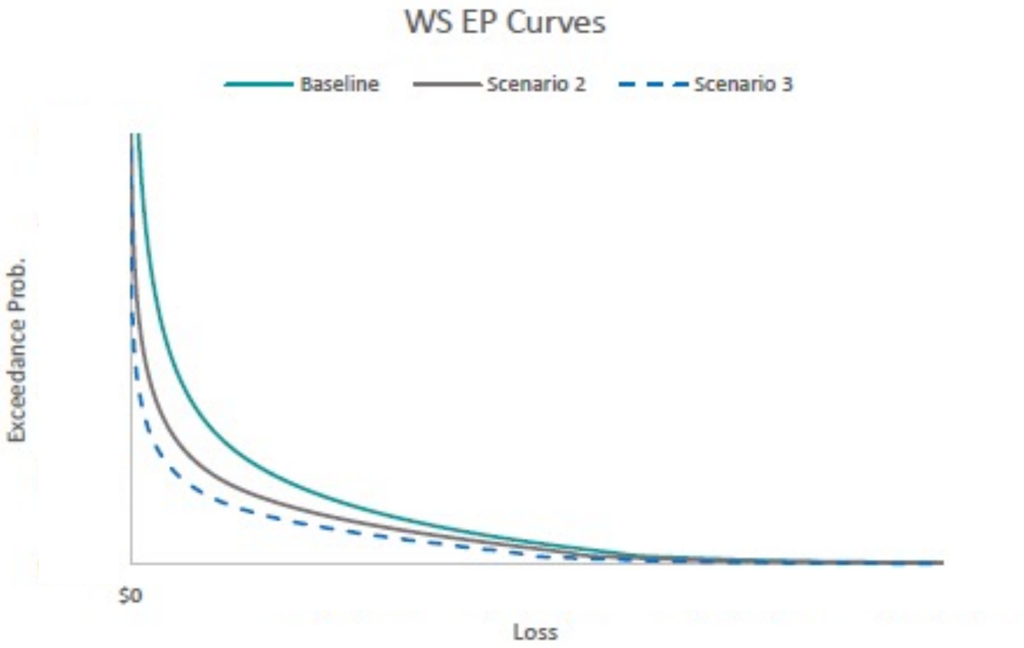
Windstorm



3. Insurance modeling projects losses after insurance is applied
   - Assumed that insurance limit is 10% of each property value
   - Modeled net losses to bank after borrower equity and insurance is considered

Results:

Windstorm



Summary of Windstorm Exceedance Probability Loss Results with % Scenario Change

Exceedance Probability	Return Period	Baseline	Scenario 2	Scenario 3
0.00%	50,000	$2bn+	-6.70%	-14.59%
0.01%	10,000	$2bn+	-6.12%	-14.60%
0.02%	5,000	$1.5bn-$1,99bn	-6.75%	-16.07%
0.10%	1,000	$1,000-$1.49bn	-9.90%	-20.39%
0.20%	500	$1bn-$1.49bn	-10.26%	-22.55%
0.40%	250	$500M-$999M	-17.22%	-35.85%
0.50%	200	$500M-$999M	-21.64%	-42.98%
1%	100	$200M-$499M	-41.35%	-65.88%
2%	50	$0-$199M	-59.59%	-84.25%
4%	25	$0-$199M	-84.89%	-98.13%

The outputs generated form RMS included Loss Outputs on each scenario they provided and the following metrics:

EP (Exceedance Probability): Probability that the single largest event loss in a year will exceed a loss threshold.

Return Period: Refers to a point on a loss curve (for example, an occurrence exceedance probability or aggregate exceedance probability curve) that describes the likelihood of exceeding a loss threshold from the single largest event (OEP) or the aggregation of one or more events (AEP). It is defined as the inverse of the annual exceedance probability. For example, a return period of 100 years corresponds to an annual exceedance probability of 1.

AAL (Average Annual Loss): Sometimes called Pure Premium or Burn Cost, AAL is the expected value of the modeled loss distribution. It is the average loss one would expect to see in a year. The actual annual losses will fluctuate around the AAL in any given year. AAL does not include expenses, non-modeled loss, profit, or risk load.

RMS can assess physical risk under actual conditions. They are working on a model to incorporate climate change to simulate future possible conditions. It would be possible to run climate change views for hurricane risk using any of the above scenario perspectives (specifically Hurricane).

- We believe that using this type of analysis helps us to assess physical risk under actual conditions.
- RMS displays clients graphically, exposing the distribution of assets by geolocation, exposure, and sector.
- Within the results of the model, RMS shows which states of our republic have the greatest risk of loss for hurricane and earthquake.
- Results could be displayed per client to see how different scenarios affect them individually.

Suggested enhancements for providers

- **How easy was the tool to use?**

  It was easy to gather the information for the exercise because RMS told us we could use an approximation of the geolocation. They only needed three indicators: sector, location (ZIP code), and total assets.

- **Do you have any modifications or suggestions that would enhance your analysis?**

  Because we did not provide details of the assets evaluated by RMS, they used some assumptions to perform the analysis:

  Asset value is building only construction class, year built, and number of stories: unknown (based on inventory database in the model)

  RMS includes construction assumptions in their model data.

  For the reasons already explained, having more details of the assets we gave RMS would have resulted in a more refined analysis.

- **What are the areas you would like to see the providers explore in the future?**

  This study did not include running RMS climate change catastrophe models. In the next phase, RMS will have the opportunity to demonstrate the capabilities of their climate change catastrophe models with detailed exposure data as part of the analysis. It would be important to see the recent capabilities they have developed around climate change. This new feature was just being finished at the time we needed to get the results to comply with the TCFD deadlines. We would like to explore it and we agreed on a demo because the new feature assesses:

- Mexico Windstorm baseline vs. RMS climate change views.
- RMS climate change views based on four RCP scenarios (2.6, 4.5, 6.0, 8.5) and/or a 2o C increase.
- Loss estimates from 5 to 80 years forward (in 5-year increments). Example output shows 2030 and 2050.

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Participant:

BMO Financial Group

Provider:

Oliver Wyman/S&P Global Market Intellgence

Risk types covered by tool:

Transition Risk

Introduction

As part of the Landscape Review exercise, BMO Financial Group worked with Oliver Wyman and S&P Global Market Intelligence to demo Climate Credit Analytics, a climate scenario analysis and credit analytics model suite. Climate Credit Analytics is a turnkey solution that enables bottom-up analysis of five high carbon-emitting sectors (oil and gas, metals and mining, power generation, airlines and automotive) as well as a generalized approach for all other sectors. For the purposes of the demo, the Bank focused on the metals and mining sector.

The scenario analysis tool is used to assess the credit risks associated with the transition to a low carbon economy. Climate Credit Analytics assesses the credit rating impact of climate scenarios on a counterparty or portfolio level by calculating climate adjusted financial statements. The tool leverages S&P Global Market Intelligence's data resources, including financial and industry-specific data, credit scoring methodologies and Trucost environmental data. This is combined with Oliver Wyman's climate scenario and stress-testing expertise.

Process

Climate Credit Analytics can be accessed through two interfaces: an Excel version or an Application Programming Interface (API) version.

To generate results through Climate Credit Analytics, the user follows a few simple steps:

- Search or upload portfolio companies in Climate Credit Analytics
    - Tool automatically populates required financial and environmental data
- Select scenarios to run and interval period of results (either at 5-year intervals or annually)
- Select the S&P Global rating model that will be used to re-rate the companies
    - Internal rating model can also be used
- Adjust or override model parameters, if desired
    - The parameters available to adjust range from financial parameters (e.g. level of dividends paid, leverage ratio) to sector-specific parameters and scenario variables

- Run the model
  - Results presented in two ways:
    - Single entity view: focuses on a single company, showing the evolution of the financial statements and the rating and probability of default changes
    - Batch view: gives the full financial statement and rating results for all counterparties selected to run in the model to allow for further portfolio analysis internally by the user

The model translates climate scenario and sector-specific supply and demand elasticities and market dynamics into drivers of financial performance to provide financial statement forecast, impact on credit score and probability of default. Core metals and mining assumptions include:

- **Price:** as demand for coal decreases prices will likely fall, while other minerals see an increase in price as the scenario emissions costs are passed through to consumers
- **Volume:** demand for coal falls in the transition while demand for energy transition minerals increases with electrification/ EV adoption. Other minerals grow with the economy
- **Unit cost:** mining production costs increase due to the carbon price and emissions intensity of production for each mineral
- **Capital expenditure:** coal capex is expected to decrease along with demand as high cost mines close, while increasing for other minerals to meet rising production levels

Based on this information, the model calculates scenario adjusted financial statements (e.g., income statement, balance sheet and cash flow statement). It then links the scenario-adjusted financial statements to S&P's credit rating model to calculate scenario-adjusted credit scores, or ratings. The user can also link the scenario-adjusted financials to internal risk rating models.

Data

A sample of North American and European publicly traded metals and mining counterparties was assessed. The data required for the analysis is included in the Climate Credit Analytics tool. Climate Credit Analytics covers 1.6 million public and private companies across all geographies. If a company is not included in the S&P Global dataset, the user can upload the required data via the API.

Climate Credit Analytics segments metals and mining production into three categories: fossil fuel minerals, energy transition minerals and other minerals and models the impact related to demand and emissions. Fossil fuel minerals include thermal/steam coals used for electricity generation and metallurgical coal used in steel making. Energy transition minerals are critical to electrical vehicle battery production and include lithium, cobalt, nickel, manganese and copper. Other minerals include iron, silver, uranium, aluminium, zinc, gold, molybdenum, diamonds, lead, platinum/PGM and titanium.

Risk factors and scenarios

Climate Credit Analytics enables analysis of climate transition reference scenarios published by the Network for Greening the Financial System (NGFS). NGFS scenarios extend to 2050 and are loaded in the model. These scenarios cover temperature pathways ranging from 1.5°C to 3°C+ and have over 1700 sector specific and macro variables, e.g., GDP. Credit risk can also be analysed under a global carbon tax scheme that is enacted over a three-year period (e.g., 2020–2022). Users also have the option to run customized scenarios.

The key transition risk factors explored in the demo were technology and carbon pricing. The following NGFS transition scenarios were assessed:

- Immediate 2°C with carbon dioxide removal (CDR) technologies
- Immediate 1.5°C with limited CDR. Limited CDR scenarios require larger reductions in fossil fuel use as CDR technology cannot be relied on

Outputs and insights

Climate Credit Analytics generates full scenario-adjusted financial statements (Income Statement, Balance Sheet, Cash Flow Statement) at a counterparty level on an annual basis. The model also generates climate adjusted credit ratings and probabilities of default using an embedded rating model from S&P Global. Counterparty level outputs can then be aggregated at a portfolio level.

Immediate 2°C, with CDR

- Diversified miners are expected to maintain profitability as losses in coal are offset by growth in other minerals, e.g., energy transition and other minerals
- As the demand for transition minerals increases, profitability should grow for companies with no coal production
- The average rating impact for the sample of counterparties was limited. This is attributed to nature of the companies included in the sample

Immediate 1.5°C, limited CDR

- Diversified miners are expected to maintain profitability due to growth of non-coal minerals provided they have sufficient profit margins
- Margins expected to shrink for companies with no coal production as growth in volume of transition and other minerals is counteracted by increased unit costs of emissions for mining these minerals, however they should remain profitable provided they have sufficient starting margins
- The average rating impact for the sample of counterparties was limited. This is attributed to nature of the companies included in the sample

The following illustrates how counterparty ratings can change under a transition scenario. Note the results depicted do not reflect demo results.

Demo results are consistent with what we would expect, namely that diversified companies are better positioned to navigate transition risk. The ratings impact is aligned with exploratory analysis that we have conducted internally on the same sample of counterparties. Climate Credit Analytics outputs can inform discussions on transition risk implications.

Climate Credit Analytics is user friendly and easy to navigate and results are generated quickly. It automatically populates the necessary input data for analysis which saves significant time and effort in sourcing data. The integration of NGFS and carbon scenarios in the model and the ability to customize scenario parameters further contributes to the ease of use.

Participant:

Desjardins Group

Provider:
The Climate Service (TCS)

Risk types covered by tool:
Physical and transition risk

Introduction

As part of the UNEP FI TCFD pilot programme, Desjardins selected The Climate Service (TCS) as one of its preferred potential suppliers to participate in a demo. The Climanomics® platform of TCS provides screening-level climate risk analysis and enables users to identify physical and transition risks across their portfolio of real assets. Desjardins provided a sample of 50 real assets from different sectors (residential, industrial, and corporate) to upload into the platform and interpret results. The platform models absolute climate risk ($M) and relative climate risk (%), reported as percent of asset value. Overall, the sample provided by Desjardins faces the highest physical risk from fluvial flooding and the highest transition risk from carbon pricing in the 2030s, in both RCP 4.5 and 8.5 scenarios. This fact remains true to 2100 with most physical risks and transition risks increasing over time. At the asset level, most impacted assets are those with high emissions, as a result of carbon pricing over time in both scenarios. Renewable energy assets have the lowest total risk in both scenarios. The platform also offers a high- level analysis of the opportunities related to climate change; however, our focus for this first assessment was on climate risks.

Process

The Climanomics® platform is accessible by creating a user profile in climanomics.com. Once the user has logged into the platform, the user will be given an option to access the Real Assets or the Listed Equities platform. Our demo was focused on the Real Assets platform, with data provided in an Excel file (see Data and coverage section) and TCS conducting the upload. Note that regular users can directly upload data through files or an Application Programming Interface (API).

Once the user has entered the platform, a view of the aggregated portfolio risk is seen with the option to drill down to the asset level. All assets have been geolocated and are visible on a map. Risk factors analyzed are listed to the left of the screen with the calculated absolute risk and relative risk, with toggles to provide values for both RCP 4.5 and 8.5 at decadal intervals (from 2020s to 2090s). The relative risk is shown in green if it is below 10% risk, yellow if it is between 11% and 15% and in red if it is above 16% to facilitate materiality analysis. The ranges for this colour coding can be modified upon request to the TCS team.

For a given asset, a deeper analysis is provided for each risk, with a chart showing the evolution of the hazard (e.g. temperature increase per decade compared to baseline) and the associated impact function (e.g. production loss per additional degree of daily max temp). The user has the option to navigate from the risk tab to the opportunities tab which has a very similar format. The platform also has a quick access to the methodology document.

Our main challenge with the platform during this demo is external to TCS and completely related to our institution's strict IT security processes. While we were able to create a profile in the Climanomics® platform website, we were not able to access the real assets platform for several weeks. This issue is completely external to TCS but other financial institutions with strict security processes may face similar issues when engaging potential suppliers of climate risk tools. Even though the data provided for this demo had already been assessed as nonconfidential, accessing the platform from Desjardins's environment required a thorough IT security analysis. The TCS team was very supportive during this process, and they even developed a findings document that enabled us to visualize and better understand the results.

Data and coverage

To conduct this analysis, Desjardins provided a list of 50 portfolio assets, along with name, value in USD millions, reported/estimated GHG emissions, and location (address or latitude and longitude). All asset data was provided by Desjardins (this included internal data and data collected from data suppliers and desktop research.) No additional data was required to conduct the physical and transition risk analysis with the Climanomics® platform software platform.

In terms of portfolio coverage, Desjardins has US$289 billion in total assets and our list of 50 assets used in this demo represents less than 1% of our investments or loan books. Our sample included assets primarily in Canada but also in the United States, Europe, Australia and Asia (see figure below) with a variety of sectors represented including, agriculture, renewable energy, fossil fuels, manufacturing, retail, corporate and residential real estate.

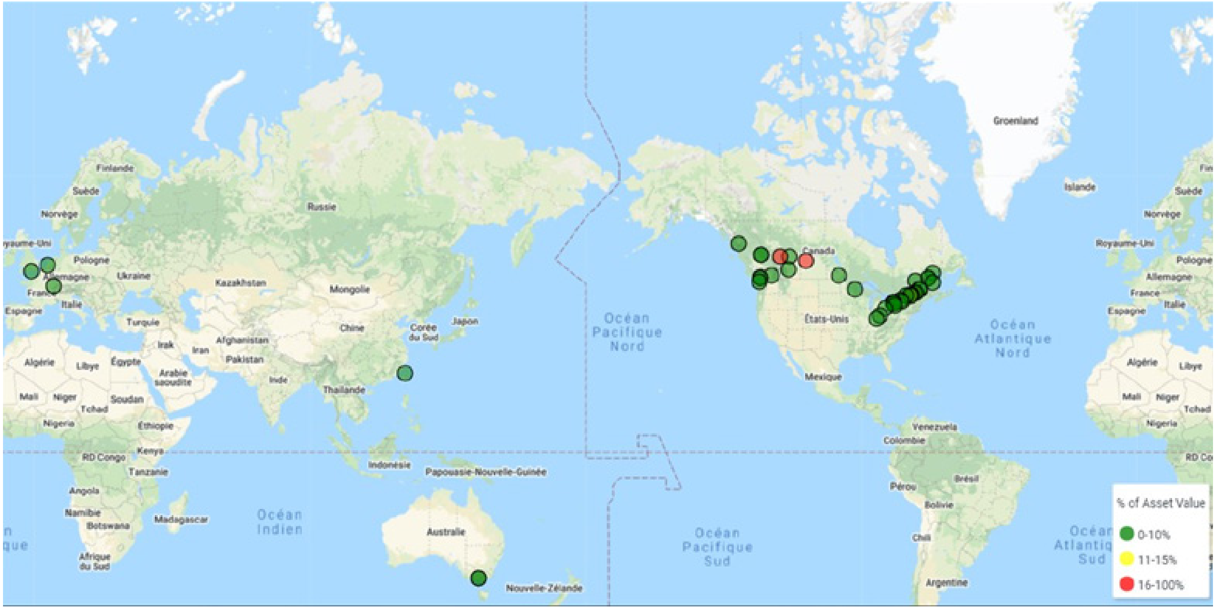


Figure 1: Locations of the 50 real assets analyzed in this demo with color coding representing relative climate risk

Risk factors and scenarios

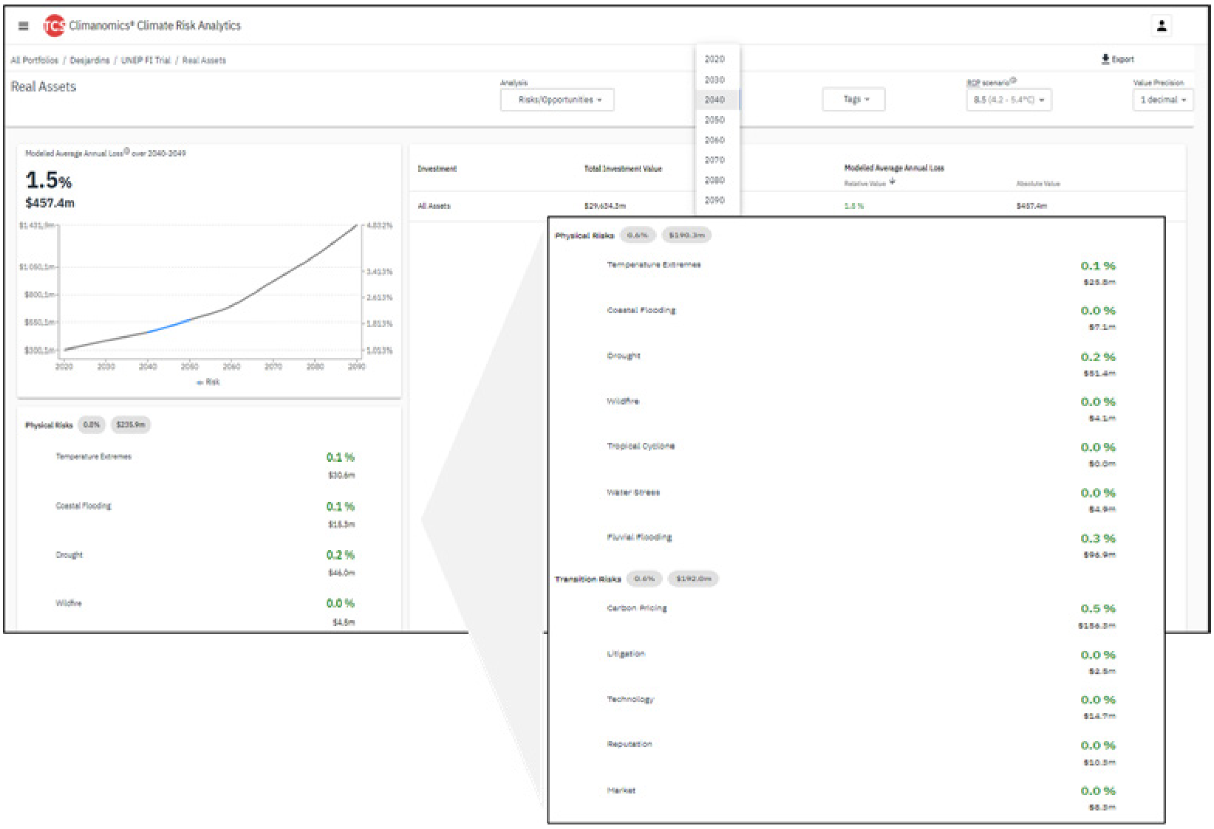
The Climanomics® platform conducts physical and transition risk hazard modelling. The risk hazards included in the assessment are shown in the table below:

Table 1. Physical and Transition hazards in the Climanomics® platform

Physical hazards	Transition hazards
Temperature	Carbon pricing
Drought	Litigation
Wildfire	Reputational damage
Coastal flooding	New technology
Fluvial basin flooding	Markets
Tropical cyclones	
Water stress	

The platform currently reports risks for 10-year increments and the user can view the modelled average annual loss (MAAL), that is the sum of expected financial losses resulting from climate change for the designated period by selecting the desired decade in the drop-down menu (see figure below). A dropdown menu is available to select the desired RCP scenario (8.5 or 4.5). The resulting MAAL in absolute and percentage terms will be shown per risk, with aggregated values for physical and transition risks overall.

Figure 2: Climanomics® dashboard view and modeled average annual loss breakdown



The Climanomics® platform includes scenarios based on the Representative Concentration Pathways (RCPs) from the International Panel on Climate Change (IPCC). Two scenarios are currently included in the platform: RCP 8.5 and 4.5; other scenarios (RCP 2.6 and RCP 6.0) are currently being integrated to the platform and are scheduled to be available by the end of September 2021. According to the Climanomics® platform methodology document, the RCP 8.5 scenario constitutes the high emissions scenario with an assumption that no major global efforts are made to limit emissions resulting in a global mean surface temperature that will be in the range of 4.2 to 5.4°C. On the other hand, the RCP 4.5 constitutes the lower emissions scenario by implying coordinated action to limit emissions and achieve a global temperature warming limit of about 2°C; the estimated mean surface temperature used for this scenario is 1.7 to 3.2°C.

Shared Socioeconomic Pathways (SSP) are integrated in the platform to model carbon pricing. For the RCP 8.5 scenario, the Climanomics® platform uses scenario SSP3-60. SSP3 scenarios assume high challenges to both adaptation and mitigation at different degrees. The price is available at the regional level, for 5 regions: OECD, REF, ASIA, MAF and LAM.[14] The SSP3-60 scenario shows carbon prices starting at $8/tonne CO_2e in 2010 and increasing to $82/tonne CO_2e by 2100. On the other hand, for the RCP4.5 scenario, the Climanomics® platform uses scenario SSP3-45 with prices starting at $8/tonne CO_2e in 2010 and increasing to $440/tonne CO_2e by 2100. Among other sources,

14 Organisation for Economic Co-operation and Development and EU member states and candidates (OECD), Reforming Economies of Eastern Europe (REF), Asian countries with the exception of the Middle East, Japan and Former Soviet Union states (ASIA), Middle East and Africa (MAF) and Latin America and the Caribbean (LAM)

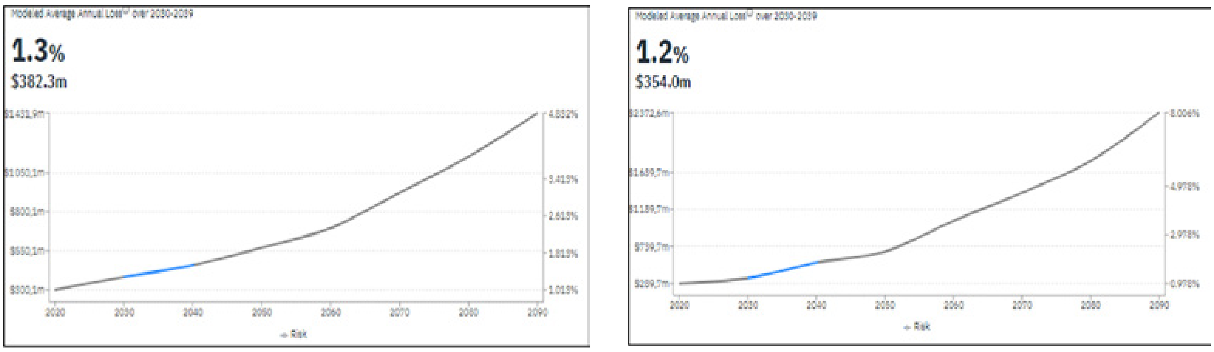
these scenarios are available at the SSP Database from the International Institute for Applied Systems Analysis (IIASA). The platform calculates carbon pricing risk for each asset depending on their location and the GHG emissions data entered.

Outputs and insights

The Climanomics® platform generates an aggregated portfolio result and an asset-level result. Overall, the highest physical risks faced by Desjardins based on the sample data provided is fluvial flooding and the highest transition risk is carbon pricing. Both top risks increase over time at different degrees for both RCP scenarios. The high-level results from the asset sample uploaded for this demo can be found in the table below for the 2030s 10-year window.

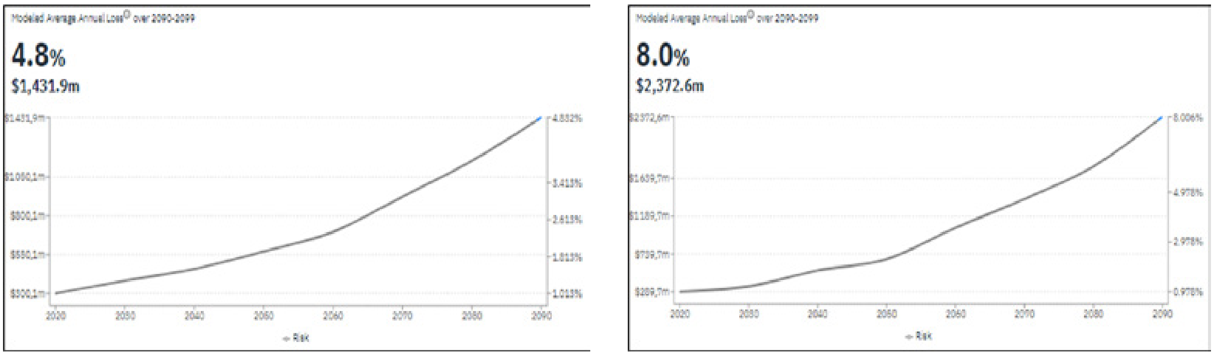
Priority	RCP 8.5 "High emissions"	RCP 4.5 "Low emissions"
Top	▪ The highest physical risk overall is faced from fluvial flooding and the highest transition risk is faced from carbon pricing in the 2030s. ▪ Two natural gas-fired power plants face the highest total risk in the 2030s.	▪ The highest physical risk overall is faced from fluvial flooding and the highest transition risk is faced from carbon pricing in the 2030s. ▪ Two natural gas-fired power plants face the highest total risk in the 2030s.
Medium	▪ Drought poses the second highest physical risk, while Technology poses the second highest transition risk in the 2030s	▪ Drought poses the second highest physical risk, while Technology poses the second highest transition risk in the 2030s.
Low	▪ Wind farm 1 has the lowest total risk in the 2030s.	▪ Wind farm 2 has the lowest total risk in the 2030s.

Figure 3: Risk in 2030s RCP 8.5 (left) and RCP 4.5 (right)



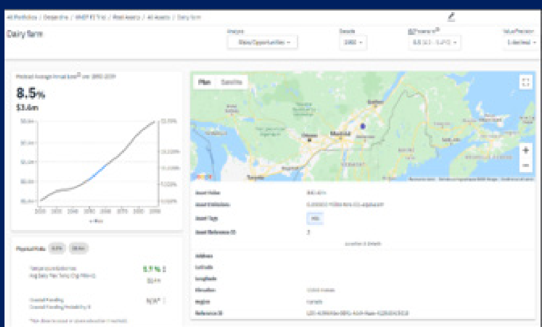
In 2030, the RCP 8.5 scenario shows a slightly higher overall risk than RCP 4.5 primarily because of higher physical risk with MAAL at $190.3m (0.6%) compared to $143.8 (0.5%). On the other hand, the RCP 8.5 scenario shows a slightly lower transition risk than RCP 4.5 with $192.0m (0.6%) compared to $210.2m (0.7%); this difference is due to higher carbon pricing projected in RCP 4.5, despite slightly higher reputation and litigation risk for Desjardins in this decade with RCP 8.5. This trend continues to the 2090s, with physical risks being higher in RCP 8.5 and transition risks higher in RCP 4.5. As shown in the figure below, the incremental risk of carbon pricing in RCP 4.5 surpasses the risk of physical risks in RCP 8.5, resulting in an 8% MAAL compared to a 4.8% in the 2090s.

Figure 4: Risk in 2090s at RCP 8.5 (left) and RCP 4.5 (right)



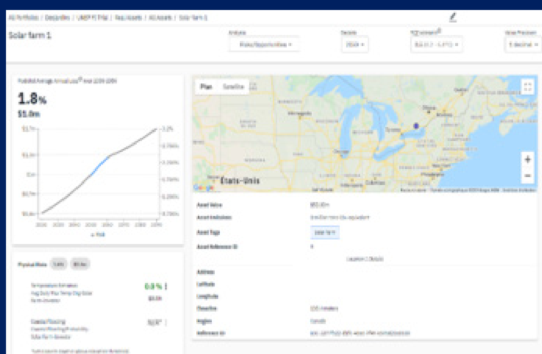
The results of this demo and the lessons learned are aligned with our current climate change risks analysis perspectives. We are using this experience to learn about the methodologies available and decide how to best conduct this type of quantitative analysis for different sets of assets, faster and at a larger scale than our capabilities allow. The outputs generated by the Climanomics® platform and other similar platforms might inform decision-making for longer term investments and financing in multiple sectors. The results further validate our net-zero strategy and the need to expand our nascent climate change adaptation analysis. We will also showcase internally a comparative view of carbon-intensive assets versus ones with low emissions to continue to build awareness on transition risk. As part of our climate action plan, we have identified carbon intensive sectors for which we are engaging with our clients to support their transition to low carbon scenarios. The outcomes and ease of use of this tool can support discussions with clients in these sectors who have not already quantified their potential transition risk.

Asset-level outlook for a dairy farm and a solar farm in the 2050s



Dairy Farm: Located about 1.5 hours northeast from Montreal at an elevation 110 meters and close to a river, the dairy farm will face a modeled average annual loss (MAAL) of 6.7% to 8.5%, for RCP 4.5 and RCP 8.5, respectively. The highest risks faced are from temperature extremes, followed to a lesser degree by fluvial flooding and drought at both the RCP 4.5 and RCP 8.5 scenarios. The largest difference among the two is temperature extremes representing a 5.7% MAAL in RCP 8.5 and 3.9% MAAL in RCP 4.5. Regarding transition risks, at this point, with the emissions estimated for the farm, there are no significant risks. However, if actual emissions are higher than estimated, or if carbon prices are higher, transition risks may become significant.

Solar Farm: Located between the cities of Toronto and Montreal at an elevation of 140 meters, this solar farm will face a MAAL of 0.6% to 1.8% for RCP 4.5 and RCP 8.5, respectively. Most of the risk faced will be from fluvial flooding in both RCP 4.5 and RCP 8.5 scenarios. Transition risks are very close to zero, primarily because estimated emissions are zero. Overall, and when compared with other assets, the solar farm faces very low risk. To put things into perspective, for the same time period, a natural gas-fired power plant in Canada in our sample asset list will face a MAAL of 32.2% and 64.6% for RCP 8.5 and RCP 4.5, respectively. This very high risk is almost entirely dependent on the high amount of emissions generated by the asset and the projected carbon pricing.



Suggested enhancements for providers

The demo was effective at demonstrating the climate risk analysis capabilities of the Climanomics® platform for several asset types. The tool is easy to understand, and the methodology document and overview provided were very helpful. The data entry function is user-friendly as well as the navigation throughout the platform. For physical risks, the methodology is perceived as robust by our team with a good coverage of hazards. The two RCP scenarios included are good options to test assumptions. Transition risk analysis is more complicated to conduct and utilize as there are multiple variables to consider and scenario data is limited. Out of the five hazards, carbon pricing is the only hazard linked to a shared data scenario (SSP3) with a key limitation being that SSPs are done at the regional level, as explained above in Risk factors and scenarios. Upon discussion with the TCS team, we were informed that carbon pricing can be modified to include more granular projections for which data is available, upon request from the user. It would certainly be an enhancement for this and other platforms to provide carbon pricing projections at the national/sub-national level. The other transition hazards, including litigation, reputational damage, new technology and markets are calculated with a high-level approach that will be refined as data and granular approaches become available. Automating a granular transition risk analysis seems to be a key challenge for this type of tools currently and in the near future.

Overall, Desjardins was satisfied with the Climanomics® platform and the TCS team. Since this is an evolving science, we will continuously explore the methodologies and data used to improve the accuracy of the projections.

Lastly, we have developed a wish list of enhancements that could be good additions to the Climanomics® platform or to other similar climate risk analysis platforms:

- A variable to incorporate remaining asset life (years) per asset or update the projected portfolio every 10–20 years
- A variable to incorporate projected emissions reduction per asset or asset type
- A variable to incorporate planned adaptation measures impacting the vulnerability per asset or asset type
- A benchmarking view on how the risk level is distributed for similar assets modelled (e.g. risk curve, or x% of similar assets in the same region or worldwide more/less exposed). This benchmarking capability is in development by TCS.
- Heatmaps to indicate where some risks (physical and transition) are higher for each asset type. This capability is in development by TCS.
- Guidance and practical examples on how to best incorporate results into existing risk analysis models in the financial sector
- A qualitative description explaining the resulting MAAL per hazard at the asset level. For instance, an automatic text box that could answer the question “why is this particular farm more exposed to flooding and drought than this other farm”?

Participant:

TD Asset Management

Provider:

The Climate Service (TCS)

Risk types covered by tool:

Physical risk

Introduction

TD Asset Management Inc. (TDAM, a wholly-owned subsidiary of The Toronto-Dominion Bank) considers climate change a systemic risk affecting economies, companies, and investors. Our approach to climate change is aligned with our overall philosophy of integrating all sources of risk and return in our investment processes.

As an investment manager of diversified asset classes, we consider climate change as an important area of research to fulfill our fiduciary responsibility on behalf of our clients. We actively engage with companies as well as our partners, and leverage our asset ownership positions to encourage improvements in company disclosures on climate-related risks and opportunities facing their businesses. In addition, we participate in numerous industry collaborations including Climate Action 100+, Carbon Disclosure Project, and the UNEP FI TCFD investor pilots, with the first two furthering our company engagement efforts, and the latter developing a better understanding of climate-related investment risks. Our approach continues to evolve to help position our portfolios to capitalize on investment opportunities arising from an accelerated transition to a low carbon economy and manage undue climate-related physical and transition risks.

About TDAM's Global Real Estate Strategy

TDAM's Global Real Estate Strategy was seeded in 2019. The strategy is invested in over 800 properties in 140+ cities throughout the United States, Europe, and the Asia-Pacific. This provides broad diversification globally by regions, property type, and risk strategy (core, value-add and opportunistic). The strategy focuses on developed metropolitan areas and urban, transit-linked, office, multi-unit residential, retail, and logistics/distribution-oriented industrial assets. The comprehensive diversified exposure of a global non-listed real estate portfolio can add significant diversification benefits to multi-asset class portfolios.

These risks and opportunities are present within all our portfolios, but are especially notable within non-listed real estate investments. Physical buildings play an integral role in climate change since properties not only contribute to, but are impacted by, their environment and their communities. However, the commercial real estate industry is at the beginning of its journey to measure and adapt to the full financial and operational impacts of climate change. Governments and tenants, increasingly concerned about physical property's contributions to climate change, are likely to mandate changes. And these changes are happening concurrently with an increase in the acute and chronic physical risks that threaten buildings. As a result, building owners are likely to be presented with additional costs, risks, and opportunities.

Part and parcel of deeply understanding risks residing in the portfolios we manage, we first seek to understand the tools and methodologies available, and then increase awareness around the strengths and potential gaps in such evaluations. As part of our efforts, members of TDAM's Investment Risk team participated in the UNEP FI Landscape Review module to gain insight into climate-related physical asset risks for a portion of our Global Real Estate Fund. We were paired with The Climate Service (TCS), who provided an estimate of the financial impacts of the physical risks due to climate change for a sample of assets from the fund's non-listed indirect Asia-Pacific Real Estate investments. Risk was estimated as an annual loss, for each decade from the 2020s to the 2090s, across two climate scenarios.

Overall, the results of the analysis were insightful and enabled the naming and quantification of vulnerabilities at the asset, metro, and region level, encouraging further locale-specific research and conversations with our investment teams and fund managers. The trial also highlighted a handful of potential improvements which could enhance the accuracy and applicability of the results.

Process Overview

After being paired with TCS, we met with them to review scope and data requirements, and subsequently populated an excel-based template with internally sourced asset data. After some processing time, we were provided logins to their web-based platform (Climanomics®) and met with TCS to review the results. We performed an exploration of the results within their platform as well as loaded the raw data into an internal database, performing our own portfolio-level analysis. We then reported our findings to internal stakeholders.

Data and Coverage

TCS requested market value, emissions, property type, and location information for each asset participating in the trial. For location, we submitted latitude and longitude, but they would have also accepted a street address, from which a latitude and longitude could be derived. Elevation was also a required input and was calculated automatically by the Climanomics® platform.

We were able to source all data internally, except for emissions data. For emissions data, we sourced it from the GRESB platform, within which some of our managers make information available to us as investors. However, mapping the data from GRESB to internal data was an arduous process. Property types also required translation from internal types to TCS sub-types.

The number of assets we could include in the trial was limited. Because of this, we narrowed our focus to the Asia-Pacific region of our Global Real Estate Fund. Within that region we selected 75 assets from the 200+ available. They spanned the industrial, office, hotel, multi-unit residential, and retail property types. In order to achieve coverage across metros and property types, we selected at least one asset per metro and type. In the event there were multiple that met these criteria, we selected based on value and/or if there was something else of interest, like having high intensity greenhouse gas emissions, being close to sea level, or having a large weight in the region. This selection method enabled us to achieve 100% coverage on 13 out of the 24 Asia-Pacific metros to which our fund is exposed, and over 70% of the value of the Asia-Pacific region of the portfolio.

Risks factors and scenarios

At a high-level, TCS covered global transition risks, physical risks, and opportunities for physical assets such as real estate, energy and power generation infrastructure, transportation, and agriculture. More specifically, the risks and opportunities covered included:

- **Physical risks:** extreme temperature, drought, wildfire, water stress, coastal flooding, fluvial basin flooding, and tropical cyclones
- **Transition risks:** carbon pricing, litigation, reputational damage, new technology, and markets
- **Opportunities:** resource efficiency, energy source, products and services, markets and resilience

We opted to focus exclusively on physical risks since we were participating in a parallel UNEP FI module focused on transition risks.

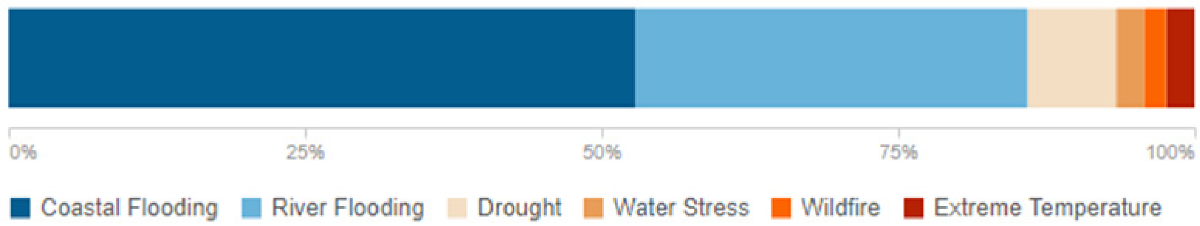
At the time of the trial, TCS supported two Intergovernmental Panel on Climate Change (IPCC) Representative Concentration Pathways (RCP) scenarios: RCP 8.5 "High Emissions" and RCP 4.5 "Low Emissions". The RCP 8.5 scenario assumes that there will be no major global effort to limit greenhouse gas emissions and the RCP 4.5 scenario implies a coordinated action to limit greenhouse gas emissions such that global warming is limited to approximately 2°C. TCS plans to add two additional climate scenarios, RCP 2.6 and RCP 6.0, by the end of September 2021.

Outputs and insights

The principal output of TCS's platform was *Modeled Average Annual Loss*, represented in two forms: a quantitative dollar amount (in millions, USD) and an annual loss presented as a percent of total asset value. Both measures were estimated for each decade, up-to and including the 2090s, for both the RCP 4.5 and RCP 8.5 scenarios. Values were available via the web-based Climanomics® platform as well as a machine-readable format.

Internal analysis of the results revealed multiple insights. First, at an aggregate level, the primary contributors to physical risk within the assets were coastal and riverine flooding, as can be seen in Figure 2. Combined, these two risks comprised 86% of all physical risks.

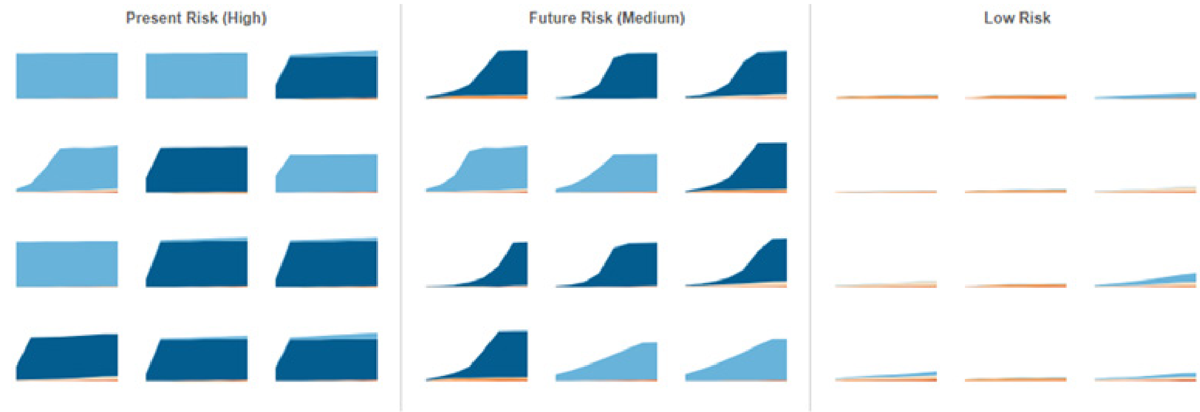
Figure 2: All-time cumulative physical risks for all trial assets, RCP 8.5



Source TDAM, TCS

Second, by classifying the assets by their cumulative risks, we observed that there were significant physical risk exposures as early as the current decade. This is readily apparent in the assets' physical risk "fingerprints" seen in Figure 3. In these low-resolution plots, time is along the horizontal axis and percentage risk is represented on the vertical axis. The Present Risk (High) class sees exposures commencing in the current decade whereas in the Future Risk (Medium) class, they commence mid-century. The majority of the assets were classified as Low Risk where the physical risks are low throughout the century.

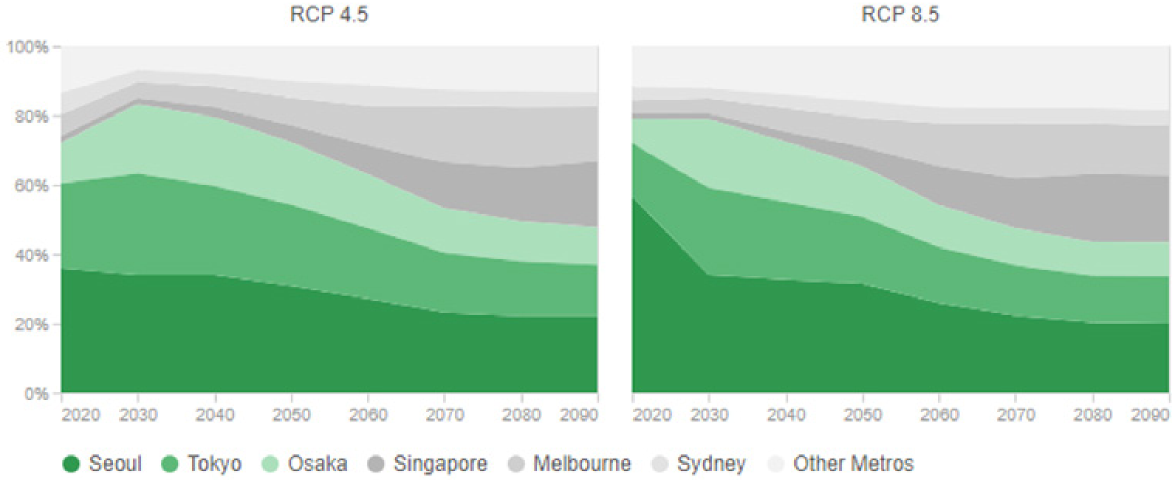
Figure 3: Sample of trial asset physical risk fingerprints, by risk class, RCP 8.5



Source TDAM, TCS

The third insight we gained was with respect to location. By aggregating the individual assets' risks by metro, we were able to see which metropolitan areas were the most vulnerable—specifically, Seoul, Tokyo and Osaka, as shown below in Figure 4.

Figure 4: Metropolitan area contribution to risk in Asia-Pacific



Source TDAM, TCS

Being presented with these three insights led us to ask questions of, and seek additional information about each metro:

- What geographic and topological features were driving the risks in each metro?
- What adaptations measures are currently in place or being planned?
- Are local governments adapting to the expected increases in frequency and intensity of events? If so, how?

Seeking answers to these questions is instructive in the sense that it is these factors that ought to be considered in our investment decisions.

Lastly, we calculated a region-level risk measure. Because the trial was limited to only 75 of 200+ assets in the region, it was necessary to extrapolate values for the portion of the portfolio that was not included in the trial. To accomplish this, we calculated the average risk for each metro and then applied that average to each out-of-trial asset before weighting the assets by their investment exposure. This method was not particularly sophisticated, but it served as a good-enough first order approximation. Having a region-level measure enabled us to contextualize its magnitude by contrasting it against the region's cash dividend yield. This demonstrated that impacts due to climate change have the potential to be material to the fund's long-run income return.

Use cases

Within the investment decision making and management processes, information like that which TCS provided can be useful at two levels.

First, it can be useful at the asset level. Knowing how an asset is physically vulnerable focuses our attention by moving our understanding from the nebulous "physical risks" to the specific, like "riverine flooding". This knowledge underpins productive conversations about asset-specific adaptations and resilience.

Still at the asset level, we see it also being of utility during due diligence when acquiring an asset. Knowing the specific risks makes it possible to at least speculate about the costs of potential adaptation measures and what impact the costs of physical risks might have on a potential asset's long-run investment returns. While the *Modeled Average Annual Loss* cannot be used directly in a discounted cash flow projection since it does not account for municipal/building adaptations or insurance, it provides at least a starting point from which we can perform sensitivity analysis.

Second, information can be useful at a metropolitan level or "locale". Commercial real estate assets are typically located in major metropolitan centers, which means that most assets within that locale are subject to similar physical risks, driven by the geography and topology. For example, both Tokyo and Osaka are coastal, situated on alluvial floodplains, and are thus enduringly vulnerable to coastal and riverine flooding. Knowing this directs our focus on civic planning and governance issues related to local adaptations and resilience measures.

Although we did not explore them, additional uses could include stress testing as well as meeting disclosure obligations.

Tool Approachability

TCS offered both a web-based platform as well as a Microsoft Excel data-download of all risk estimates for each asset, for each decade, and for each scenario. The website was clear, simple to use, and enabled basic analysis and identification of individual asset vulnerabilities. Information could be viewed at a variety of levels of detail, including at the asset or portfolio levels. If tags were provided with the data, they could be further viewed along those user-defined dimensions. In addition, their web-based platform embeds methodology details alongside the measures, which enabled interpretation of the results.

However, the amount of time we spent within the web platform was limited since we have internal analytics capabilities and gravitated towards performing our analysis using them. Importantly, TCS enabled this not only by contractually allowing it, but by providing a methodology document and then arranging to meet with us to review it within the context of their platform. Having this understanding made it possible for us to independently validate how we were using their data by proving we could calculate aggregate values as they appeared in their website.

Throughout the duration of the trial, TCS was notably transparent with respect to their modeling methodology. This transparency enabled us to tune and interpret the results of the modeling with greater understanding and confidence.

Suggested Enhancements

Over the course of the trial, a handful of potential enhancements within the platform emerged. We reviewed and discussed each of these with TCS. They acknowledged the limitations and indicated that improvements were either already in progress, or on their product roadmap:

1. Support for the RCP 2.6 scenario

With the policymakers around the world advancing commitments and changes necessary to meet the objectives of the Paris Agreement, insights from the RCP 2.6 scenario, which is a low physical risk/high transition risk scenario, would complement the other scenarios already supported. TCS plans to incorporate two additional scenarios, RCP 2.6 and RCP 6.0, by the end of September 2021.

2. Tropical cyclone risk in the Northwest Pacific basin

Although tropical cyclone risk was covered in the Atlantic Basin (eastern North and Central American coasts), it was not yet covered in the highly active Northwest Pacific basin (Japan, China, South Korea, Singapore, etc.) where our in-trial assets were located. TCS plans to extend the tropical cyclone model to the Pacific basin by the end of September 2021.

3. Flash flooding risk

TCS had coverage for both riverine and coastal flooding, but not for flash (a.k.a. pluvial or inland) flooding due to extreme precipitation. The assets we submitted for the trial were in the Asia-Pacific region where flash flooding is a substantial risk.

4. 10km threshold for coastal flood risk

At the time of the trial, TCS's coastal flooding model had a 10km cut-off from the coastline where any asset beyond that point was assigned a risk of zero. Some of the assets submitted for the trial were in Tokyo and Osaka. These are coastal metropolitan areas situated on alluvial floodplains, meaning most of the territory is near, at, or below sea-level. These factors combined to create some curious results, such as having two assets at opposite ends of the same street, one with a very high coastal flooding risk, and the other with no coastal flooding risk at all—because it was just beyond the 10km threshold. TCS has an enhanced coastal flood model in development which will remove this limitation and be released later in 2021.

5. Coastal and riverine flooding risk-ceiling

Within TCS's model, both coastal and riverine flooding risks are measured as the probability that a 1-in-100 year flood event occurs within a given year. However, the model stops calculating additional impacts once the annual probability of such an event reaches 100% (certainty). That is, the risk impacts have a ceiling, as can be seen in Figure 5.

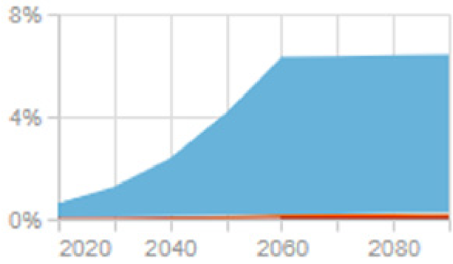


Figure 5: Example of flooding risk ceiling

Source TDAM, TCS

6. Quantification of uncertainty

TCS's primary measure, the *Modeled Average Annual Loss*, is currently only available as a point estimate. They have plans to make the distribution of potential outcomes available to end-users.

7. "Missing data"—when no data value is available

The data exported from the platform was in a standard format except for when a risk was not available for an asset. For example, in the case of tropical cyclones, which were not yet covered in the region of the trial assets, the risk was assigned a value of zero. This resulted in ambiguities where a value of zero could be due to the risk actually being zero, or because the risk was not available. The only way to tell these apart was to review the asset manually within the web-based platform, where a note and explanation could be seen.

Conclusion

Participating in the UNEP FI Landscape Review module was a valuable experience that allowed us to identify assets at highest risk, begin to pinpoint the causes of that risk, and advance a conversation about how to mitigate those risk causes. Our participation in the module has also provided us an opportunity to raise awareness within both TDAM and the commercial real estate industry on the importance of understanding, measuring and mitigating climate risks. We look forward to continuing to build on the progress achieved over the past several months and collaborating with our internal and external partners to advance the conversation on the impacts of climate change.

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Participant:

Folketrygdfondet (FTF)

Provider:

Willis Towers Watson (WTW) and JBA Risk Management

Risk types covered by tool:

Physical risk

Introduction

In this piloting exercise, we focused on various physical climate risks and assessing how these affect a selected portfolio of Fixed Income real estate investments. We chose to analyze a portfolio of real estate companies with a primarily Nordic scope. The analysis was done in two steps; 1. analyzing how various climate hazards evolve from the present-day to future time periods in specific property locations under different temperature scenarios, and 2. Assessing how the key climate hazard identified in step 1, affects property value and business interruption, the latter reflected as loss of rental income and relocation expenses.

The piloting exercise enabled us to look at the evolution over time of climate hazards that can impact real estate. In the two temperature scenarios, we find that extreme precipitation and flooding are two key hazards that emerge and can cause disruption of business activity as well as loss of market value. The findings make clear what the key climate hazards are in the Nordic region, and thus provides guidance on what measures real estate companies should focus on to mitigate the negative effects of these climate hazards.

Process

The piloting exercise consisted of a two-step approach. First, we looked more high-level at various hazards for the real estate investments in our Fixed Income portfolio. The second step entailed a more detailed focus on one real estate company and the impact of the most important hazard expressed in financial terms.

In the first step, we used the Climate Diagnostic tool from Willis Towers Watson (WTW), to pilot a physical climate stress test for the portfolio sample, with diagnostics and ranking of climate hazards. In the second step, we used probabilistic catastrophe/flood models from JBA and analysis provided by WTW.

The Climate Diagnostic tool was applied to the real estate portfolio, and the geographic coverage was primarily the Nordic region, and some additional locations. The exercise included a wide range of cities. The climate variables evaluated were fire, heat stress, heavy precipitation, and river flood for the present-day and the 2050s under two temperature scenarios.

In the second step, to quantify property damage and business interruption in financial terms for the deep dive analysis of one real estate company, JBA's flood models for Scandinavia were used. The objective was to quantify the expected physical climate losses from asset damage and business interruption due to flooding. The models simulated thousands of events to quantify the range of physical damage and business interruption losses which the company's properties could experience, under present-day conditions and future climate scenarios.

Data and coverage

For the piloting exercise, we used publicly reported company data on property locations, market values, occupancy classes, and average rental values. WTW used their own database for the Climate Diagnostic modeling, based on locations for each property. The JBA probabilistic modelling used data based on four elements: exposure, hazard, vulnerability, and financial information.

The Climate Diagnostic tool can cover a wide range of sectors and is global in coverage. For this piloting exercise, the portfolio selection was narrowed down, due to the challenges of data collection and accessibility for our portfolio. Web scraping software was used by WTW to identify property locations for each real estate company, for input into Climate Diagnostic.

For the JBA probabilistic modelling, one company was selected for a deep dive analysis of flooding, which Climate Diagnostic had demonstrated is the key hazard for the locations of the company's investments. The modelling looked at property damage and business interruption due to flooding and quantified the impact in financial terms. Property damage assumes losses related to the reconstruction costs, including costs for material and labor. Tax values were used as a proxy for market value as real estate companies don't report market values per property, but rather they report value on an aggregated level. Since tax values are not an ideal representation for actual market losses, we chose to focus on business interruption as a metric and expression of climate risk. The input for business interruption estimates were calculated by WTW from the total area of each property multiplied by the average rental value (SEK/sq.m) for different regions and occupancy classes. For business interruption, the residential losses are estimated costs for relocation expenses, while for commercial assets the model estimates possible loss of earnings and downtime.

Both tools (Climate Diagnostic and JBA's flood model) can be applied to a range of sectors and geographic locations. The selected real estate portfolio for this exercise totaled 14 companies, constituting approximately 2,9% of the total FTF Fixed Income portfolio.

Risk factors and scenarios

The climate variables included in the first part of the pilot (Climate Diagnostic) were fire, heat stress, heavy precipitation, and river flood. Climate Diagnostic covers a broader range of variables, but not all were relevant for the portfolio selection. JBA's flood model covered scenarios related to flooding. The following climate scenarios for 2050s were assessed:

- 2°C (Representative Concentration Pathway, RCP 4.5)
- 4.5°C (RCP 8.5)

Outputs and insights

In the first step, the Climate Diagnostic tool measured climate hazards for investment locations in the present and future scenarios. The hazards were ranked 0–5 in terms of severity of their impact.

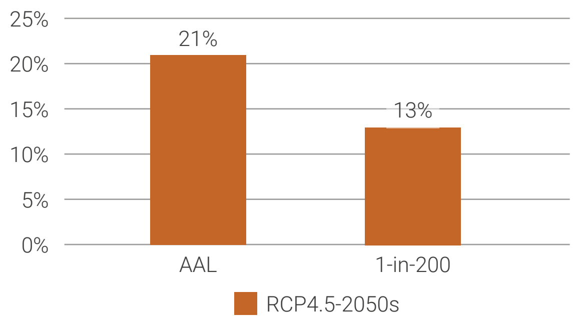
In Norway, the primary hazards from the present-day to the 2050s under the two scenarios, were heavy precipitation (which can lead to surface water flooding) and river flood. We saw increased heavy precipitation in Bergen, Sandvika and Baerum under both scenarios, and the latter two also had increased risk of flood under the RCP 8.5 scenario. There was a modest increase in fire hazard under the RCP 8.5 for areas such as Larvik. The figure below shows the climate hazards in Norway for the 2050s, ranked by importance.

In Sweden, flood is the primary hazard at present, and remains high under future climate scenarios. There is modest increase in heat stress under RCP 8.5 for cities such as Malmo.

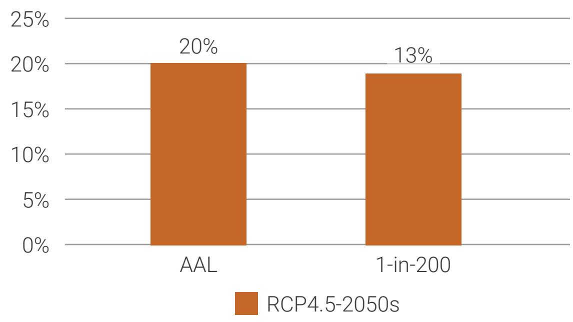
In Finland, the predominant hazard is river flood in Turku. There were no major changes in climate hazard factors by the 2050s, but modest increases in fire hazard and heavy precipitation were identified in selected cities.

In step two, JBA's probabilistic flood modelling was used on one company to analyze in detail and quantify expected physical climate losses in financial terms as asset damage and business interruption. The model provided annual average losses (AAL) and 1-in-200-year return period losses. The figure below shows the percentage change in property damage as market value loss, and business interruption as relocation expenses and earnings loss, in an RCP 4.5 2050s scenario compared to the present day.

Property damage: AAL and 1-in-200RP % increase by 200s, RCP4., compared to current



Business interruption: AAL and 1-in-200RP % increase by 2050s, RCP4.5, compared to current



We found this pilot to be an important tool for understanding climate risk and how these risks play out in different scenarios. The models used have provided us with a starting point for looking more closely at the connection between climate risk and financial risk.

The exercise has also identified a main challenge as it relates to the lack of granularity of reported company data. For the real estate sector in the Nordic region, most reporting on property values is done on an aggregated level. Therefore, we don't have correct values for each property, and so we used tax values as a proxy instead. The output of the models does therefore not reflect actual property value loss in monetary terms but does however more clearly reflect change in loss in percentage terms. In general, we recognize that lack of granular portfolio data remains the main obstacle to properly evaluating the financial impacts of climate change on our portfolio.

The tools presented in this case study, were quite complex, but our understanding of the tools was facilitated by the thorough presentations given by the team at WTW. The modelling was done by WTW and JBA, so our time was spent more on understanding the tools themselves and the output generated for this pilot. A challenge due to time constriction for the pilot is that it did not allow for much time for us to test the tools for ourselves. We are therefore not familiar with the full extent of the tools and its coverage and scope. The portfolio selection was narrowed down to balance the extensive data collection and analysis required against the limited scope and time at our disposal for this pilot. For this reason, we were not able to test the entire portfolio, however, the selected portfolio gave a good representation of the possibilities of the tools tested.

The pilot has connected us with industry experts, and insightful discussions have given us a better understanding of the impact of climate risks on real estate and key climate hazards in the Nordic region. This pilot is a good starting point for gaining a better understanding of climate risks and the negative financial impact it can cause. As such, this pilot has been a valuable learning experience.

Participant:

Manulife Investment Management

Provider:
Willis Towers Watson (WTW)

Risk types covered by tool:
Transition risk

Introduction

Global decarbonization efforts are underway, with a long journey ahead for both investors and issuers. Developing tools that can assist in providing clarity around the impact of decarbonization pathways is critically important, as transition risk has been shown to carry a high likelihood of negatively, or in few cases positively, affecting companies' financial statements.

This is the second UNEP FI pilot project in which Manulife Investment Management has participated. As part of the pilot, we participated in a climate tool demonstration using WillisTowersWatson's (WTW) climate transition analytics tool.

Steps taken by Manulife Investment Management for this case study

- Provided a list of global large-cap stocks across multiple industries; some are held in existing portfolios and some are not
- Analyzed an abbreviated compilation of output
- Held discussions with WTW to review the original output, take a deeper dive into the methodology, run trade simulation impacts, and review revised output

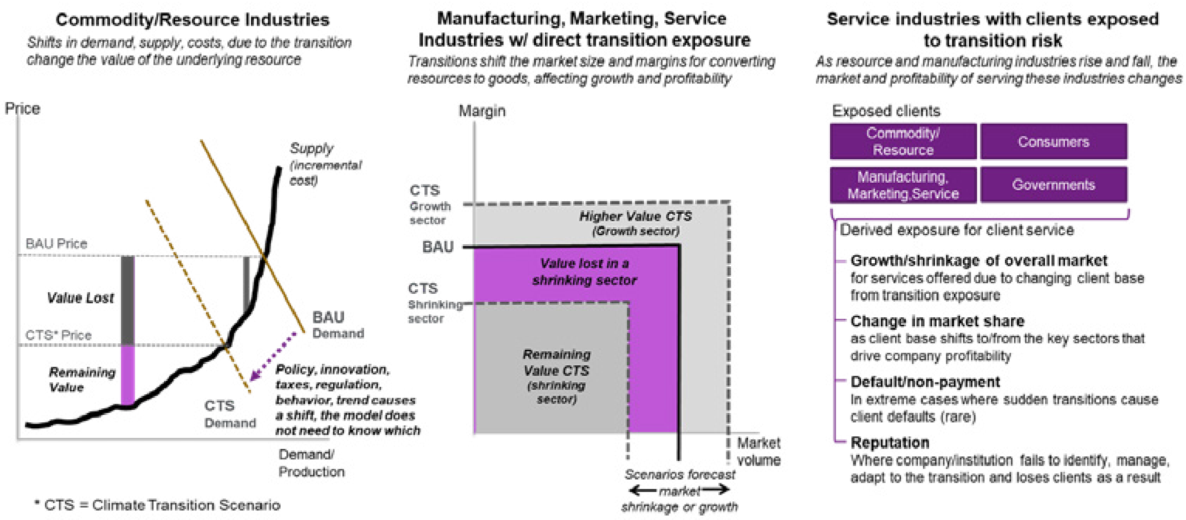
Objective of the tool

WTW's climate transition analytics tool is designed to help portfolio managers understand the explicit and unintended risks of the climate transition in an investment portfolio. It elevates the risk awareness at a company, industry, and sector level, which in turn enables the portfolio manager to create a more climate resilient portfolio through more risk-aware security substitution and/or hedging activities. The tool allows for sensitivity analysis based on the factors of security weight and selection. Consequently, a portfolio manager can model and change the portfolio, and thereby avoid unintentionally betting against the high likelihood of the global decarbonization.

Understanding the methodology

A core functionality of the tool is its methodology to measure the climate transition value-at-risk (climate VaR) of publicly listed companies (6,000 primary listings from 45 countries). Climate VaR represents the difference between the discounted free cash flow (DCF) valuation of the business under "current market expectations" (aka Business as Usual or BAU) and a climate transition scenario (CTS) consistent with a well below 2 degrees outcome (WB2C). The approach taken to estimate a company's climate VaR depends mostly on its industry, as illustrated in Figure 1, which shows how commodity-focused companies are modelled through a fundamental analysis of their underlying commodities and valuation impact to the applicable resource(s). Companies outside the resources space with direct exposure in carbon intensive businesses are modelled by business segment, assessing the potential shrinkage of the market driven by less carbon intensive alternatives.

Figure 1



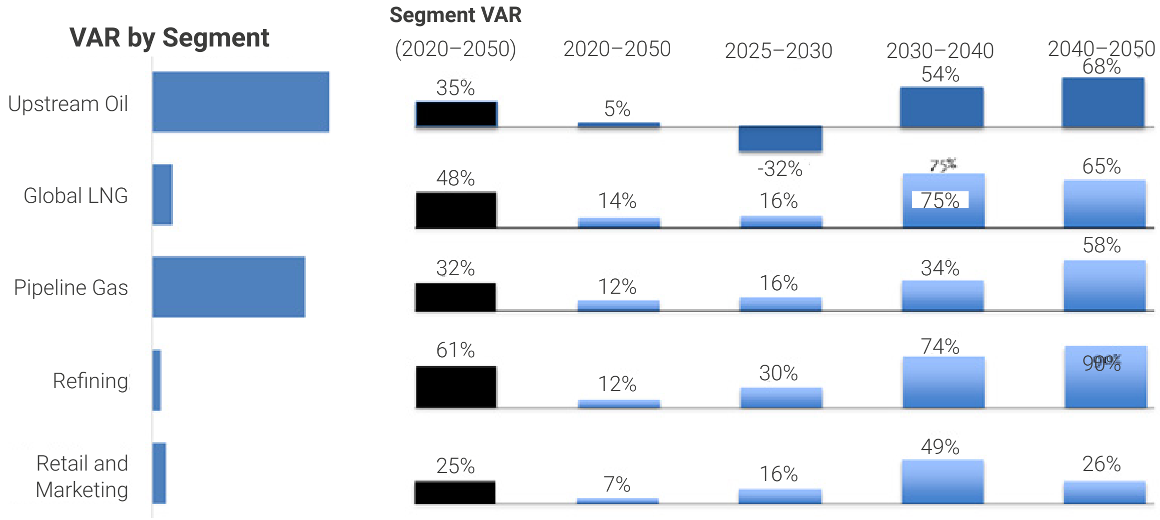
Source: WillisTowersWatson, 2021.

The resulting dataset of (debt and equity) climate VaRs is exploited by the tool in multiple ways, notably to:

1. Construct and periodically rebalance proprietary climate transition indices (CTIs)
2. Create and manage hedging investment solutions (e.g., partial clones of CTIs)
3. Improve a portfolio's resilience to climate transition risks

As previously mentioned, total decarbonization of emissions is the long-term goal, but it's important to appreciate the market and financial impacts will not be linear. The severity, as well as the growth opportunities, will become greater over time by orders of magnitude. Figure 2 below provides the climate VaR for the energy sector across industries as well as the segmentation of the impact by time periods. The quantification of climate VaR can be particularly helpful to investors as they try to assess current valuation within specific time horizons.

Figure 2:



Source: WillisTowersWatson, 2021. Not derived from Manulife Investment Management test portfolio.

Data, coverage, and output

The tool covers over 6,000 primary listings: 2,400 in North America, 1,200 in Europe, 600 in Japan, and the remaining geographically spread out across multiple countries, including Australia and emerging markets.

At the individual security level, the output from the tool consists of 4 sections:

1. A **climate transition risk** tab, which reports:
   - Debt and equity climate VaR for a given transition scenario
   - Underlying CTCs (whenever applicable)
   - Market index vs. climate transition index weights
2. A **signals** tab, which covers:
   - Fundamental attractiveness (fitness, value, momentum) and controversy levels
   - Global macro profile and sensitivities
   - Miscellaneous information (business description, brokers' view, peer group, etc.)
3. A **signal timeline** tab, which provides a visual representation of the above over time
4. Another side tab, which offers a perspective from the point of view of the investor taking the other side of one's trade (e.g., bull/bear arguments, top institutional buyers/sellers).

Portfolio-level output

At a portfolio level, the tool offers insight into historical performance and return attribution on the one hand, and prospective risk/return on the other, with two notable features:

- **"Mitigate" function**: The tool singles out the largest detractors from the portfolio's climate VaR, suggests investment candidates to rotate into, and simulates the impact of the resulting turnover on the portfolio's fundamental and climate characteristics

- **"Tracking error impact"**: which helps visualize turnover-tracking error trade-offs and run portfolio optimizations that minimize downside tracking error relative to a CTI under set constraints (mandate, turnover, minimum trade, etc.).

Market-level output

At a market level, the tool provides proprietary signals aimed at complementing the bottom-up, forward-looking security/portfolio analytics described above. This consists of a top-down "nowcast" of expectations priced in by financial markets, which informs asset allocation and factor exposure decisions.

Portfolio management viewpoints[15]

For the model portfolio we provided, the WTW climate transition analytics tool calculated the average transition climate VaR to be higher than that of the (Europe CTI) benchmark, with an average of -6% for the portfolio (Figure 3). In the bottom chart, BP PLC and Eni S.p.a. contribute the greatest climate exposure. In addition, of the top five contributors, four of them are in the energy industry.

Figure 3

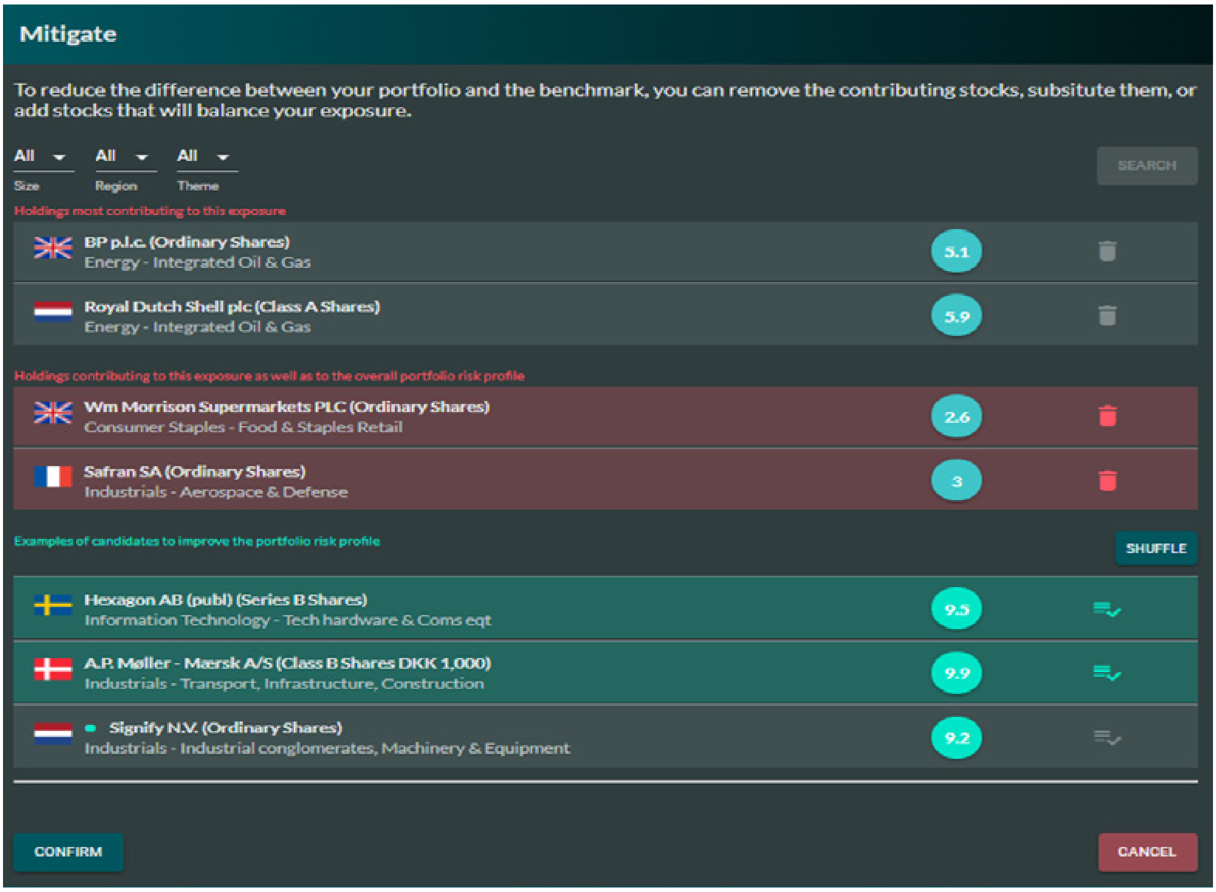
Source: WillisTowersWatson, 2021.

To mitigate the difference between the benchmark and the portfolio, these energy companies could be replaced to reduce climate VaR—for example, by divesting from BP and Royal Dutch Shell (Figure 4).

15 Analysis provided for illustrative purposes only to demonstrate a potential approach to understand the explicit and unintended risks of the climate transition in an investment portfolio. It is not a recommendation to buy or sell any security.

The transition tool also identifies other actions a portfolio manager could employ that would reduce climate VaR as well as tracking error (Figures 4 and 5). In this example, selling WM Morrison and Safran will reduce climate VaR and reduce the tracking error of the portfolio simultaneously.

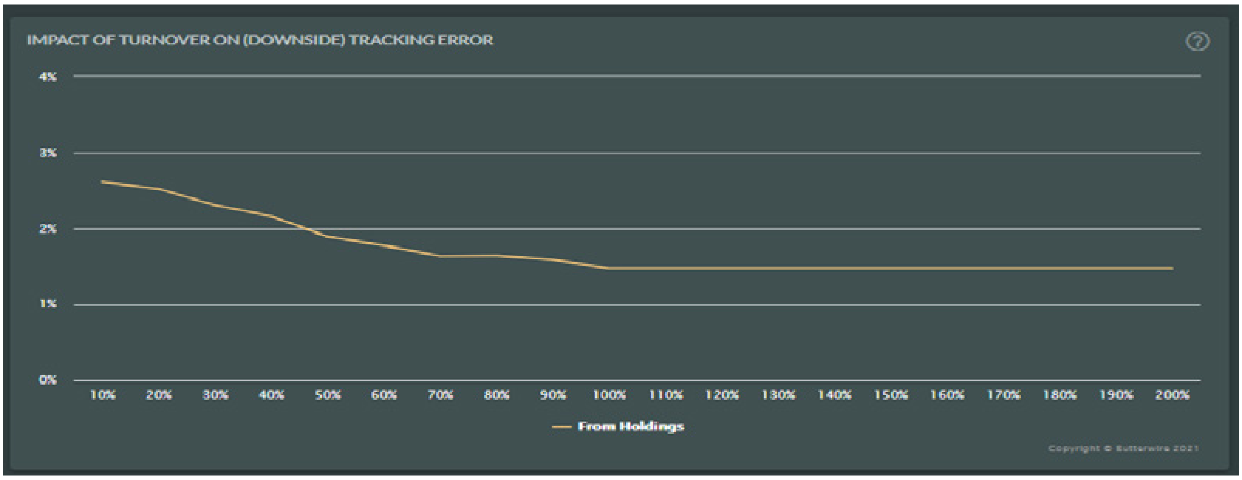
Figure 4



Source: WillisTowersWatson, 2021.

The tool enables easy optimizations to achieve certain objectives. In this example, by rotating 25% of the portfolio, which equates to 50% turnover, the tracking error declines from 2.6% to 1.9% (Figure 5).

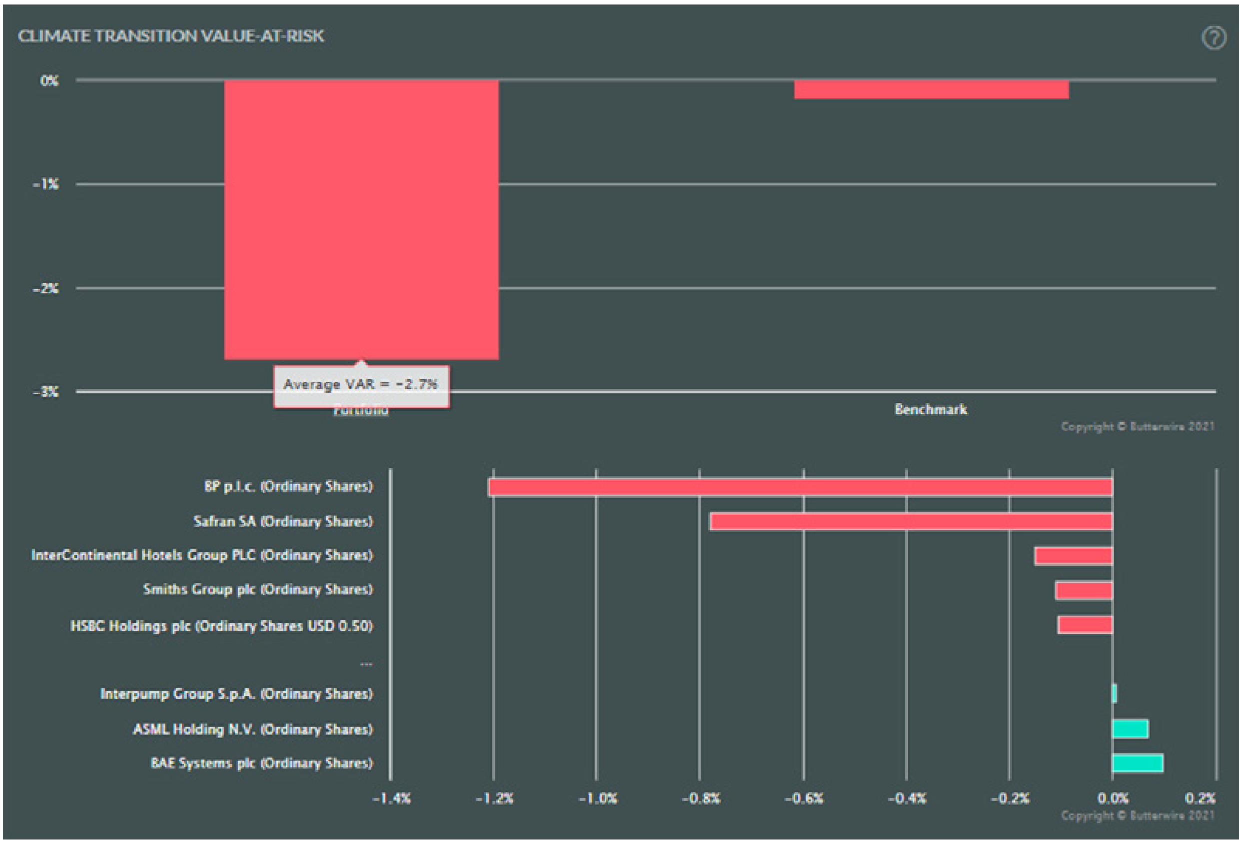
Figure 5



Source: WillisTowersWatson, 2021.

In addition, with this optimization, the portfolio's climate VaR is reduced from -6% to -2.7% (Figure 6).

Figure 6



Source: WillisTowersWatson, 2021.

Potential enhancements for the climate transition analytics tool

There are several enhancements to consider for the tool. In particular, we think it could be helpful to expand the tool's integration of proprietary climate research insights:

Expanding stock coverage

- Consideration should be given to increase the number of individual stocks modelled bottom-up by sector analysts relative to the number of stocks whose climate VaRs are estimated by the tool's machine learning application. As of September 2021, 75% of the World CTI weights were set using climate VaRs ascertained by sector analysts, which means 25% were estimated by the tool utilizing machine learning. From Manulife Investment Management's perspective, we don't have high confidence in estimated climate VaRs; however, we have no quantitative evidence to support any particular shortcomings associated with the tool's estimates.

Integrating physical climate risk data

- By integrating WTW physical climate risk models with the model of climate transition risk, the tool could offer a comprehensive climate risk picture that could also account for climate transition scenario assumptions. Note that Manulife Investment Management did not review the physical climate risk models and so cannot speak to their efficacy or quality.

Participant:

GLS Bank

Provider:

right. based on science

Risk types covered by tool:

Transition risk

Introduction

As a social-ecological bank, GLS Bank is firmly committed to the goal of limiting global warming to 1.5°C above pre-industrial levels. Providing full and detailed impact transparency (“*Wirkungstransparenz*”) is a core promise we make to our customers.

We therefore partnered with right. based on science GmbH (right.) to calculate the climate impact of our “*GLS Bank Aktienfonds*” (DE000A1W2CK8), a mixed fund of mainly equities and bonds from particularly climate-friendly companies. right. developed the X-Degree Compatibility (XDC) Model, which is recognized by the Task Force on Climate-Related Financial Disclosures (TCFD). The XDC Model calculates the impact a company, a portfolio or any other economic entity has on global warming and expresses it in a degree Celsius (°C) value (Temperature Alignment). It answers the question: “What degree of global warming would occur by 2050 if everyone behaved as the company/entity in question?”

Our aim with this analysis was to assess whether our *GLS Bank Aktienfonds* already meets the 1.5°C target, identify where action is still needed and potentially use the information as a basis for active engagement. The results were insightful. However, the close collaboration on this analysis also revealed the need for additional emission data, for a methodology to measure the emissions of a green bond, easier integration of emission reduction goals, as well as the “fair” consideration of scope 2 and 3 emission data.

Process

We analysed the Temperature Alignment/climate impact of “*GLS Bank Aktienfonds*” by using right.’s “*XDC Portfolio Explorer*”, a web-based software built on the XDC Model. It can be accessed by registering directly on the website. Once the user is logged in, a portfolio must be uploaded for analysis.

1. We created and uploaded a csv-file containing the ISIN codes and portfolio weights of all securities in the “*GLS Bank Aktienfonds*”.

2. The software then calculated XDC metrics for the fund itself as well as each security, providing
    - Temperature Alignment values (XDCs) for the fund as well as each security,
    - an indication of alignment/misalignment to a 1.5°C, 1.75°C as well as a 2.0°C scenario,
    - sector benchmarks (Sector XDCs) for each company in the fund as well as the fund itself.
3. We downloaded the results, again as a csv-file.
4. We analysed the results and had a deeper look especially at those companies not yet aligned with the Paris Agreement in order to see whether (1) there are other reasons (e.g. on the social side) to keep them within the fund, (2) they have a climate strategy and thus in a scenario-based approach would be aligned or (3) could/should be replaced.

Main challenges encountered

At GLS Bank we have our own sector classification. However, the XDC Model and XDC Portfolio Explorer make use of the classification according to NACE (Statistical Classification of Economic Activities in the European Community). This created a need to co-develop a customized sector classification to meet our requirements.

Another main challenge was the question of dealing with Scope 3 emissions and the risks of double counting. As a default, the tool counts Scope 1 at 100%, and Scopes 2 and 3 at 50% each to compensate for double-counting. Since Scope 3 emissions usually make up the largest share of a company's carbon footprint, excluding these emissions from the analysis would mean a blind spot, neglecting all upstream and downstream activities as well as the significance of integrating the full value chain in the transition. Including Scope 3 emissions brings concerns of double-counting, since these emissions are not solely attributable to one company. We decided to follow the XDC Portfolio Explorer default here and include Scope 3 at 50%.

Data and coverage

We used the XDC Portfolio Explorer to analyse the contribution to global warming of the "*GLS Bank Aktienfonds*" (i) at security level (102 companies) as well as (ii) at portfolio level. The data required from our side were: unique identifiers (ISINs) and portfolio weights for all securities, provided in a csv-file.

The analysis draws on additional data to calculate the XDC metrics. These are all sourced by right. and integrated in the XDC Portfolio Explorer software:

Company level data

- Current economic productivity, as measured by gross value added (GVA). Source: FactSet Research Systems.
- Current greenhouse gas emissions for scopes 1, 2, and 3. Source: Urgentem.

Global economy data

- Current economic productivity as measured by GVA. Source: World Bank.

Growth rates ("Middle of the Road/Current Trends Continue" scenario)

- Annual growth rate of the entity's emissions and GVA. Source: Shared Socioeconomic Pathways (SSPs) or E3ME (by Cambridge Econometrics).

The tool covers all geographies and sectors. Wherever XDC values could not be calculated, this was indicated in the software. 97.4% of securities in our portfolio were covered (102 out of 105). The remaining three securities were excluded from the analysis.

To project the future developments from the base year until 2050, the XDC Model works with assumptions derived from socio-economic and climate mitigation scenarios, as well as macro-economic data. Geographically, the XDC Model and XDC Portfolio Explorer include both (i) country-specific assumptions forapproximately 185 countries as well as (ii) five world regions: OECD, Asia, Middle East & Africa, Latin America, and Reforming Economies.

The sector is defined by a NACE code; normally either a 1- or 2-digit NACE code, except in special circumstances where a higher granularity may also be used. All International Energy Agency (IEA) sectors are considered to derive sector-specific target pathways from the IEA mitigation scenarios. The IEA sectors are then converted to the more detailed NACE sector classification system.

Risk factors and scenarios

The temperature alignment analysis used here mainly focuses on the "inside-out" risk perspective of double materiality. This concept was stated by the EU Commission in June 2019 in a supplement to its Guidelines on Non-Financial Reporting (NFRD): Complementary to the "outside-in" perspective, the "inside-out" perspective describes the influence of a company on the climate, which can be financially material and therefore also has to be reported.

By this, we also followed TCFD recommendation 1 on "Portfolio Alignment"[16]

> **We recommend all financial institutions measure and disclose the alignment of their portfolios with the goals of the Paris Agreement using forward-looking metrics. Hence, the key risk factor explored was the alignment of our "*GLS Bank Aktienfonds*" with the Paris Agreement.**

16 Consultation just ended. https://assets.bbhub.io/company/sites/60/2021/05/2021-TCFD-Portfolio_Alignment_Technical_Supplement.pdf

The **target scenarios** used in XDC Portfolio Explorer are based on International Energy Agency (IEA) mitigation scenarios "2°C Scenario" (2DS), "Beyond 2°C Scenario" (B2DS) (corresponding to max. 1.75°C global warming), and "Net Zero by 2050" (NZE2050) (corresponding to max. 1.5°C global warming). The focus of the analysis conducted here was the 1.5°C benchmark. Further target benchmarks based on mitigation scenarios from the Network for Greening the Financial System (NGFS) and the One Earth Climate Model (OECM) are also available, but were not employed by us.

The **baseline scenario** used to project future development until 2050 is derived from Shared Socio-Economic Pathway 2 (SSP2), also known as the "Middle of the Road" or "Current Trends Continue" scenario. Soon, all SSPs will be available with the XDC Portfolio Explorer.

Outputs and insights

For the fund as well as each security, a range of metrics were calculated by the tool and provided for download:

Table 1: XDC metrics and results

Output	Unit	Description
Baseline XDC	°C	The expected degree of global warming if the entire world were to operate at the same Economic Emission Intensity (EEI)* as the company/fund until 2050.
Target XDC	°C	The sector-specific temperature benchmark for the company to be aligned to the selected target scenario (in our case 1.5°C based on IEA NZE2050).
Sector XDC	°C	The expected degree of global warming if the entire world were to operate at the same Economic Emission Intensity (EEI) as the 'typical' company within a specific sector (sector median) until 2050.
XDC Gap	±°C	The difference between Baseline XDC and Target XDC—it shows by how much the portfolio or the single security is aligned/misaligned with the selected scenario.
Alignment assessment	Aligned/Not aligned	Summary of the analysis.
*EEI is defined as emissions over gross value added (CO_2e/PPP$)		

Further results provided were Baseline XDC and Target XDC values per emission scope for each security (see Fig. 1) as well as a dashboard overview of the portfolio's sector breakdown and the Top/Bottom Five securities in the portfolio by XDC Gap (see Fig. 2).

Figure 1: Analytics Tab of XDC Portfolio Explorer with results for GLS Bank Aktienfonds (redacted)

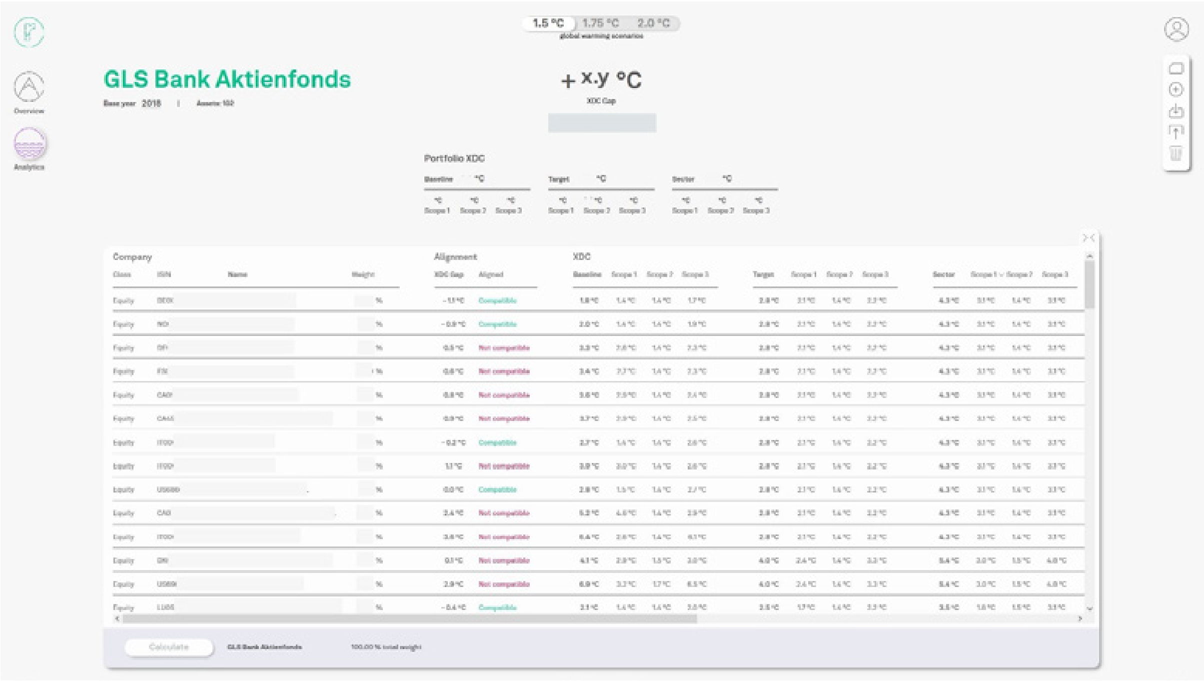
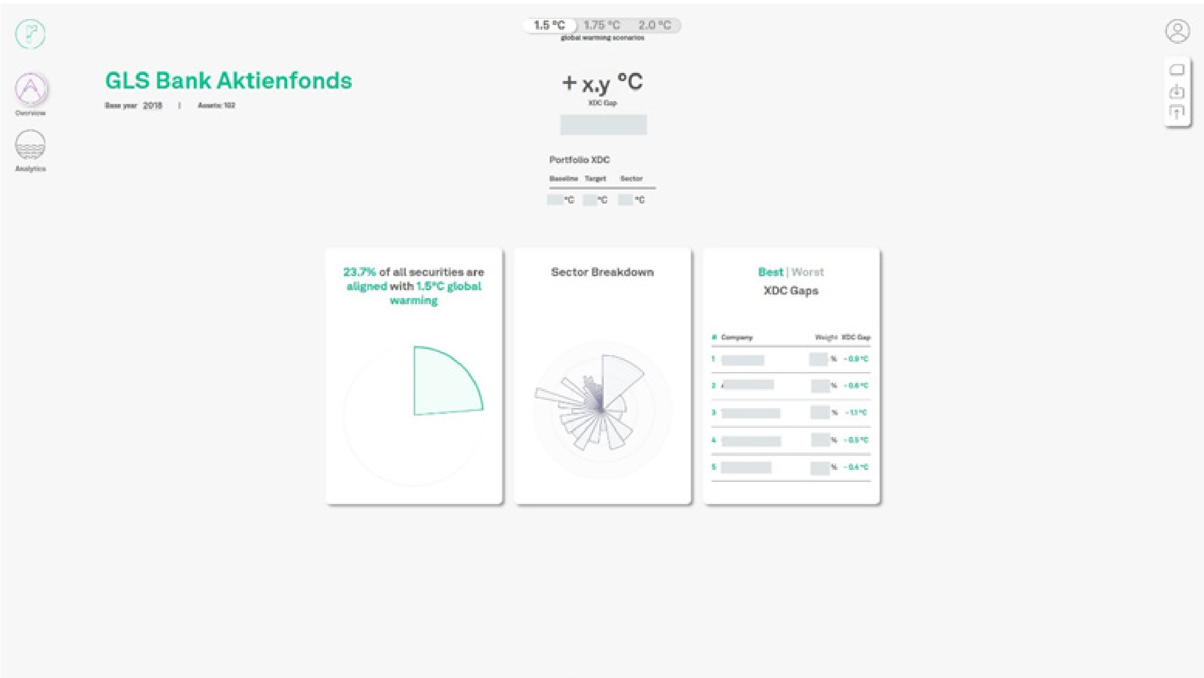


Figure 2: Overview Tab of XDC Portfolio Explorer with results for GLS Bank Aktienfonds (redacted)



The information retrieved from this analysis provides information is a strong basis for engagement with those portfolio companies that are not yet aligned to the 1.5°C target. As companies are the ultimate entities that cause emissions, this is where solutions to significantly reduce emissions must be found and implemented. The XDC Model is already used by companies and the methodology was first developed for application in the real economy. This allows us, as a financial institution, to ‘speak the same language' tocompanies and track progress in the transition with one shared approach—at the same time, this is the language that climate science and global policy have already set out:˚C.

While this example analysis was conducted as a snapshot view of the Temperature Alignment/Paris Alignment of the fund, we see great potential for integrating the use of XDC Portfolio Explorer in the earlier stages of the investment process, informing decisions about e.g. portfolio allocation and optimization. The software allows fund managers to test in advance how rebalancings would affect overall Portfolio Alignment. This enables active steering towards the 1.5°C goal we have determined for the fund. The forward-looking nature of the analysis (developments until 2050) is also a key factor here.

We at GLS Bank are quite familiar with "impact transparency" (*Wirkungstransparenz*) and the challenges it poses. In this case, a key learning—although it almost goes without saying—is that the simplification of portfolio alignment metrics such as the XDC cannot capture the full complexity of climate change and earth system processes. However, science-based alignment metrics expressed in˚C—such as the XDC Model—have a great potential to close the gap between abstract climate change and financial actor's perception of how they can contribute to reaching the goal of the Paris Agreement. We have already extended the XDC analysis to include our own investment portfolio (treasury) and other investment funds, our credit portfolio, customer portfolios and our own operations.

As the XDC Model allows for conducting forward-looking scenario analysis by adapting the input data for the calculation along chosen assumptions at security level (e.g. high-growth projections, net-zero targets, transition to green energy etc.), we aim to analyse the climate strategies of our portfolio companies. This will allow us to determine the transition companies in our portfolio and to actively engage with them on setting emission reduction targets that are ambitious enough to align with 1.5°C.

Suggested enhancements for providers

Once familiarized with the various XDC metrics (see Table 1), the tool is very intuitive to use. The data requirements are minimal and since the software is web-based, no installation or setup is needed.

The XDC Portfolio Explorer should support steering towards below 2°C through engagement or divestment by suggesting alternative securities to portfolio managers that would be suitable to replace a security which has a detrimental impact on portfolio alignment.

While the XDC Model can cover various asset classes and multi-asset portfolios, including (i) public listed equity, (ii) private equity, (iii) private debt, (iv) corporate bonds, (v) sovereign bonds and (vi) Real Estate, not all asset classes are available yet in the software. This would allow for more comprehensive analyses.

We would also like to see an uncertainty quantification of the XDC Model. Currently this is being worked on by right. but is not yet finalized.

Participant:

Standard Chartered Bank

Provider:
Baringa and BlackRock

Risk types covered by tool:
Transition risk

Introduction

In 2021, a number of regulatory stress tests were planned (e.g. Hong Kong Monetary Authority and Bank of England) to focus on climate change and the associated risks to financial institutions. In order to support its climate risk capability for scenario analysis, Standard Chartered Bank (Standard Chartered) worked with Baringa, using a Climate Change Scenario Model.

In June 2021, BlackRock and Baringa announced a long-term partnership focused on innovation and ongoing co-development of transition risk models. BlackRock acquired Baringa's Climate Change Scenario Model and integrated it within Aladdin Climate. This Climate Change Scenario Model is used by financial institutions and corporates with more than $38 trillion of assets around the world to help them (i) understand the climate risk exposure and the value that may be lost from balance sheet or investment assets; (ii) how deployed capital and investments are impacting the climate with comparisons against benchmarks; and (iii) identify opportunities to re-allocate capital to improve impact on climate and make commercial returns. The Climate Change Scenario Model is designed to provide full integration of both physical and transition risk modelling across a range of assets. It is modularised to enable clients to select those components relevant to them and to enable straight-forward integration of third-party scenarios and physical risk analysis.

This case study focuses on the Standard Chartered pilot in early 2021 of 100 corporate clients to run though the Climate Change Scenario Model to determine Probability of Default and Temperature Alignment. Under the 2-degree orderly scenario, it showed that energy clients were the most susceptible to transition risk with Weighted Average Probability of Defaults rising to over 8% by 2050, compared to <1% as at 2019. Using the same clients, analysis produced an average temperature alignment of 3.14°C, which indicates that Standard Chartered's portfolio is broadly in line with global trends. Since the pilot, Standard Chartered has extended the Climate Change Scenario Model coverage across its corporate and sovereign portfolios, augmented its scenario analysis and has used the insight in their 2021 TCFD Report.

Collaboration process

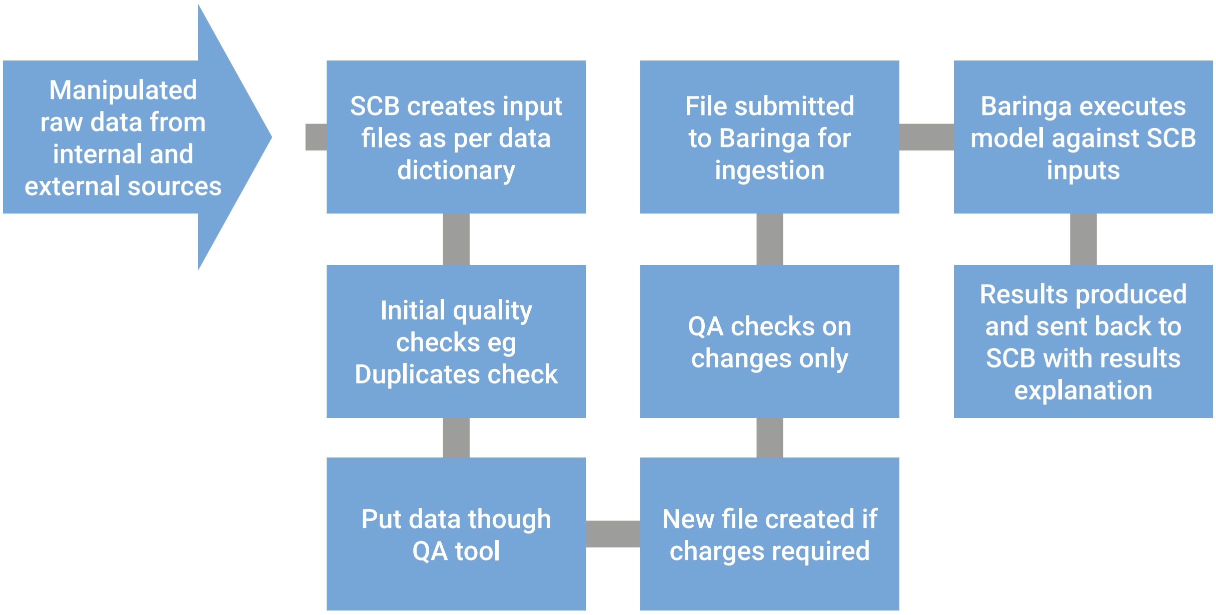
It is possible to choose several integration options with the Climate Change Scenario Model. For a swift implementation, Standard Chartered utilised the Climate Analytics Service (CAS) which provides Data-as-a-Service output capabilities. This is where Standard Chartered pass the requisite input files containing company emissions, financials and production data, as defined by the Climate Change Scenario Model input data dictionary, to Baringa for ingestion into the model. Once Baringa has executed a modelling run and quality assurance (QA) has been performed, the results are shared back to Standard Chartered via output files, as defined by the Climate Change Scenario Model output data dictionary.

The Climate Change Scenario Model is now integrated within BlackRock's Aladdin Climate, where it is available both as an integrated Software-as-a-Service offering and Climate Analytics Service (CAS) offering for banks, asset managers, asset owners and corporates to support a range of investment and climate disclosure needs.

The data dictionaries and QA act as preventive and detective control layers in the run process. Furthermore, to help ensure the integrity of the model, rigorous internal and external validation has taken place.

The external validation was performed by Kroll, and Professor Steve Pye of the UCL Energy Institute.

Figure 1: Flowchart showing Model execution

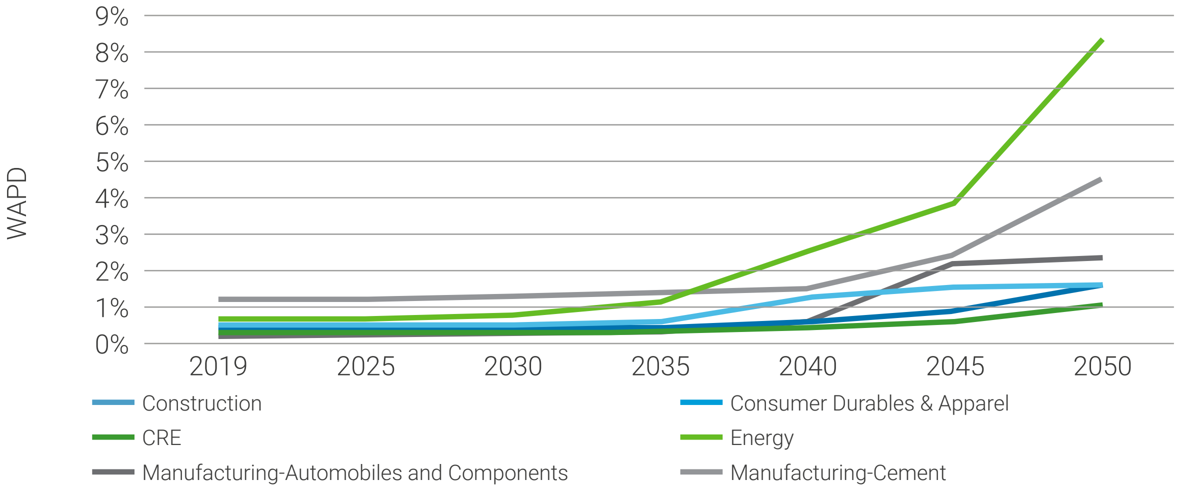


Outputs and insights

One of the key outputs Standard Chartered used was the evolution of Probability of Default. Here, the model assesses the changes in company financials, and consequent changes in credit ratings and probability of default under orderly and disorderly transition scenarios. From the preliminary scenario analysis work, aggregated results on

100 corporate clients, the below chart shows how Probability of Default changes over the 30-year time horizon across the different client sectors. The pathway of Probability of Default is driven by changes to underlying company earnings and debt which is modelled within Climate Change Scenario Model based on the 2 Degrees scenario (explored further under Risk Factors and Scenarios section). This Probability of Default quantifies the transition risk for each individual client and at a portfolio level for Standard Chartered. The results from the below chart highlight the largest transition risk sectors; Energy and Manufacturing.

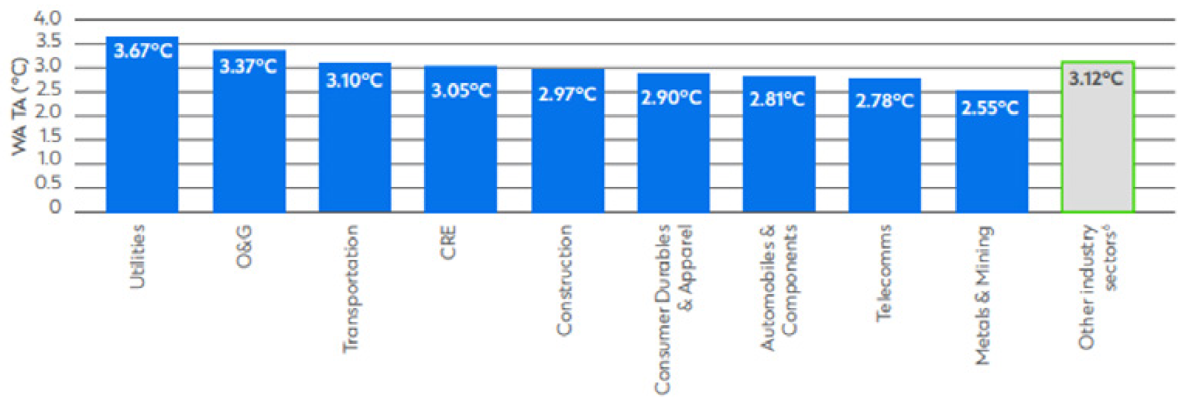
Figure 2: Probability of Default under orderly 2 degrees transition scenario



This chart is sourced from Standard Chartered's [2020 TCFD report]

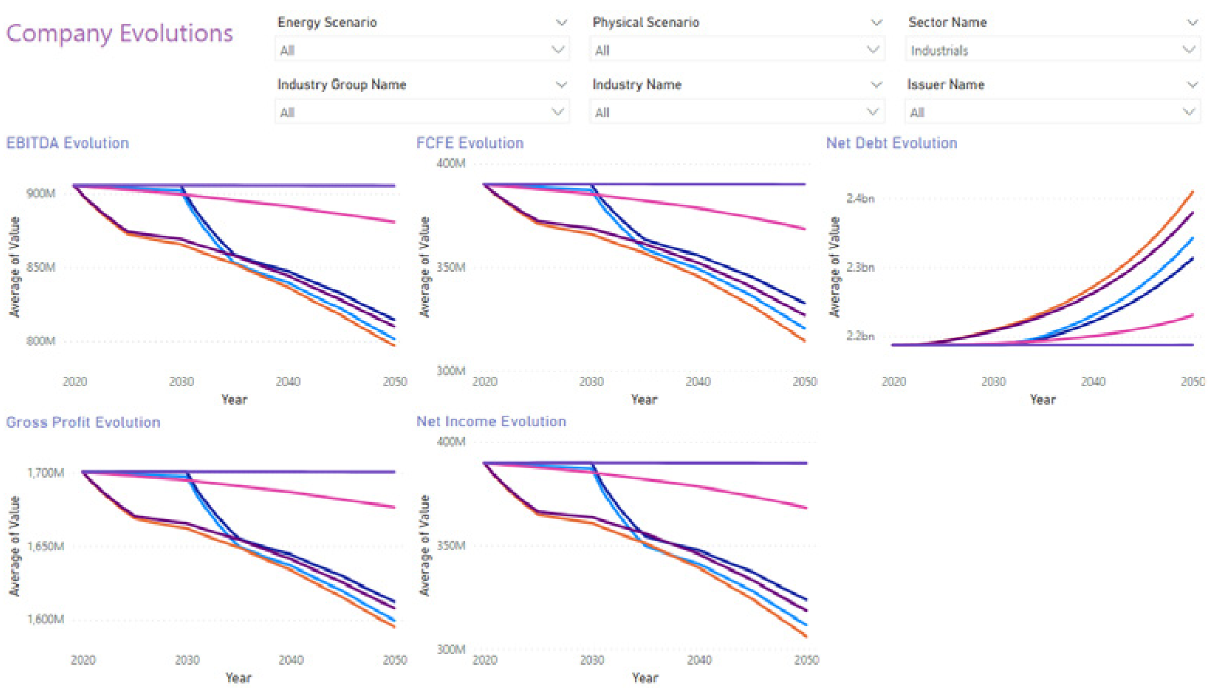
Another key output from the Climate Change Scenario Model is Temperature Alignment. Temperature alignment is a way of quantitatively assessing a company's impact on the climate and is calculated based on emissions intensities, and volume of hydrocarbon produced. In 2021, Standard Chartered applied the Climate Change Scenario Model to around 2000 of its clients within the corporate portfolio. Standard Chartered's portfolio Temperature Alignment is 3.10C, with Utilities and Oil & Gas sectors scoring the highest (furthest from Paris Agreement alignment). This allows Standard Chartered to assess how their portfolio compares with global and regional economies to track its progress on supporting a net-zero pathway.

Figure 3: Temperature alignment



This chart is sourced from Standard Chartered's 2021 TCFD report: https://av.sc.com/corp-en/content/docs/tcfd-climate-change-disclosure.pdf

Figure 4: Company evolutions across 3 scenario 2020–2050



Data and coverage

For the initial pilot, Standard Chartered wanted to conduct scenario analysis against 100 corporate lending clients assessing transition risk, it was later extended to around 2000 clients. The data which Standard Chartered provided covered individual company financials and emissions.

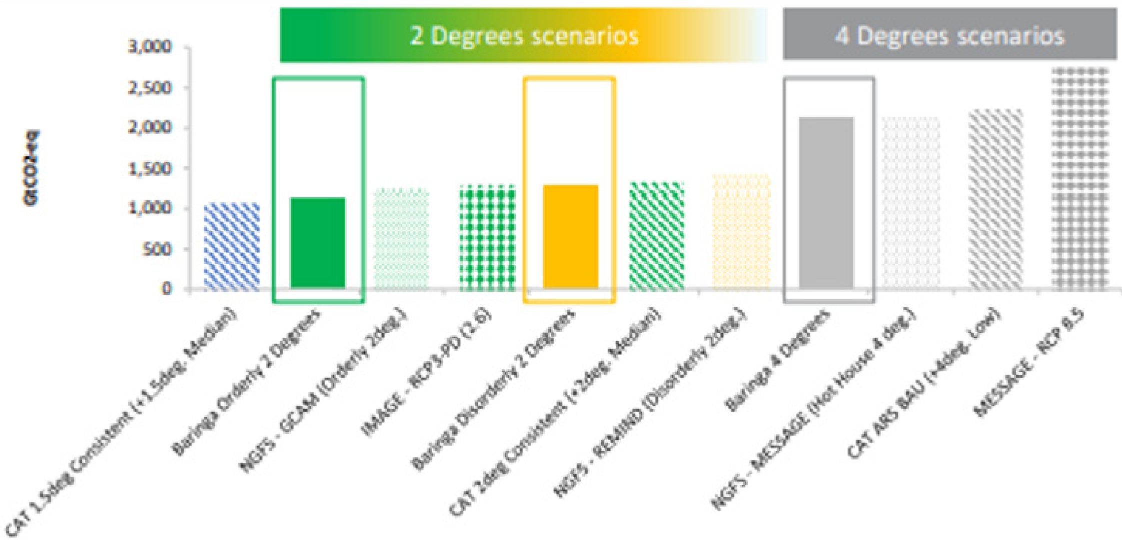
To get the richest results, Standard Chartered provided additional data points for Oil & Gas and Electric Utilities companies which detailed their production figures. Outputs include remodelled company financials, equity valuations, Probability of Default evolution and temperature alignment per company. In addition to these services, the Climate Change Scenario Model also covers other asset classes such as corporate bonds, sovereign bonds, property and vehicles. The Climate Change Scenario Model can ingest physical risk outputs from other providers to create a combined view of transition and physical risk.

Risk factors and scenarios

To assess the transition risk of their corporate clients, Standard Chartered utilised three scenarios: Baringa Orderly 2 Degrees, Baringa Disorderly 2 Degrees and Baringa 4 Degrees. As Standard Chartered commented in their TCFD 2020 report, these scenarios use assumptions focused on government policies, availability and deployment of technologies to limit emissions to a certain target. Outputs from scenario analysis indicate how variables such as energy demand and supply, economic activity, macroeconomic and other socio-economic factors will evolve, based on the specified set of underlying scenario assumptions. Furthermore, specific sets of assumptions for transition risk scenarios usually surround technological advancement, timing and ambition levels of policy actions and societal preference.

To assess the temperature alignment of the Standard Chartered portfolio, the Climate Change Scenario Model uses historical emissions or production data to evaluate how a company's emissions intensity will evolve into the future. The model maps future emissions intensity and hydrocarbon production against sub-industry/region benchmarks to compute company Temperature Alignment.

Figure 5: Benchmarking of Standard Chartered—Baringa scenarios to external scenarios



Use cases

Standard Chartered utilised the Climate Change Scenario Model outputs initially to feed into TCFD 2020 disclosures where aggregated Probability of Default and Temperature Alignment were shown for the selected 100 corporate clients. Standard Chartered has since applied the Climate Change Scenario Model to almost 2000 of its corporate clients.

Beyond this, the Climate Change Scenario Model, now integrated within Aladdin Climate, has many business use cases, including:

- Probability of Default and Temperature Alignment
- Equity and debt valuation changes
- Contribution into external reporting such as TCFD and other climate/sustainability disclosures
- Multi-jurisdictional regulatory stress tests e.g. Bank of England, Hong Kong Monetary Authority
- Internal stress testing, credit and market risk assessments
- Sensitivity analysis and supports net-zero business planning.

Standard Chartered uses the Probability of Default output from the Climate Change Scenario Model in its climate stress testing and as a risk identification metric and proxy for gross transition risk. Client level climate risk assessments are being integrated into Standard Chartered credit underwriting processes. At Standard Chartered, the Temperature Alignment score helps provide a quantitative measure when evaluating potential climate related reputational risks and is used in client and transaction reviews for selected clients operating in some high carbon sectors. For more information on how Standard Chartered uses the Climate Change Scenario Model in its risk identification processes, refer to the Standard Chartered 2021 TCFD report.[17]

Suggested enhancements for providers

As with all models, development is ongoing and we continue to explore ways in which to enhance and expand our functionality and coverage. These can be broadly characterized into three main areas of focus within the development roadmap to enhance the:

- breadth of sectors covered by specific models
- climate specific functionality within the model, including enhancing competitive dynamics and the impact of company transition plans and costs of abatement
- operation of balance sheet, cash flow, debt and capital funding dynamics across the long term modelling horizon

Authors
Ian Clarke, Expert in Banking, Baringa

17 av.sc.com/corp-en/content/docs/tcfd-climate-change-disclosure.pdf

Participant:

European Bank

Provider:
PricewaterhouseCoopers (PwC)

Risk types covered by tool:
Physical and Transition Risk

Introduction

As part of the UNEP-FI TCFD pilot programme, we as a bank performed a climate risk analysis of our loan portfolio with the help of PwC. The Climate Excellence Tool of PwC allows us to perform a climate risk screening, enabling us to identify physical and transition risks on a sectoral, portfolio and individual asset level. These screenings can subsequently be used to calculate financial impact on asset level as well as aggregated on portfolio level. Within Climate Excellence, we can review the overall risk to the selected portfolio across time and sector exposure as well as explore company-specific vulnerabilities and resilience in a given scenario. The entire corporate client loan portfolio was analyzed. The analyses returned that the portfolio faces elevated physical risk from droughts and coastal and fluvial flooding across regions. Transition risk in the analysis depended on the hypothetical adaption activities of companies (inaction, mainstream, achiever). Under the inaction scenario, agriculture, mining, manufacturing, electricity, and real estate all faced significant transition risks. Based on these results, further sectoral deep dives were proposed from PwC to analyse the asset-specific impact within sectors.

Process

1. In an onboarding session, the dashboard is introduced, including the different possible views for the relevant stakeholders to learn about the tool functions and features (such as the scenario and time filters, the different views on adaptive capacity pathways of companies etc.)
2. In a next step, we choose the preferred scenarios (both for transition and physical risks) and the scope for the analysis (time horizon, depth of analysis, define the portfolio for analysis)
3. After the log-in to the Climate Excellence Tool, we can see a template for preparing the portfolio in the according structure for the upload
4. After uploading the portfolio, the results can be analyzed on different levels within the tool. The tool is structured top-down for different use cases. At first, there is a portfolio overview showing the different sectors present in the portfolio as well as an overall materiality assessment at the sector- or region level for the identification of risk and opportunity hotspots in the portfolio. On the next window, individual companies can be benchmarked across or within sectors and lastly individual companies' results can be split into the different risk drivers (e.g. what sectoral activities, geographies or also technologies (transition) and hazards (physical) drive the changes).

5. The Climate Excellence Tool provides the option to download the scenario analysis results for further evaluation and integration into the bank's processes.
6. To aid the interpretation of results, a degree of upfront effort is required to foster understanding on the different levels of the analysis and the underlying model assumptions and scenario narratives. Furthermore, for the successful integration in the internal processes, additional effort and collaboration across departments is highly recommended.

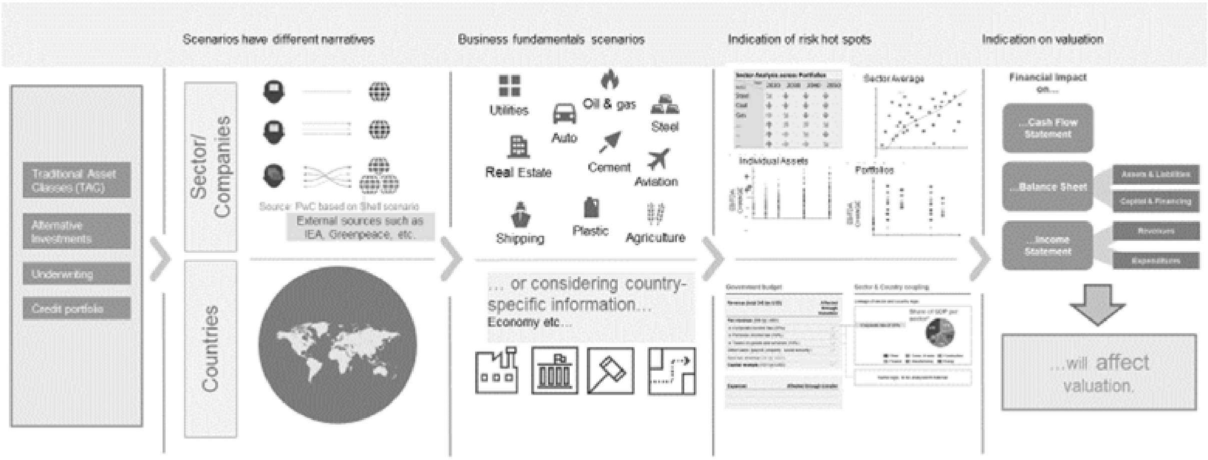


Figure 1 Conceptual image of Climate Excellence analysis

Data & Coverage

- **Data upload:** For the analysis with Climate Excellence, the loan portfolio data is required to be transformed according to the provided template. Furthermore, if not available internally already, the internal sector classification needs to be translated to the NACE sector logic.
- **Input required:** The entire corporate loan portfolio was analyzed and the following data for the portfolio was required:
  - Company Identifier: ISIN, LEI OR Company Name
  - Classification: Main NACE Code and country of operations
  - Exposure: Loan Amount
- **Coverage of the analysis:**
  - 99% of the analyzed portfolio of our corporate clients was covered in the tool
  - The Climate Excellence tool covers all NAICS (translation into NACE sectors is performed and used in the Tool) sectors up to the most granular level (given NAICS is the most granular sector classification system) and all world regions are covered.
  - The results for the high-emitting sectors are based on granular sector models, while the results for sectors with lower relevance are based on factor models (e.g. price changes), which are in turn derived from the high-impact sectors.

	Risk types	Time horizon	Scenarios	Sectoral coverage	Regional coverage	Addi-tional Feature
Transition	Market, technology, regulation	2025, 2030, 2040, 2050	1.8°C, 2.0°C, 3.0°C	Full sectoral coverage	Worldwide cover-age, with regional partly national granularity	Company specific analysis incl. asset level data with technology breakdown
Physical	Both acute and chronic: Heatwaves, Thunder-storms, Droughts, Hurricanes, Flood, sea level rise, fire	2030, 2050, 2100	2.0°C, 3.0°C, 4.0°C	Full sectoral coverage	Worldwide cover-age, with national granularity	Company specific analysis

Table 1: Climate Excellence Coverage

- **Results integration:** The scenario analysis results in Climate Excellence provide sufficient depth of analysis and a high degree of portfolio coverage for potential subsequent integration in the user's organization, e.g. in Probability of Default (PD) calculations.

Risks factors and scenarios

During the trial period demo, the **key risk drivers** for high-risk sectors were analyzed in focused sector deep dives

- We are able to see the sectoral, regional and technological drivers for individual companies: the analysis happens down to NACE-level 4, depending on materiality, further results are presented, with a driver analysis (e.g. on the sector, country and technology level (transition) and hazard-level (physical), where applicable and meaningful
- Technology-level outputs are based on Asset-Level Data and the technological mix of the company (e.g. for a steel company it's the mix of different steel ovens in the company's portfolio)

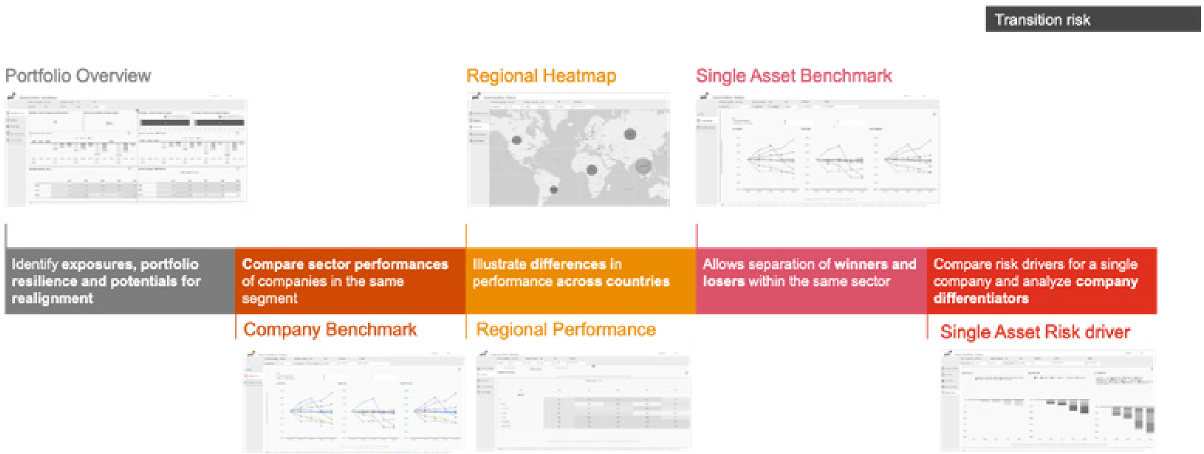


Figure 2 Climate Excellence Transition Outputs

Temperature pathways and scenarios analyzed:

Focus during trial period on one scenario for transition and physical risks respectively:

- 1.8°C (triggering transition risks) based on IEA ETP B2DS and ETP WEO SDS
- 3.0 - 4.0°C (triggering physical risks) based on IPCC RCP 6.0

Outputs and insights

Output

- During the trial period, the focus was on EBITDA changes compared to the base year for individual counterparties
- Where data availability does not allow for granular counterparty analysis EBITDA results are based on sector-geography combinations
- Sales (for transition) and EBIT (for physical) are also available as additional output variables

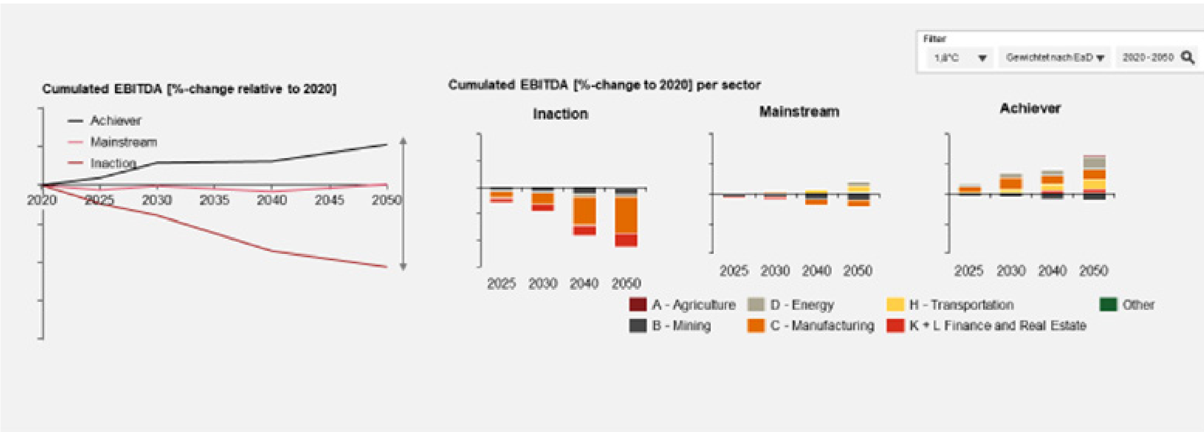


Figure 3 Illustrative results view on portfolio level

- The tool provides insights into the order-of-magnitude financial impacts within and across scenarios
- Sector- and scenario- or even geography-specific risk drivers with significant financial impacts based on changes to revenues and costs
- Understanding of the company-, project-, plant- or product-specific characteristics that imply vulnerability
- The combination of physical and transitory risks helped us a lot in classifying the risks and contributed to a very good understanding of a scenario future world.

Insights on integration options

- Company results as EBITDA change (and Sales) can, for example, be integrated in the respective Probability of Defaults (PD) and Loss given Default (LGD) models of the individual institutions. In this way, for example, a risk premium and its variance can be determined via the modelled adjustment capabilities of companies. Alternatively, based on company results, clusters of risk factors can be integrated.

- Based on the analysis, knowledge is built up across the bank w.r.t. to sector-specific transition and physical risks. Content insights are used for sectoral outlooks and understanding of the required changes in a low-carbon future. Insights are condensed and used to ask further, climate-related questions in the credit processes. Additionally, results are included in future steering concepts.

- The analysis can be directly linked to our Net Zero strategy, thereby covering both sides of the double materiality.

- Optional extension: Evaluation of capex requirements over time (see parallel project: Pathways to Paris) and also embed this for PD and LGD considerations

Suggested Enhancements for the tool provider

The performed analysis of the Financial Institution's portfolio provided a comprehensive geographic and sectoral overview over transition and physical risks within the time period of 2020–2050 and 2020–2100 respectively. The procedure and methodology were well-documented and easy to understand. Outputs provided by the Climate Excellence Tool were integrated within a wider scenario narrative to aid interpretation. Climate Excellence focuses on the financial impact, thus risks and opportunities from climate scenarios. In future versions, the impact side could be included in the tool.

As of now (31.12.2021), PwC has extended the functionality of Climate Excellence modules and now includes the IEA NZE 1.5°C scenario, as well as various Network for Greening the Financial System (NGFS) scenarios. Also, an upgrade of functionality to allow for the analysis of combined impact (thus aggregate transition and physical risk) is available. The analysis' backend has been fed with more recent portfolio data to improve the baseline fidelity of its outputs. Also, the Climate Excellence output has been integrated to generate a climate risk score based on the client's PD model.

An extension to include more extensive analyses of other parts of the client's portfolio, e.g. commercial real estate and mortgages will follow.

UN environment programme

finance initiative

United Nations Environment Programme Finance Initiative (UNEP FI) is a partnership between UNEP and the global financial sector to mobilise private sector finance for sustainable development. UNEP FI works with more than 450 members—banks, insurers, and investors—and over 100 supporting institutions—to help create a financial sector that serves people and planet while delivering positive impacts. We aim to inspire, inform and enable financial institutions to improve people's quality of life without compromising that of future generations. By leveraging the UN's role, UNEP FI accelerates sustainable finance.

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