UNEP FINANCE INITIATIVE

Beyond the Horizon

New Tools and Frameworks for transition risk assessments from UNEP FI's TCFD Banking Program

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Disclaimer

This report was commissioned by the UN Environment Programme Finance Initiative ("UNEP FI") TCFD Banking Program Working Group, which includes the following thirty-nine banks: ABN-AMRO, ABSA, Access Bank, Bank of Ireland, Barclays, BMO, Bradesco, Caixa Bank, CIBC, CIMB, Citibanamex, Credit Suisse, Danske Bank, Deutsche Bank, DNB, EBRD, FirstRand, ING, Intesa Sanpaolo, Itau, KBC, Lloyds, Mizuho, MUFG, NAB, Nat West, Nedbank, NIB, Nomura, Nordea, Rabobank, Santander, Scotia Bank, Shinhan, Standard Bank, Standard Chartered, TD Bank, TSKB, UBS (the "Working Group"), to provide an overview of climate risk applications throughout the financial sector and specific guidance on good practice. This report extends the work of UNEP FI and the participating banks in Phase I of UNEP FI's TCFD banking program. UNEP FI and the Working Group shall not have any liability to any third party in respect of this report or any actions taken or decisions made as a consequence of the results, advice or recommendations set forth herein. This report does not represent investment advice or provide an opinion regarding the fairness of any transaction to any and all parties. The opinions expressed herein are valid only for the purpose stated herein and as of the date hereof. Information furnished by others, upon which all or portions of this report are based, is believed to be reliable but has not been verified. No warranty is given as to the accuracy of such information. Public information and industry and statistical data are from sources UNEP FI and the Working Group deem to be reliable; however, UNEP FI and the Working Group make no representation as to the accuracy or completeness of such information and has accepted the information without further verification. No responsibility is taken for changes in market conditions or laws or regulations and no obligation is assumed to revise this report to reflect changes, events or conditions, which occur subsequent to the date hereof. This document may contain predictions, forecasts, or hypothetical outcomes based on current data and historical trends and hypothetical scenarios. Any such predictions, forecasts, or hypothetical outcomes are subject to inherent risks and uncertainties. In particular, actual results could be impacted by future events which cannot be predicted or controlled, including, without limitation, changes in business strategies, the development of future products and services, changes in market and industry conditions, the outcome of contingencies, changes in management, changes in law or regulations, as well as other external factors outside of our control. UNEP FI and the Working Group accept no responsibility for actual results or future events. UNEP FI and the Working Group shall have no responsibility for any modifications to, or derivative works based upon, the methodology made by any third party. This publication may be reproduced in whole or in part for educational or non-profit purposes, provided acknowledgment of the source is made. The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of UN Environment concerning the legal status of any country, territory, city or area or of its authorities, or concerning delimitation of its frontiers or boundaries. Moreover, the views expressed do not necessarily represent the decision or the stated policy of UN Environment, nor does citing of trade names or commercial processes constitute endorsement.

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1. Introduction

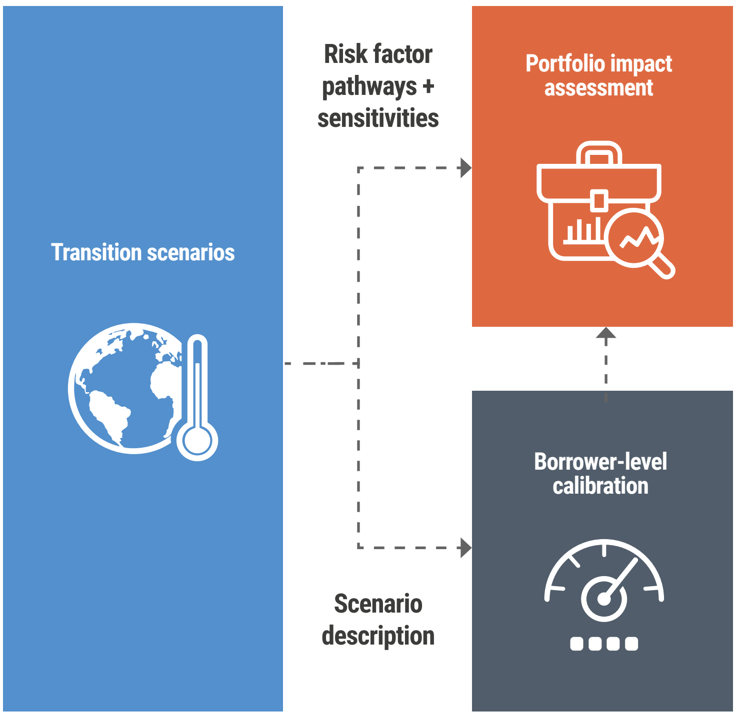
1.1. The Phase I TCFD program

After the Task Force on Climate-related Financial Disclosures (TCFD) released its guidance on climate risk disclosures in 2017, the United Nations Environment Programme Finance Initiative (UNEP FI) convened a consortium of banks to pilot these new recommendations. This exercise included 16 international banks and became known as Phase I of UNEP FI's TCFD Banking Program. The consortium collaborated with Oliver Wyman, a global management consulting firm, to develop an approach for evaluating corporate lending portfolio exposure to transition risk under different climate scenarios (UNEP FI 2018). A similar effort was conducted to develop a physical risk assessment methodology in collaboration with Acclimatise, a climate-focused consultancy.

On transition risk, the UNEP FI program participants and Oliver Wyman engaged leading climate modelers to identify suitable climate scenarios for inclusion in the model. Through a selection process, the group settled on the integrated assessment models (IAMs) produced by the Potsdam Institute for Climate (PIK) and the International Institute for Applied Systems Analysis (IIASA).

The methodology developed by the group incorporated the best available science through partnership with these globally recognised climate modelers. The three-step approach (see Figure 1) integrated climate scenario data with borrower-specific information to produce a view of climate risk on a firm's portfolio. This methodology was adaptable and flexible for banks in varied geographies and the outputs enabled comparability across sectors and institutions. By applying the pilot approach to their portfolios, banks were then able to better implement the TCFD recommendations to assess and disclose their climate risks.

Figure 1: Transition risk methodology from Phase I of the UNEP FI TCFD Banking Program



Transition scenarios describe an evolving economic environment in a consistent manner across time, sectors, and geographies. Scenarios provide detailed outputs which help assess the economic impact on sectors.

Portfolio impact assessment uses a systematic and repeatable approach to extrapolate the risk assessed by the other modules (i.e. transition scenarios and borrower-level calibration) to the remainder of the portfolio.

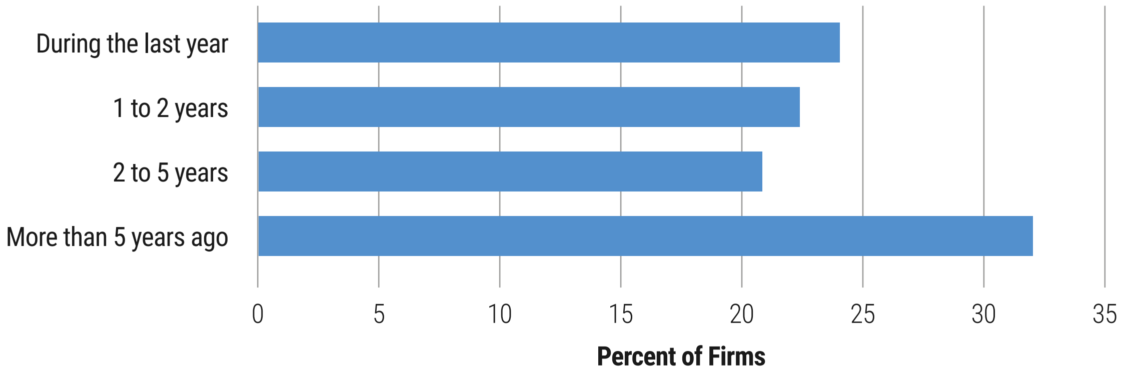
Borrower-level calibration addresses the lack of empirical data on corporate exposure to transition risk by using industry experts and tailored assessment to estimate the scenario's impact on individual borrowers. Calibration specifies the relationship between economic scenarios and credit outcomes.

Using this methodology, program participants evaluated exposures in the Oil & Gas sector, the Power Utilities sector, and the Metals & Mining sector. These sectors were selected given the high level of emissions produced and their likelihood to be impacted by a low-carbon transition. However, the pilot methodology was developed to be applicable to other sectors as well. Many program participants reported using model outputs to guide discussions and decisions around climate risk, and some incorporated their results in their TCFD reports and climate-related disclosures.

1.2. The evolving climate risk space

Since the completion of Phase I of the UNEP FI TCFD Banking Program, the climate risk space has evolved rapidly. Not only has the public paid increasing attention to climate change, but financial regulators have also begun to incorporate climate change into their prudential regulatory mandate as a threat to financial stability. Financial institutions have likewise recognised climate change as a major potential risk to their business and operations. As a result of societal, regulatory, and business pressures, banks are looking to better understand and assess their climate risks. The 2020 Global Association of Risk Professionals (GARP) Climate Risk Management Survey demonstrates just how recently many institutions have begun to formally explore climate risks.

Figure 2: GARP survey- Introduction of climate risk



As firms devote more resources to climate risks, TCFD reports continue to become more detailed and include new and more sophisticated forms of climate scenario analysis (TCFD 2019). Improved climate data, either sourced internally or provided by third-parties, has helped to advance the quality and comprehensiveness of climate risk assessments and TCFD disclosures (although data gaps remain a challenge for the industry). With the proliferation of tools and data providers, banks have more options than ever before to examine, report, and act on their climate risks.

As noted above, regulatory pressure has been an important driver of climate risk assessments and disclosures in the financial sector. Since the conclusion of Phase I, a number of regulators have developed climate stress tests or mandated climate disclosures. The Dutch Central Bank (DNB) has run climate stress tests for the past couple of years to assess the resiliency of their supervisees to climate threats (DNB 2018). At the end of 2019, the Bank of England's (BOE) Prudential Regulatory Authority (PRA) proposed the most comprehensive climate stress test to date (BOE 2019). While the implementation of that stress test has been delayed due to COVID-19, its release sent a clear message that regulatory expectations are rising on climate risk.

Advances have not just occurred in the ambition level of banks and their regulators, but also in the climate scenarios themselves. In June 2020, the Network for Greening the Financial Sector (NGFS), a body of global banking regulators and observers, published a set of "reference" scenarios (NGFS 2020). In addition to orderly transition scenarios similar to those explored by the banks in Phase I, these also provide additional storylines such as a disorderly transition from delayed policy action for firms to explore. PIK and IIASA were involved in the development of these scenarios along with other climate modelers. Separately, PIK and IIASA also worked with others in the Integrated Assessment Modelling community to develop a set of online tools to increase the understanding of the key assumptions of climate scenarios. This project, called SENSES, was made available to the public in early 2020 (SENSES 2020).

1.3. Phase II: Expanding the toolkit

Given the significant changes taking place around TCFD disclosures and climate risk analysis, UNEP FI decided to convene another TCFD program for banks in 2019. Phase II of the UNEP FI TCFD Banking Program was designed to help financial institutions expand their toolkit for climate risk assessment and disclosure. In addition, in determining the program structure, UNEP FI consulted with the Phase I participants and solicited feedback on reasonable next steps. A few recurrent themes emerged from these conversations: a desire to evaluate more sectors, create methodological standardisation, and evaluate new scenarios. UNEP FI also aimed to increase the geographic footprint of the participants and foster collaboration between the financial sector and climate modelers.

Phase II saw a marked expansion in the number of participants, 39 global institutions from six continents, compared to the 16 participants in Phase I. Not only did this larger group support the objective of globally increasing engagement and knowledge of climate risk, but it also provided a diverse range of viewpoints on important issues. With good representation across regions and sectors, the program was able to discuss ideas that were more reflective of the overall industry. As a result, the program could aspire to propose industry-wide good practices for climate risk assessment and disclosure.

Phase II was divided into three pillars based on the most pressing climate risk topics. These pillars included climate scenarios, data and methodology, and reporting and governance. Each pillar was supported by a set of objectives and focus areas as shown in Figure 3.

Figure 3: Pillars of Phase II of the UNEP FI TCFD Banking Program

Climate Scenarios

- Explore the spectrum of climate scenarios
- Identify scenario differences and key assumptions
- Learn how to use scenarios to assess risks and opportunities
- Identify relevant internal and comparable reference scenarios

Data and methodology

- Determine availability of climate relevant asset-level data
- Advance and refine phase I methodologies for risk and opportunity assessment
- Create a comprehensive risk taxonomy across sectors and geographies
- Develop best-practices around sector/geographical assessments

Reporting and governance

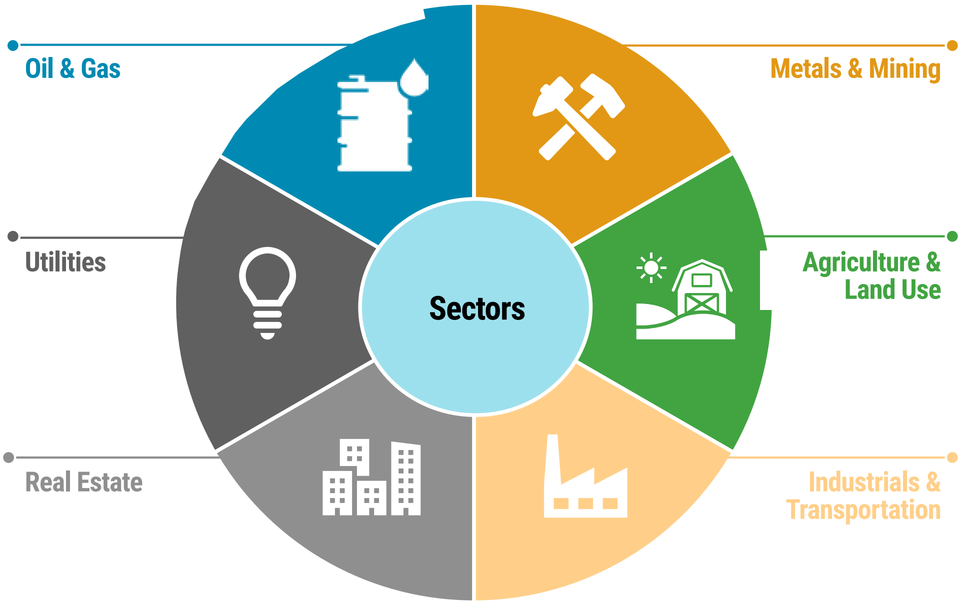
- Understand expectations around TCFD disclosures
- Develop approaches to standardize disclosures
- Develop practices for creating an internal climate risk program
- Draft TCFD disclosures

This paper provides a deep-dive into three main ways that Phase II carried forward the work of Phase I to provide participants with improved tools for assessing climate risk. The first of these enhancements involves applying the transition risk methodology to new sectors. The second enhancement was the development of a webtool in conjunction with Oliver Wyman called Transition Check, which includes a variety of new climate scenarios and a simple user interface for conducting climate scenario analysis and is accessible to all UNEP FI members. The final enhancement was the creation of a group transition risk heatmap that provides a perspective on the sectors and segments within a sector that would be most impacted in a rapid transition. By offering a common set of segments and sensitivities to the four different risk factors used in the transition risk methodology, this heatmap can be used to provide greater standardisation to the implementation of the methodology across institutions. It also enables banks to view a high-level snapshot of their own concentrations of exposure to transition risks. Its development and justification form the bulk of this paper.

2. Expanding to new sectors

Given differences in portfolios, Phase II participants had different exposures to transition risks and different areas of interest. A bank with a significant oil & gas portfolio, for example, will face different challenges than one with predominantly agricultural exposures. In order to enable the large set of participating banks to more effectively discuss topics of shared interest, sectoral working groups were created. Six sectors was selected based on feedback from participating institutions. Three of these sectors were explored by the banks in Phase I: oil & gas, metals & mining, and utilities, while three others were new to Phase II, real estate, agriculture, and industrials/transportation (a catch-all sectoral designation). Of these six sectors (shown in Figure 4), participants were given the option of selecting up to two sectoral groups to join. To promote active engagement and dialogue between group members, the working groups were limited to a maximum of eight institutions. Sectors with more than eight institutions were then split into two separate groups.

Figure 4: Phase II working groups

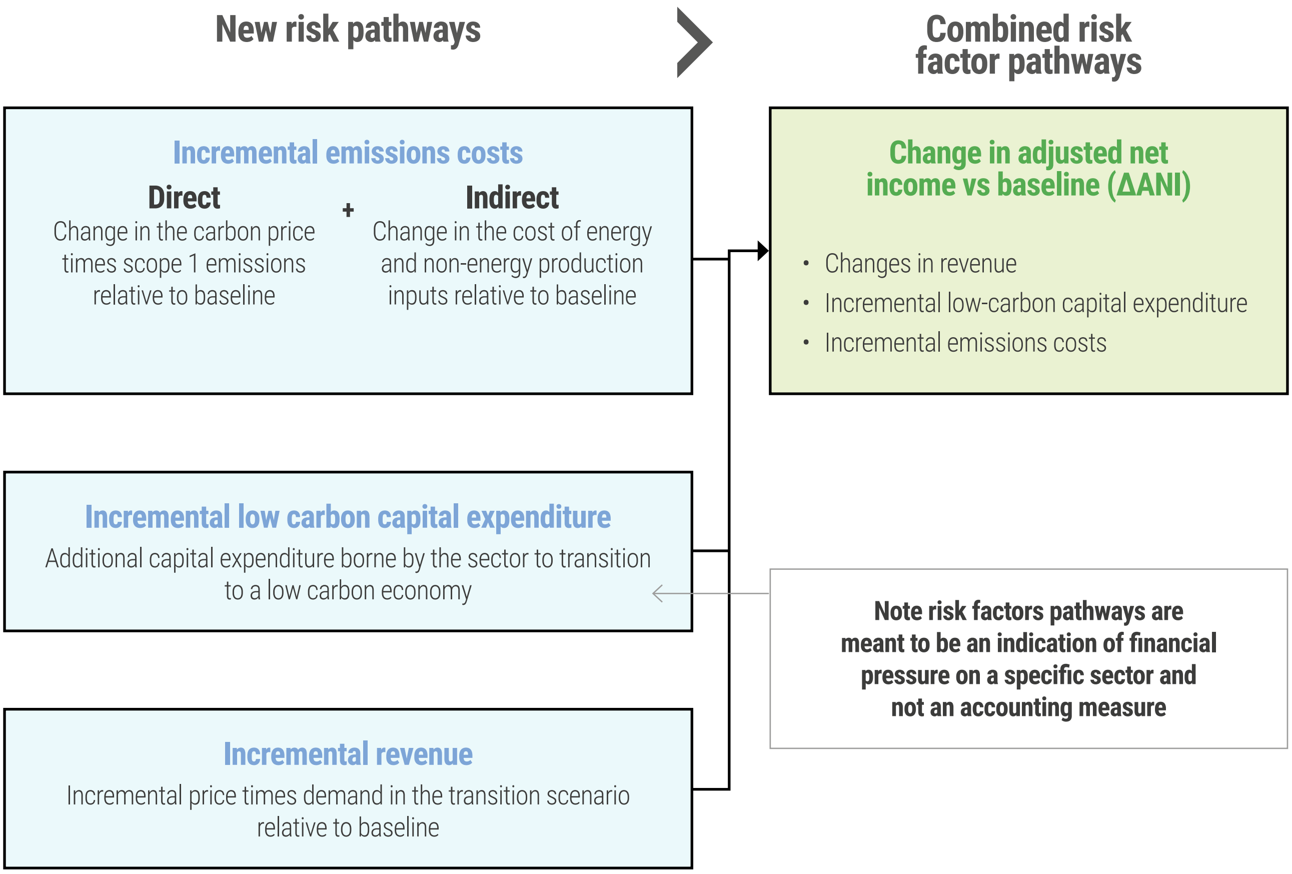


The working groups provided institutions with an opportunity to go deeper into sectoral transition risks and discuss these risks with industry peers. A similar approach was followed for physical risks. During Phase II, working group participants investigated the technological, market-based, and policy drivers of transition risk within their sectors. Not only did the working groups support these discussions, but they also provided a place where institutions could discuss implementation of the Phase I methodology for assessing transition risk (see Figure 1).

When implementing the transition risk methodology, institutions calibrated their portfolios based on a chosen climate scenario. The first step in that process is the translation of climate scenario outputs into financially useful measures. That translation is done through the creation of "risk factor pathways." These risk factor pathways represent financial pressures experienced by firms. As shown in Figure 5, three of them are related to costs of a low-carbon transition: direct and indirect emissions costs and required low-carbon investment. The final risk factor pathway is change in revenue. As the drivers of these changes in costs and revenues will vary significantly by sector, different variable combinations were developed by Oliver Wyman and UNEP FI in Phase I. The full methodology is described in significantly more detail in UNEP FI and Oliver Wyman's Extending Our

Horizons Report (UNEP FI & Oliver Wyman, 2018). In Phase II, working group participants revisited the variable combinations that comprise the risk factor pathways for their sectors and used them in the calibration process.

Figure 5: Risk factor pathways



In order to fully assess the risk factor pathways for their given sector, participants needed to understand two things: the impacts of transition risks on borrowers in the sector and the climate scenario forecast for that sector. As noted previously, the working groups explored the specific ways that transition risks could manifest within their sectors. In addition, they discussed the effects these risks would have on creditworthiness and the extent to which their current rating processes captured transition risks. Banks engaged their credit experts in these conversations along with sector experts within their institutions.

To grasp the storylines and key assumptions of the climate scenarios, bank participants spoke at length with the climate modelling teams who created the IAMs. Through sessions with PIK and IIASA modelers, the banks came to appreciate the high-level narratives within each scenario as well as the specific definitions of each variable. This information allowed the banks to understand each variable that went into the risk factor pathways. Each sector working group could examine whether the major transition risks were captured by the existing risk factor pathways. Detail on specific sectoral risk factor pathways is shown in Figure 6.

Figure 6: Risk factor pathways by sector

<table>
<tr><th>CATEGORY</th><th>SECTOR</th><th>DIRECT EMISSIONS COST</th><th>INDIRECT EMISSIONS COST</th><th>LOW-CARBON CAPITAL EXPENDITURE</th><th>REVENUE</th></tr>
<tr><td rowspan="7">Energy</td><td>Oil and gas</td><td rowspan="3">Product of emissions and carbon pricing, by energy source</td><td rowspan="5">Not applicable</td><td rowspan="4">Not captured</td><td rowspan="7">Product of price and demand, by energy source</td></tr>
<tr><td>Oil</td></tr>
<tr><td>Gas</td></tr>
<tr><td>Coal</td><td rowspan="7">Product of emissions and carbon pricing, by energy source</td></tr>
<tr><td>Renewables</td><td>All renewables investment</td></tr>
<tr><td>Electricity</td><td>Product of fuel demand and price, by fuel type</td><td>All non-thermal technology investment and CCS</td></tr>
<tr><td>Energy</td><td>Not applicable</td><td>All energy supply side investment</td></tr>
<tr><td rowspan="3">End-use</td><td>Industrial processes</td><td rowspan="3">Product of sector energy demand and price</td><td rowspan="3">Energy efficiency and other low carbon investment</td><td rowspan="3">Sector-specific revenue (derived from incremental costs and price elasticity assumption)</td></tr>
<tr><td>Transportation</td></tr>
<tr><td>Residential and commercial buildings</td></tr>
<tr><td rowspan="4">Agriculture and forestry</td><td>Crops</td><td rowspan="2">Product of carbon-equivalent methane and nitrous oxide emissions and carbon price</td><td>Not captured</td><td rowspan="3">Annual investment, derived from supplementary scenario source</td><td>Product of non-energy crop price and demand</td></tr>
<tr><td>Livestock</td><td>Product of crop feed and price</td><td>Product of livestock price and demand</td></tr>
<tr><td>Forestry</td><td>Not captured</td><td>Not captured</td><td>Revenue from lumber and sequestration through international scheme</td></tr>
<tr><td>Agriculture and forestry</td><td colspan="4">Sum of crops, livestock, and forestry</td></tr>
</table>

Green	Directly calculated from the climate variables (no or minor assumptions required)
Orange	Requires additional assumptions based on external sources
Grey	Not applicable or not captured

Many of these pathways had previously been validated in Phase I by participants in that earlier program. Working groups in Phase II found that most risk factor pathway combinations remained appropriate for capturing the transition risks experienced by their sectors. In a few cases, additional granularity was desired to enable a more complete view of the impacts of the scenario on certain sub-sectors. For some sectors, granularity was limited by the variables output by the IAMs. As these models continue to evolve, new variables may add further useful information regarding sectoral risks. Another potential source of granularity could come from external sources that are consistent in their assumptions with the climate scenarios being used. In the future, the risk factor pathways will be periodically reassessed by UNEP FI's TCFD program as new data from IAMs and other sources becomes available.

Phase II saw the application of risk factor pathways for assessing transition risk across a wider range of economic sectors. However, there are still areas of sectoral enhancement that future programs will consider. Phase II participants identified three areas where this enhancement can occur. First, as mentioned above, there is a desire to explore more granular sectoral assumptions and variables that are compatible with the overall climate scenarios. Second is a question of firmwide risk aggregation and analysis. At present, portfolios can be assessed for a given sector and geography. The resulting loss estimates could be integrated together to give a fuller picture of the firm's transition risks. In addition, the combination of transition and physical risk losses could be integrated for a given temperature projection to provide a holistic estimate of the firm's climate exposure. Finally, firms, regulators, and stakeholders are increasingly indicating the desire to assess portfolio performance across a wide variety of scenarios with differing storylines (e.g., disorderly transitions, aggressive regional climate action, etc.). On this topic, the newly developed webtool, Transition Check, discussed in Section 3, promises to be of value.

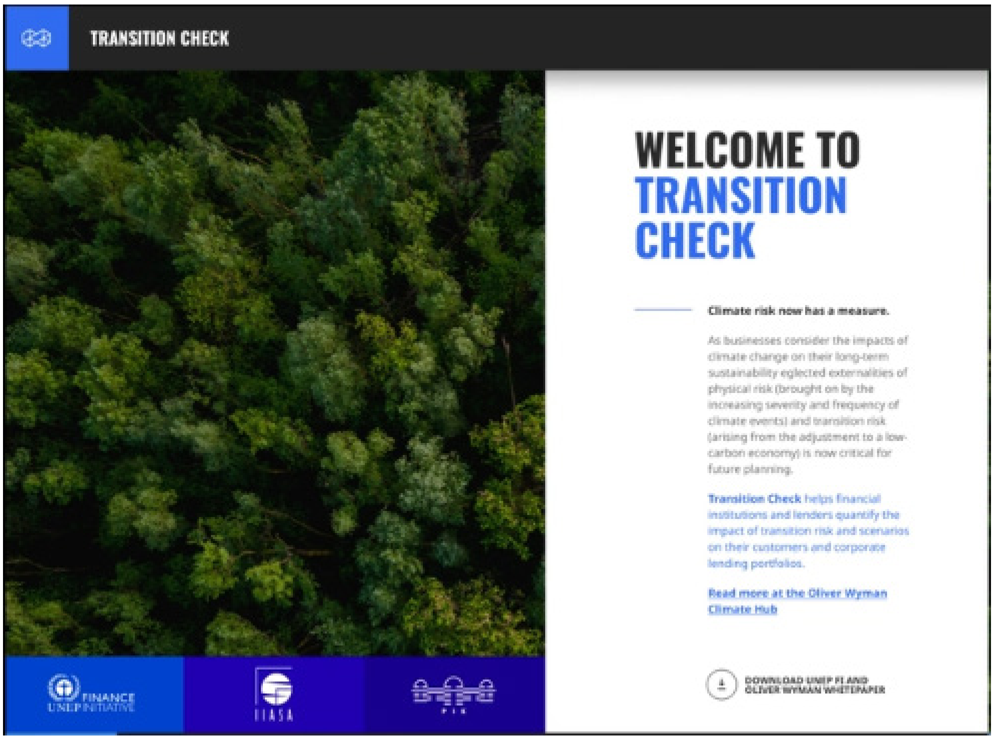
3. A user-friendly tool

During Phase I, the extrapolation of portfolio losses due to transition risk was implemented in an Excel workbook. The risk factor pathway data for each scenario was pre-processed and included in the tool. Users could select a sector-geography combination for their portfolio and run through the calibration process. Sensitivities and sample borrower ratings would be directly keyed into the workbook. Once completed, the model would run and produce portfolio probability of default (PD) and loss estimates.

While this tool met the needs of the institutions in Phase I, there were a few limitations to be addressed. First, while those who developed the tool were quite familiar with its structure, the large number of tabs and settings required the user to have a deep understanding of the methodology. In addition, given the large number of user-input fields, there was potential for user error, especially for new users. Given the nature of Excel, running different sector-geography combinations and different scenarios required saving a new instance of the workbook. In Phase II, as users explored more sectors and more scenarios, this made comparing results more difficult.

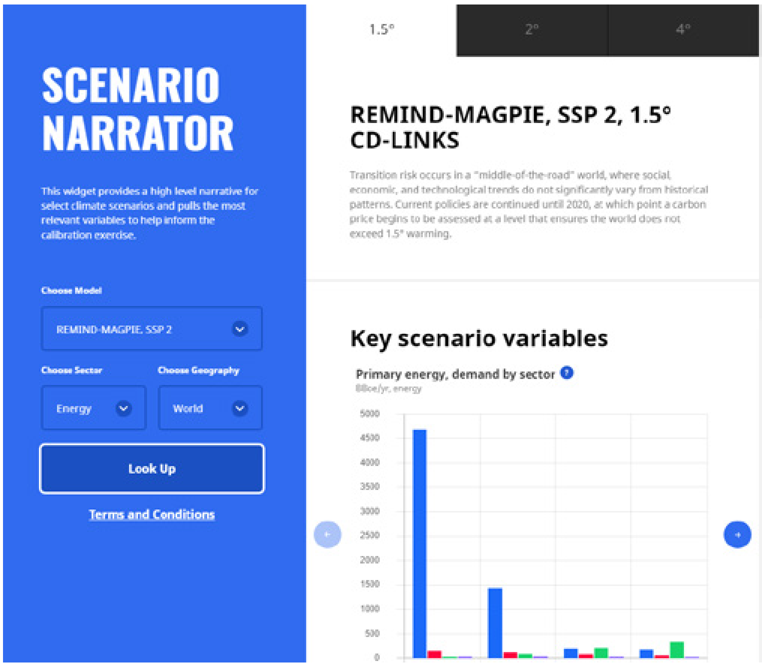
To support the widespread exploration of climate scenarios and the application of the UNEP FI and Oliver Wyman methodology, a webtool was developed. This webtool, called Transition Check, provides a user-friendly interface that makes it easier to conduct climate scenario analysis.

Figure 7: Transition Check webtool homepage



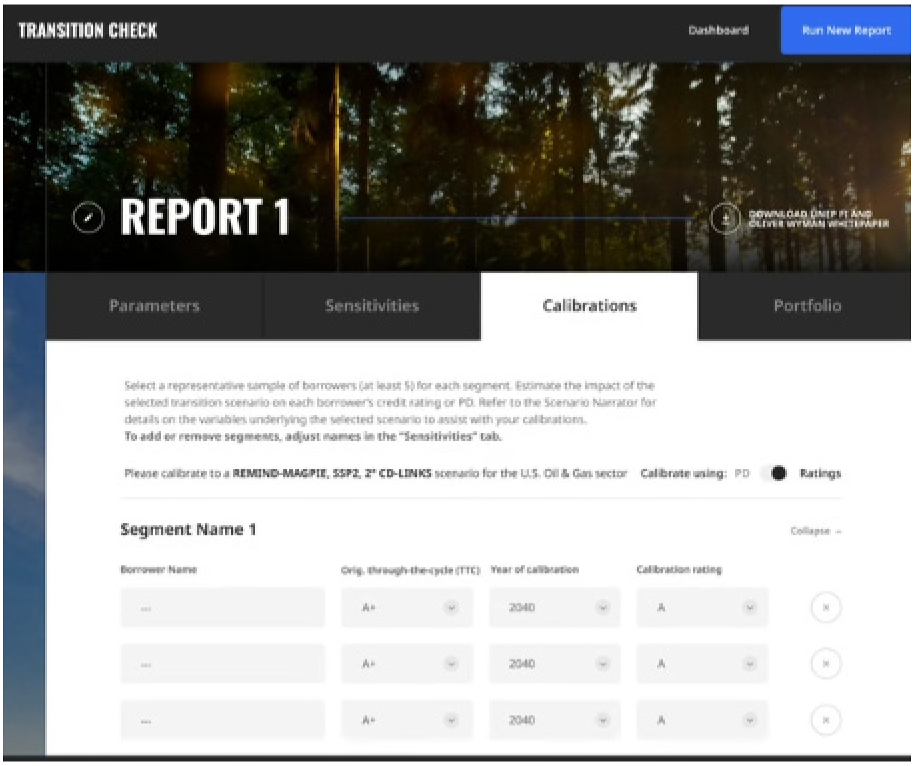
Transition Check contains a scenario narrator, which provides visualisations of key variables under different scenarios as well as an overall description of each scenario. Given that Phase II introduced a number of new scenarios with varied storylines (e.g. orderly vs. disorderly transitions, immediate vs. delayed climate action, etc.), the scenario narrator will prove particularly helpful for those seeking to understand and compare climate scenario assumptions (see Figure 8).

Figure 8: Transition Check webtool scenario narrator



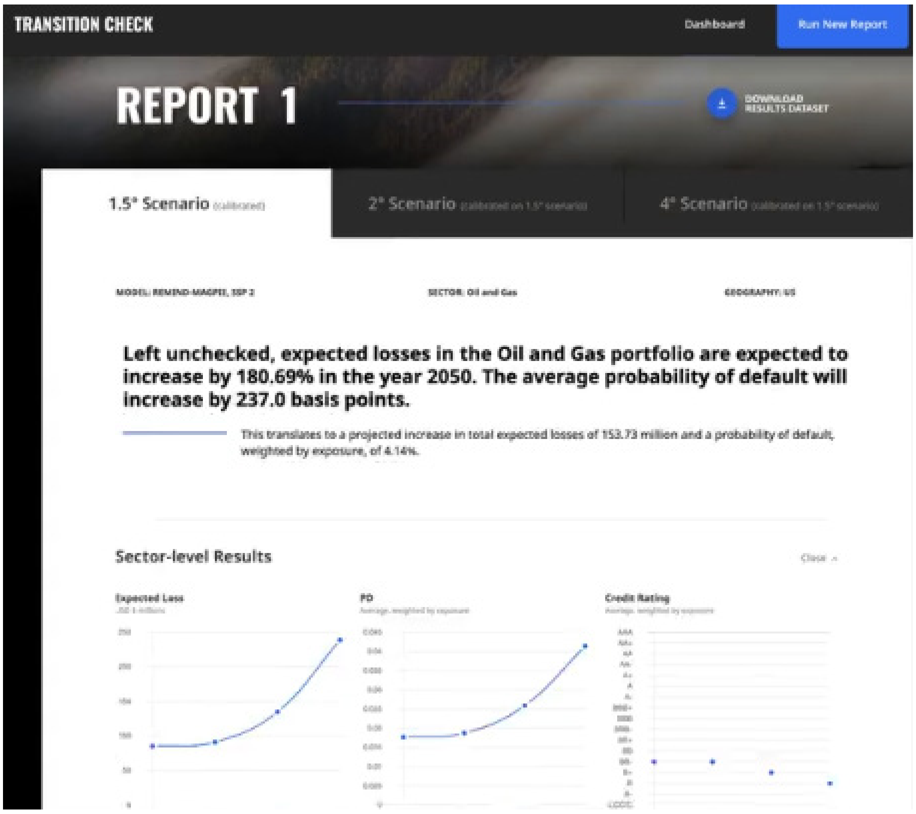
Another advance comes from the modularisation of the calibration process. A visual interface provides instructions for each step of the process, with validation to eliminate opportunities for user error (see Figure 9). Session settings can also be saved and shared across a team of analysts, making it easier to collaborate and evaluate the impacts of different scenarios, segmentations, sensitivities, and ratings. The following section of this paper presents the UNEP FI group transition heatmap, which can be used as a starting point in setting these segmentations and sensitivities within Transition Check.

Figure 9: Transition Check webtool report creator



Finally, the output viewer has also been enhanced to display several graphical representations of loss forecasts that can be used in climate reporting (see Figure 10).

Figure 10: Transition Check webtool output viewer



Transition Check was designed not only to help individual institutions conduct transition risk assessments, but also to enhance standardisation and comparability of climate scenario analysis across the financial sector. By working with PIK and IIASA and incorporating their NGFS reference scenarios into the webtool, UNEP FI and Oliver Wyman are helping to facilitate the adoption and understanding of these scenarios. Since Transition Check is freely accessible to all UNEP FI members (the scenario narrator is publicly available), the tool will be disseminated across the industry. The structured outputs of Transition Check along with the UNEP FI transition risk heatmap described in the next section will increase the ability of stakeholders to compare climate risks across different institutions. Comparative analyses can be run using the same scenario, segmentation, and sensitivities, to focus on the differences in transition risk within each institution's portfolio. If these outputs are published in TCFD disclosures, benchmarking can be conducted and an overall picture of transition risk across the financial sector can develop. These sector-wide insights will be valuable for regulators, investors, and institutions themselves.

While Transition Check provides users with a wide range of scenarios, sectors, and geographies to explore, there is opportunity for future enhancements. As noted in the sections on sectoral assessments and heatmapping, the specific risk factor pathways and sensitivities can be re-evaluated periodically to ensure they remain appropriate for use. New sectors and geographies can also be incorporated into the tool as IAM models evolve once risk factor pathways are developed for the new sectors. Additional scenarios and storylines from the IAM modelling community can also be easily added into Transition Check. These new scenarios will provide further opportunities for comparison between different climate futures.

A final area of potential enhancement that UNEP FI may explore is the extension of Transition Check to investors. The structure of the tool is particularly dynamic and flexible and many of the scenarios that are relevant for banks would likely be relevant for investors as well. For investors who are using the tool, rather than converting the intermediate outputs into credit risk metrics (PDs and losses) the final step could be to predict forward-looking changes in asset values. Given the Merton framework of the tool (discussed in further detail in the Extending our Horizons report), the tool could effectively be adapted to serve this purpose. In the future, a determination will be made whether to pursue this option in consultation with UNEP FI investor networks.

4. A Group transition risk heatmap

4.1. Designing the Heatmap

During Phase I, in order to calibrate their portfolios, participants had to evaluate the degree of transition risk within certain sectors and sub-sectors. This task is particularly important not only for the transition risk approach used in the program, but also for the institution to set strategy and targets around exposures. As institutions seek to develop a full view of their transition risks, they must understand how different types of companies within a sector may similarly be affected by policy, technology, and demand risks under differing scenarios. These groups of companies are referred to as segments here.

The Phase II program recognised that the segmentation and assessment of given sectors posed a few challenges. First, some institutions may not have experience in evaluating the climate risks within certain sectors. Next, different analysts would likely disagree on the prospects for an industry segment or sector. Finally, even the specific sectors and segments used might vary depending on the institutions. These realities made it difficult to obtain views of transition risk that are comprehensive within a firm and comparable across firms.

The benefits of comprehensiveness and comparability are many in climate risk assessment. A full accounting of a firm's transition risk is necessary to enable executives to set strategy and to disclose exposure to external stakeholders. Equally important is the ability to standardise climate risk outputs in order to benchmark a firm against its peers. The application of similar assessment methodologies to a standard set of scenarios and sectors makes TCFD disclosures significantly more decision useful.

Given the benefits of sharing perspectives of sectoral risks and developing a "common language" for expressing these risks, the Phase II participants created a transition risk heatmap for the program. The development process involved the several steps listed below. Each of these steps is elaborated in the sections that follow:

1. **Creating a climate-sensitive sector inventory**
2. **Determining the use cases for the heatmap**
3. **Defining the segmentation for each sector**
4. **Rating the "sensitivity" of each segment to transition risk drivers**
5. **Validating the ratings with the full group of participating banks**

1. Creating a climate-sensitive sector inventory

The first step in creating a heatmap was to develop a common understanding of climate-sensitive sectors. Program participants consulted regulators, rating agencies, and standards setters for a variety of well-regarded lists of climate-sensitive sectors. The different lists considered included the TCFD's list of climate-sensitive sectors, the Sustainability Accounting Standards Board (SASB) list of greenhouse gas emitting sectors, the UK Prudential Regulatory Authority's (PRA) list of climate-sensitive sectors from their insurance stress test, Moody's Analytics' high-risk sectors from their 2019 heatmap, and the sectors considered climate-sensitive in Phase I of the TCFD pilot among others.

These climate-sensitive sets of sectors were linked to standard industry classification systems. A variety of internal and external classifications exist for sectors and industries. Using the EU's Reference and Management of Nomenclatures (RAMON), UNEP FI participants created mappings that linked together differing classifications. These include global classification systems like the International Standard Industrial Classification (ISIC) and Global Industry Classification Standard (GICS), as well as regional classifications like the North American Industry Classification System

(NAICS), and Statistical Classification of Economic Activities in the European Community (NACE), and others. A complicating factor was also the use of different versions of these classification schemes.

Once this process was completed (with the mappings consolidated), each of the sectoral working groups examined the segments and industries within their sectors to validate which were climate-sensitive. After this validation process was completed, the program participants could use the new climate-sensitive sector inventory to identify their climate-sensitive exposure. By mapping the flagged climate-sensitive industries to internal databases, banks are also able to monitor and report on their relative exposure to different climate-sensitive sectors. This inventory also enabled the creation of a common language between group participants during the heatmapping exercise.

2. Determining the use cases for the heatmap

Once the UNEP FI participants developed the climate-sensitive inventory, the group moved on to consider the practical use cases for a transition risk heatmap. These use cases would inform the structure of the heatmap itself. Creating a heatmap would prove useful in several ways:

- To provide a collective view of how different sectors would be impacted by transition risk. The heatmap would also provide suggested segmentation for the various sectors. This information would enable participants with limited knowledge or exposure of particular sectors to benefit from the expertise of others in the UNEP FI program.
- The exercise would improve financial institutions' own climate risk identification, while reducing resource requirements for detailed credit analysis. By serving as a tool to identify concentrations of exposure to sectors with elevated transition risks (e.g. high, moderately-high) institutions could quickly highlight sectors for further analyses. Institutions can also use the heatmap to communicate to stakeholders about these concentrations (or lack thereof).
- Finally, the heatmap helps banks in applying the UNEP FI and Oliver Wyman transition risk methodology (exemplified by Transition Check), by standardizing the segments and sensitivities used during the calibration process. This enables institutions to conduct a more comprehensive assessment of the transition risks throughout their portfolio and benchmark their results to those of their peers. Having the bank participants apply the segments and sensitivities from the heatmap would allow stakeholders to more easily compare disclosures from different firms under the same scenarios.

3. Defining the segmentation for each sector

Within sectors, it was recognized that there were certain companies that may "win" in a low-carbon transition and certain companies that may "lose" with shades in between. These companies may share characteristics in how the different risk factors (e.g. policy, technology, and demand shifts). Segmentation is a step in the methodology that aims to group companies by vulnerability to these risks. This step of the methodology fits neatly with the use cases of the heatmap. Segments are sometimes aligned with traditional subsector classifications or breakdowns, but can also differ and be more granular. The exercise of linking the heatmap to the risk factor pathways had the benefit of providing participants with a structured framework for assessing transition risk. Using risk factor pathways also led to further thinking by the bank working groups around potential segmentations. The guiding questions used to determine segmentation and sensitivity can be seen in Figure 11.

As an example, within the oil & gas sector, a distinction can be drawn between conventional deposits and tar sands. Using the risk factor pathways, it becomes clear that due to the higher per barrel emissions of tar sands oil and its higher production costs, it will be more heavily affected by direct emissions costs than conventional oil. In addition, high levels of public pressure against the continued expansion of tar sands production and challenges to the construction of new pipelines may threaten future revenues.

Figure 11: Assessment framework for heatmap

Assessment framework			
Risk factor	**Guiding question**	**Evaluation scale**	**Sources for analysis**
Incremental direct emissions costs	How large of an impact would emissions costs have on segment production, based on current emissions intensity?	▪ **Highly adverse impact:** Segment has higher emissions per unit of production relative to others in the sector ▪ **Moderately adverse impact:** Segment has moderate emissions per unit of production relative to other segments in the sector ▪ **Low adverse impact:** Segment has lower per unit of production relative to others in the sector ▪ **No impact:** Near zero emissions segment	Carbon intensity of production
Incremental indirect emissions costs	Is the segment's supply chain likely to become more expensive due to climate policy, based on its current mix of inputs?	▪ **Highly adverse impact:** Segment is highly reliant on carbon intensive inputs (e.g. oil, cement, steel, coal) relative to others in the sector ▪ **Moderately adverse impact:** Segment is moderately reliant on carbon intensive inputs relative to others in the sector ▪ **Low adverse impact:** Segment is less reliant on carbon intensive inputs relative to others in the sector ▪ **No impact:** Negligible carbon intensive inputs into production	Input-output database analysis, e.g. World Input Output Database
Incremental low-carbon capital expenditure	To compete in a lower carbon economy, will the segment have to invest in new fixed capital that is difficult or costly to replace?	▪ **Highly adverse impact:** Segment requires higher investment in low-carbon capital required to compete relative to others in the sector ▪ **Moderately adverse impact:** Segment requires moderate investment in low-carbon capital to compete relative to others in the sector ▪ **Low adverse impact:** Segment requires lower investments in low-carbon capital to compete relative to others in the sector ▪ **No impact:** Segment will not rely on low-carbon capital to compete	Marginal abatement cost curves
Change in revenue	Could the segment experience decreases in demand, due to competition with low-carbon alternatives or an increase in price from a cost passthrough?	▪ **Highly adverse impact:** Segment experiences highly adverse demand responses relative to others in sector ▪ **Moderately adverse impact:** Segment experiences moderately adverse demand responses relative to others in sector ▪ **Low adverse impact or positive impact:** Segment experiences limited adverse impacts, or demand increases relative to others in sector ▪ **No impact:** Segment revenue will not change	Industry price elasticity of demand Industry price cross-elasticity of demand relative to high-carbon producers

Key

Level of (negative) impact- higher is worse						
High	Moderately High	Moderate	Moderately Low	Low	Positive Impact	No impact

4. Rating the sensitivity of each segment to transition risk drivers

Using the criteria in Figure 11, sectoral working groups considered how best to segment each sector by risk vulnerability and how to rate that vulnerability (sensitivity). Working groups engaged industry analysts and experts within the participating institutions for discussion, review, and challenge. Outside sources were also consulted while discussing appropriate segments and ratings including Moody's Environmental Risk Heatmap and the Mercer Climate Risk Investing Heatmap.

5. Validating the ratings with the full group of participating banks

Once working groups aligned internally on their sector, they debated their ratings with other working groups that covered the same sector. After this harmonisation process was complete, the full heatmap was shared with the UNEP FI bank participants for their validation and comment. This plenary review led to minor changes in segmentation and rating and enabled the construction of the final heatmap.

4.2. The nature of the heatmap

The ratings in the heatmap reflect the levels of risk that participants believed would likely occur under an ambitious transition. Such a world would represent a major departure from the present economy and would put significant pressure on a variety of sectors. An ambitious transition is the type of transition necessary to limit warming to well-below 2˚ C in line with the Paris Agreement. As a result, 1.5˚ C scenarios are the ones most aligned with the spirit of the heatmap.

An ambitious transition was contemplated for multiple reasons. First, the financial sector must play a constructive role in helping society hit its climate targets, so a wholesale transition was demanded both by the science and social responsibility. Second, the banks wanted to explore the most severe transition stresses in order to get a full picture of their exposure and risk. Furthermore, well-below 2˚ C scenarios are likely to be a central aspect of any future climate stress test (whether internal or external).

However, focusing on an ambitious transition did require trade-offs. The heatmap does not reflect the group consensus view on what is mostly likely to happen, but rather on what is expected under an ambitious transition. Thus, the ratings of the heatmap would likely vary if a less ambitious climate scenario were contemplated. Institutions are encouraged to consult this heatmap as a guide in their risk identification and assessment processes. Institutions should consider their own unique exposures when making final decisions on segmentation and sensitivities.

As noted above, the heatmap considers the sensitivity of different segments to the financial pressures exerted by the risk factor pathways. At the overall level, the heatmap compares sector sensitivities to each other. However, at the sector level, segments are compared to the sector average, which means that some segments in a high-risk sector can have a lower rating than might otherwise be expected. It is important to note that the severity of sector level impacts are already calculated by the risk factor pathways generated for each climate scenario. This sector-level approach is in keeping with the transition risk methodology developed by UNEP FI and Oliver Wyman and implemented in Transition Check.

Expanding on the discussion of use cases above, UNEP FI believes that this heatmap can aid in the management of climate risk in multiple ways. Three primary applications for financial institutions are detailed below:

1. Risk identification- The heatmap can be used to identify sectors and segments that a group of industry participants (the UNEP FI program participants) considered potentially susceptible to transition risk. This can provide a perspective on what types of risks are likely to be experienced during the climate transition.
2. Strategic prioritisation- The heatmap can be mapped to a portfolio to see how materiality and transition risk intersect. This exercise can identify concentrations high-risk, high-materiality assets or segments that require deeper investigation and more thorough analysis. It can also paint a rough picture of the relative magnitude of a firm's transition risk.
3. Risk assessment- The heatmap and segmentation can be directly leveraged for use in the transition risk methodology developed by UNEP FI and Oliver Wyman. The heatmap can serve as a useful guide when thinking about sensitivities to various risk drivers, especially in sectors that the firm has not previously assessed.

However, as discussed throughout this section, it is important for institutions to recognise that this heatmap represents a global "average" view of the impacted sectors under an ambitious transition scenario. Depending on the specific exposures and geographic footprint of an institution, along with the scenario contemplated, the segments and ratings may need to be adjusted accordingly.

4.3. Sector and segment ratings and rationale

Meeting the Paris Agreement goal of keeping warming well below 2° C demands major changes to the global economy. Given the limited carbon budget remaining to hit these aggressive targets, individual sectors are likely to require wholesale transformation to remain relevant in a low-carbon future. The sections that follow detail the impacts of an ambitious transition on specific sectors and provide a rationale for the ratings and segmentation of the heatmap. The broad set of sectors explored in the heatmapping exercise is indicative of the widespread effects (both primary and secondary) that a transition is likely to have across the economy. As a result, some sectors in the heatmap (e.g. Services and Technology) have not been traditionally considered "climate-impacted." However, by looking at the risk factor pathways, it becomes apparent that even low-emitting sectors will be affected by the transition whether through their supply chains, technological shifts, or changes in market demands.

Each sector in the heatmap in Figure 12 is discussed in more detail within its relevant section. Those sections cover the overall impacts of an ambitious transition scenario on that sector and then note the specific considerations made for the underlying sub-segments.

Figure 12: Sector level heatmap- Absolute (sectors compared to each other)

Sector	Direct Emissions Cost	Indirect Emissions Cost	Low-Carbon CapEx	Revenue	Overall
Oil & Gas	High	Low	Moderately High	High	High
Agriculture	Moderate	Moderate	Moderate	Moderate	Moderate
Real Estate	Moderately Low	Moderate	Moderate	Moderately Low	Moderate
Power Generation	Moderately High	Moderate	Moderately High	Moderate	Moderately High
Metals & Mining	Moderately High	Moderately High	Moderate	Moderately Low	Moderate
Industrials	Moderate	Moderately High	Moderate	Moderately Low	Moderate
Transportation	Moderately High	Moderate	Moderate	Moderate	Moderate
Services and Technology	Low	Moderately Low	Moderately Low	Low	Low

Sectoral considerations

- Oil & Gas- As a major driver of global emissions, scenarios show that these sectors would see significant contraction during a rapid transition.
- Agriculture- Land use change and raising livestock are the primary ways this sector produces emissions. More food will be needed for a growing world population, but significant shifts in consumption habits are necessary for sustainability.
- Real Estate- Older buildings will need to be retrofitted, incurring costs. The income potential of buildings may increasingly be related to their energy efficiency, especially if efficiency standards rise.
- Power Generation- Old forms of baseload power such as coal are increasingly uncompetitive with newer renewable technologies. The role of gas plants is less certain as they are needed for demand spikes. Much will depend on the deployment of renewables, their storage potential, and their integration into the grid.
- Metals & Mining- Many activities in this sector necessary for the modern economy have high intensity of emissions. Some reduction in emissions could be seen through new technologies and increasing use of electrification. Rising demand for electronics and renewable energy infrastructure may increase demand for certain types of ores and materials.
- Industrials- Significant potential for electrification of processes in certain activities. However, a full evaluation of transition prospects requires segment-level assessment of the intensity of emissions and changing demand.
- Transportation- On-going development and innovation in this sector is coupled with growing policy pressure to limit emissions. The automobile industry is likely to see significant disruption due to mass transit and electric vehicles. Other segments may see growth, such as rail for freight and passengers.
- Services and Technology- Limited exposure to direct transition risks, but potentially exposed to indirect impacts such as rising electricity or transportation costs.

4.3.1. Oil & Gas sector heatmap

In an ambitious transition scenario, oil and gas use would need to fall significantly to hit climate targets. This phaseout would need to take place rapidly and would have the potential to cause industry wide disruption. As a result, many parts of the Oil & Gas sector face high transition risks. However, owing to emissions intensity and economic viability, some activities will be more affected than others.

Extraction method is a key consideration in costs confronting oil and gas producers both today and in a transition scenario. Unconventional oil and gas assets are often more resource and emissions intensive than conventional assets. In particular, oil sands projects incur some of the highest extraction and refining costs (Liggio et al 2019). These costs would rise with the application of a carbon tax and might make these and other unconventional sources of oil unprofitable. For natural gas, while fracking is only modestly more emissions intensive than conventional natural gas, extraction costs are significantly higher.

Natural gas is significantly less emissions intensive than oil or coal and viewed as a "bridge fuel" that is expected to be less impacted than oil. However, recent studies have shown that methane leakage from fracking has been vastly underestimated and underreported (EDF 2019). These "fugitive emissions" represent significant potential costs under an emissions tax, which may cast doubt on the notion that natural gas is a viable and acceptable "bridge fuel" on the road to renewables. However, there are significant regional differences.

On the demand side, investors, consumers, and governments are increasingly aware of the central role that oil and gas play in climate change. As a result, companies in the sector have faced protests, engagement and divestment campaigns, climate-linked shareholder resolutions. With the price of renewables continuing to fall, there is a growing desire to wind-down oil and gas production. Under an ambitious transition, many oil and gas companies would be left with fossil assets that are uneconomic to produce and sell. These stranded assets could cost companies and investors over $300 billion according to the IEA (IEA 2019).

Oil companies have recognised the existential threat posed by decarbonisation to their business model. A number of these companies have begun to invest in renewable energy, as they try to reposition themselves as energy companies rather than fossil fuel companies. However, a major portion of their current valuation depends on their reserves being extracted, refined and sold. The declining nature of production and reserves in the Oil & Gas sector will mean that fewer investments will be made in the industry than in the past. While lower-cost producers will remain active and profitable as the world will continue to depend on fossil fuels during the transition, scenarios suggest that long-term prospects for the industry are weak in a low-carbon future.

Figure 13: Oil & Gas sector heatmap

	Segment	Direct Emissions Cost	Indirect Emissions Cost	Low-Carbon CapEx	Revenue	Overall

Upstream	Oil Sands	High	No Impact	Moderately High	High	Moderately High
	Shale Oil	Moderately High	No Impact	Moderately High	Moderately High	Moderately High
	Shale Gas	Moderately High	No Impact	Moderately High	Moderate	Moderately High
	Deepwater	Moderate	No Impact	Moderately High	Moderate	Moderately High
	Conventional Oil (on/offshore)	Moderate	No Impact	Moderate	Moderate	Moderate
	Conventional Gas (on/offshore)	Moderately Low	No Impact	Moderate	Moderately Low	Moderately Low
Mid & Down Stream	Transportation & Storage (Gas)	Moderately Low	Moderately Low	Moderate	Moderate	Moderately Low
	Transportation & Storage (Oil)	Moderately Low	Moderately Low	Moderate	Moderately High	Moderate
	Oil Refining	Moderately High	Moderate	Moderately High	Moderate	Moderately High
	Gas Processing (LNG)	Moderately Low	Moderate	Moderate	Moderate	Moderate
	POS	Low	Moderately Low	Low	Moderately High	Moderately Low
Integrated		Moderate	Moderate	Moderately High	Moderately High	Moderate

Segment considerations

- Oil Sands- Highest emissions of oil extraction methods and under significant public and governmental pressure. Challenges include both future financing and the completion of pipelines to transport the oil.
- Shale Oil- Higher emissions and more resource intensive than conventional oil extraction. Some regions and operators do significant amount of routine flaring and venting. There are concerns regarding breakeven prices for this capital-intensive work.
- Shale Gas- More resource intensive than conventional oil extraction, increasing evidence of higher-than-expected methane leakage. Gas is a more regional commodity than oil and may persist longer due to its role in power generation.
- Deepwater- Primary concerns with this type of extraction centre around its capital intensity. Mostly confined to the largest players in the market.
- Conventional Oil (on/offshore)- A rapid transition will see significant reductions in oil, but conventional oil, with the lowest cost of production, may be least impacted by lower prices or carbon taxes.
- Conventional Gas (on/offshore)- In comparison to other segments within Oil & Gas, conventional gas will fare somewhat better due to its lower carbon intensity and use in power production.
- Transportation & Storage (Gas)- In comparison to other segments, relatively little impact on costs, revenues may decline as gas demand decreases.
- Transportation & Storage (Oil)- In comparison to other segments, relatively little impact on costs, revenues may decline as oil demand decreases.
- Oil Refining- Refining is emissions intensive, but likely to be required for all types of upstream production. Refiners have limited ability to absorb CO_2 pricing and will need to pass on the costs to users, but falling demand will challenge their operating margins.
- Gas Processing (LNG)- While gas demand may decrease less in a rapid transition scenario than oil, LNG demand may fall as regional gas supplies meet local needs.
- Point of Sale (PoS)- Low emissions at PoS mean relatively low increases in costs; demand for products will fall, which will reduce revenue.
- Integrated- Represents the average across the segments. Integrated players will be impacted both in terms of production and refining.

4.3.2. Agriculture & Forestry sector heatmap

Agriculture and forestry are essential activities for feeding the global population. However, they are also major contributors to climate change, primarily through land use change, fertilisers, and livestock emissions. Livestock emissions alone represent nearly 15% of all anthropogenic greenhouse gas emissions (World Economic Forum 2019). A rapid transition cannot succeed without considering the Agriculture & Forestry sector.

In an ambitious transition scenario, activities such as cattle ranching, and industrial livestock production would face significant disruption. Cattle have an emissions footprint that is several times higher than most other animals and dozens of times higher than food plants (Poore and Nemecek 2018). As part of a rapid transition, not only would land-use practices be more tightly controlled, but the high intensity of emissions would also incur major costs from a carbon tax. Even without direct regulation, changes in consumer behaviour have the potential to reduce revenues. Shifts to plant-based diets for health, ethical, or environmental reasons will result in a decrease in livestock production. Similarly, as climate change puts greater strains on water and other natural resources, resource intensive crops will also face rising costs.

However, within this sector, a rapid transition will also produce winners. Agricultural biotechnology firms who can increase yields while reducing land and resource use will experience growing demand for their innovations (Singh et al. 2018). Other winners are likely to be developers of meat substitutes and replacements as evidenced by the success of companies like Beyond Meat.

Although transition risks may vary across regions for all sectors, differences for Agriculture and Forestry may be particularly regionally dependent. Nevertheless, this heatmap attempts to present a global picture that identifies broad vulnerabilities and opportunities in the sector.

Figure 14: Agriculture & Forestry sector heatmap

Segment	Direct Emissions Cost	Indirect Emissions Cost	Low-Carbon CapEx	Revenue	Overall
Forestry	Moderately Low	Low	Low	Moderately Low	Low
Fishing	Moderately Low	Moderately Low	Moderately Low	Moderately Low	Moderately Low
Aquaculture	Moderate	Moderate	Moderate	Moderate	Moderate
Livestock- beef intensive grazing	High	High	Moderate	Moderately High	High
Livestock- beef extensive grazing	Moderately High	Moderately High	Moderate	Moderately High	Moderately High
Livestock- other	Moderate	Moderate	Moderate	Moderate	Moderate
Crops - high emissions intensity	Moderate	Moderate	Moderate	Moderate	Moderate
Crops - low emissions intensity	Moderately Low	Moderately Low	Low	Low	Low
Horticulture	Moderate	Moderately High	Moderate	Moderate	Moderate
Other agri services	Moderate	Moderate	Moderate	Moderately Low	Moderate
Biofuels	Moderately Low	Moderately Low	Moderate	Positive	Low

Segment considerations

- Forestry- Sustainable forestry will likely grow due to afforestation and reforestation policies, but logging activities may face additional costs and restrictions.
- Fishing- While there are relatively limited emissions costs from fishing, significant concerns around sustainability and rising global awareness of environmental issues exist for the segment.
- Aquaculture- Farmed seafood outlook depends on the practices followed and the type of seafood farmed. Crustaceans and large fish have a significant footprint.
- Livestock (beef intensive grazing)- Use of feedlots and industrial farming methods are more emissions intensive than extensive grazing, and beef also has land use change impacts.
- Livestock (beef extensive grazing)- Less intensive compared to industrial farming but still produces a sizable carbon footprint.
- Livestock (other)- Other livestock vary widely in their emissions intensity to raise and bring to market. Some may be substitutes for beef, while others are nearly as intensive.
- Crops (high emissions intensity)- Includes any crop or production method that has high emissions intensity (e.g., those grown using high fertilisers or grown in greenhouses). Feed production is also grouped into this segment.
- Crops (low emissions intensity)- Can include any crop or production method that has low emissions intensity (e.g., no fertiliser or open field). These crops are likely to see growth in a decarbonising world.
- Horticulture- Relatively higher intensity of emissions than crops in fields due to energy use of greenhouses and additional fertilisers.
- Other agricultural services- Other services includes support activities for crop production and post-harvest activities. Impacts on this segment will vary based on what types of agriculture are being supported.
- Biofuels- Will see growing demand, but important to consider that supply chains and production still use GHGs. Efficiency of production will be a determinant of their ultimate performance.

4.3.3. Real Estate sector heatmap

The primary challenge of an ambitious transition to banks who are providing capital to the Real Estate sector will be the need to upgrade old, low-efficiency structures to comply with new energy efficiency and emissions regulations (Sjöblom et al. 2018). Though the process of transforming existing structures will be expensive, it may prove more affordable than simply demolishing old buildings and replacing them (CRREM 2020). Efficiency and emissions regulations already exist in a number of US states and across Europe. In some jurisdictions, these regulations can directly limit rental income by requiring the owner meet certain standards before renting the building.

In a study of efficiency regulations in Europe, more stringent regulations were tied to higher property values for energy efficient buildings (Chegut et al. 2020). Not only are high-efficiency buildings unencumbered by rental restrictions, but they will also experience lower energy costs. Energy costs have the potential to significantly affect the desirability of a property. New buildings that produce their own energy or are highly efficiency are likely to benefit from an ambitious transition.

Figure 15: Real Estate sector heatmap

Segment	Direct Emissions Cost	Indirect Emissions Cost	Low-Carbon CapEx	Revenue	Overall
Residential - high eff.	Low	Low	Low	Positive Impact	Low
Residential - low eff.	Moderate	Moderate	Moderately High	Moderate	Moderate
Commercial - high eff.	Low	Low	Moderately Low	Moderately Low	Moderately Low
Commercial - low eff.	Moderately High	Moderately High	High	Moderately High	Moderately High
Construction- infrastructure	Low	Moderate	Moderate	Positive Impact	Low
Construction- non-infrastructure	Moderately Low	Moderate	Moderately High	Moderately Low	Moderately Low

Segment considerations

- Residential (high efficiency)- High efficiency properties will likely see increases in value and thus, revenue, during an ambitious transition.
- Residential (low efficiency)- Low efficiency residential properties may face restrictions on renting, higher energy costs, or additional costs for retrofitting to become compliant with new efficiency standards.
- Commercial (high efficiency)- Commercial tenants (whether renters or owner-occupiers) are likely to seek out energy efficient buildings. Additional regulatory scrutiny will likely apply to emissions and energy use in commercial buildings.
- Commercial (low efficiency)- Commercial tenants (whether renters or owner-occupiers) are likely to avoid buildings that require extensive retrofits or have high energy costs. Additional regulatory scrutiny will likely apply to emissions and energy use in commercial buildings.
- Construction (infrastructure)- Infrastructure construction will likely benefit from adaptation demands and other major improvement projects such as new mass-transit.
- Construction (non-infrastructure)- Non-infrastructure construction will face higher costs from the need to build to higher standards and use more efficient materials.

4.3.4. Power Generation sector heatmap

Electricity is essential for the functioning of the modern economy. Electrification is also one of the most effective steps in decarbonising different sectors. However, how the electricity is produced matters a great deal to global emissions. Under an ambitious low-carbon transition scenario, electrification would proceed rapidly as would the deployment of renewable energy sources. These changes would have important implications for the electricity grid and the existing power infrastructure.

Given the long lifespan of power plants, the construction of new fossil fuel plants is likely to lock-in emissions for decades. The temperature goals of a transition scenario provide a major challenge to the operators of these plants, who have expected to offset their construction costs with decades of revenues. Not only are these plants incompatible with climate goals, but they are becoming ever less competitive with renewable energy. As a result, fossil fuel producers are now facing "substantial risks of stranded assets" (Renewable Energy Institute 2019).

While coal and oil plants are likely to be hardest hit, even natural gas will be affected by an ambitious transition. All forms of fossil energy will face increasing emissions costs from a rising carbon tax. Some have discussed the use of carbon capture technologies in order to continue operating coal and gas plants. However, with current technologies carbon capture and storage (CCS) represents a major capital investment that can make power generation unprofitable. As a result, only a few CCS projects have been undertaken at scale across the world.

While traditional sources of power generation face transition risks, opportunities exist for renewable generation. As innovation continues to drive down the costs of solar and wind power, these technologies will see more widespread adoption. However, grid operation and transmission will need to be updated to support renewable power generation, and there will need to be significant investment in batteries and power storage to maintain reliable and available energy (Greening the Grid).

Figure 16: Power Generation sector heatmap

Segment	Direct Emissions Cost	Indirect Emissions Cost	Low-Carbon CapEx	Revenue	Overall
Regulated high-carbon (predominantly coal and oil)	High	Moderately High	Moderately High	Moderate	Moderately High
Regulated medium-carbon (predominantly gas)	Moderately High	Moderate	Moderate	Moderate	Moderate
Unregulated high-carbon (predominantly coal and oil)	High	High	High	High	High
Unregulated medium-carbon (predominantly gas)	Moderately High	Moderately High	Moderately High	Moderate	Moderately High
Wind and solar	Low	Moderately Low	Moderately Low	Positive Impact	Low
Other renewables (non-nuclear)	Low	Low	Low	Positive Impact	Low
Nuclear	Low	Low	Moderate	Moderate	Moderately Low
Grid operation/transmission	Low	Low	Moderate	Moderate	Moderately Low
Batteries/storage	Low	Moderate	Moderate	Positive Impact	Moderately Low

Segment consideration

- Regulated high-carbon (predominantly coal and oil)- Highly impacted as emissions-related costs increase, and extensive capital expenditure is required for carbon capture and sequestration. In addition, many of these plants are no longer cost competitive with greener sources of power.
- Regulated medium-carbon (predominantly gas)- Some revenue decline expected and rise in costs due to higher carbon prices. However, these plants are more flexible in their use and less emissions intensive than coal plants.
- Unregulated high-carbon (predominantly coal and oil)- Similar rationale as for regulated high-carbon generators, but in an open market, their lack of cost-competitiveness significantly shrinks revenues.
- Unregulated medium-carbon (predominantly gas)- Similar rationale as for regulated medium-carbon generators.
- Wind and solar- Both sectors have seen dramatic price drops in the past decade along with rapid growth in investment and installation. The degree of their proliferation in the future energy mix will depend on integration into the grid and storage capabilities.
- Other renewables (non-nuclear)- Innovative renewable technologies are likely to grow in a low-carbon transition, even if hydropower growth remains relatively flat.
- Nuclear- there is innovation potential in the segment, but significant public opposition remains and construction and regulatory costs can make new plants relatively uneconomical.
- Grid operation/transmission- Grid infrastructure has relatively low emissions costs, but traditional grids may face competition from microgrids and home installations.
- Batteries/storage- A tremendous amount of financing and demand are likely to increase the market for better storage technologies to accompany renewables, but their production may be resource intensive.

4.3.5. Metals & Mining sector heatmap

The Metals & Mining sector is both a major source of emissions and essential for the execution of a low-carbon economy. The raw materials that are essential to nearly every economic activity have variable footprints that depend on the material, the extraction method, and the refinement process.

Unsurprisingly coal production and coal use will be threatened by a rapid transition. In the face of mounting emissions costs, producers and refiners will need to turn to new sources of energy (potentially electrification) as well as alternative materials. Across the sector, efficiency improvements and higher recycling rates for secondary production will need to be made along with the implementation of emissions capture technologies to reduce emissions from mining and manufacturing (Global Climate Action 2018).

The mining and refinement of precious metals and rare earth metals present a more complex case. The production of these metals often has meaningful emission and environmental impacts. However, they are also needed in the manufacture of electronics and renewables. As a result, rising costs will be offset by rising revenues. Nevertheless, a rapid expansion in demand may prove disruptive for global prices and supply chains and represents another form of transition risk. Research suggests that given the unequal distribution of these raw materials around the world, certain regions may benefit more than others from growing demand (World Bank 2017).

Figure 17: Metals & Mining sector heatmap

Segment	Direct Emissions Cost	Indirect Emissions Cost	Low-Carbon CapEx	Revenue	Overall
Coal	High	Moderately High	High	High	High
Iron ores	Moderate	Moderately High	Moderate	Moderately Low	Moderate
Rare/precious metal ores	Moderate	Moderate	Moderately Low	Positive Impact	Moderately Low
Metal ore mining n.e.c.	Moderately Low	Moderate	Moderate	Moderate	Moderate
Quarrying	Moderate	Moderate	Moderate	Low	Moderately Low
Support activities for mining/quarrying	Low	Moderate	Moderately Low	Moderate	Moderately Low
Steel/iron manufacture	High	High	High	Moderate	High
Manufacture of other metals	Moderately High	Moderately High	Moderately High	Moderately Low	Moderately High
Conglomerates	Moderate	Moderate	Moderate	Moderate	Moderate

Segment considerations

- Coal- Coal is the most carbon intensive of the fossil fuels and not surprisingly increasingly, being displaced by cheaper gas and other fuels in power generation. Consequently, coal mining faces increasing market pressures, regulatory restrictions and negative public sentiment. In the marketplace, demand for coal is falling and companies will struggle to find financing. In particular, thermal coal will be most severely affected by these changes.
- Iron ores- Iron ore extraction is carbon intensive yet there is large global demand. Some of that demand may slightly erode over time but will likely remain a major commodity.
- Rare/precious metal ores- Extraction process is moderately carbon intensive, but electronics and renewables are likely to drive demand and prices higher.
- Metal ore mining n.e.c.- Other types of metal ore mining will be impacted by higher emissions costs, but those costs and changes in revenue are likely to vary based on the metal considered.
- Quarrying – The segment faces a relatively lower impact compared with the other sector activities given that many types of activities in this sector require quarrying.
- Support activities for mining/quarrying- The segment faces relatively lower impact compared with the other sector activities given that all types of mining require support activities.
- Steel/iron manufacture- High impact expected due to carbon intensity of steel production, but the ubiquity of steel and the potential to electrify production might reduce long-term risks.
- Manufacture of other metals- Relatively carbon intensive practices for other metals are somewhat offset by growing demand (e.g. aluminium).
- Conglomerates- Diversified conglomerates will be exposed to most aspects of the metals and mining sector and will have risks in line with the sector average.

4.3.6. Industrials sector heatmap

The Industrials sector represents the production of a range of products from petrochemicals and concrete to consumer goods. Under an ambitious transition scenario the performance of these specific sub-sectors is likely to vary significantly.

Petrochemicals, derived from fossil fuels, will face new costs from carbon taxes and other emissions limitations. The plastics industry is likely to be disrupted and already innovators are beginning to explore the potential of bioplastics (Yale 2019). Similarly, the manufacture of concrete produces a high quantity of greenhouse gas emissions (mostly through the use of cement). At present, cement is a staple of the construction industry, though substitute products are beginning to emerge (Greenspec 2019). However, as these plastic and cement substitutes remain a small share of the market, companies must also consider measures like carbon capture, efficiency improvements, and changes in chemical feedstocks to reduce their emissions (Material Economics 2019).

Given the sizable emissions footprint for many Industrial segments, in an ambitious transition scenario there is revenue potential for technologies that can capture or reduce emissions.

Figure 18: Industrials sector heatmap

Segment	Direct Emissions Cost	Indirect Emissions Cost	Low-Carbon CapEx	Revenue	Overall
Petrochemicals	High	High	Moderately High	Moderate	High
Cement or concrete manufacture	High	High	Moderately High	Moderate	High
Renewables manufacture	Moderate	Moderate	Moderate	Positive Impact	Low
Electronics manufacture	Moderately High	Moderate	Moderate	Low	Moderately Low
Clothing manufacture	Moderately High	Moderately High	Moderate	Moderate	Moderately High
Consumer durables manufacturing	Moderately High	Moderately High	Moderately High	Moderately Low	Moderately High
Other consumer goods manufacturing	Moderate	Moderate	Moderate	Moderate	Moderate

Segment considerations

- Petrochemicals- While used in a variety of applications, emissions costs are likely to hit petrochemicals particularly hard.
- Cement or concrete manufacture- One of the largest single sources of global emissions is the production of concrete. While currently integral to global construction, alternative materials with smaller carbon footprints are likely to threaten revenues.
- Renewables manufacture- Some renewables productions have high emissions associated with them, but continuing innovation of their production methods and strong demand in a decarbonizing world will offset incurred emissions costs.
- Electronics manufacture- Electronics demand has grown rapidly as parts of the developing world become wealthier, and this trend is likely to continue even with emissions costs hitting the production of these goods.
- Clothing manufacture- The garment industry has faced increasing pressure around its resource consumption and changing consumer demands have the potential for disruption.
- Consumer durables manufacturing- Many production processes are resource intensive and face challenges both in terms of their direct emissions costs as well as indirect costs along their supply chain.
- Other consumer goods manufacturing- This segment is aligned to sector averages as it is a catch-all for goods not falling into other segments.

4.3.7. Transportation sector heatmap

The Transportation sector faces both risks and opportunities under an ambitious transition scenario. Emissions intensive modes of transportation will be pressured by higher fuel costs and specific policy restrictions. In the case of the aviation industry (the most emissions intensive transportation segment), consumers would likely face higher ticket costs and certain shorter routes may be eliminated, as has happened in some European countries. The shipping industry accounts for 2.2% of global emissions and demand for international goods continues to grow rapidly (IMO 2014). Higher fuel prices and environmental requirements will lead to higher emissions costs for this important segment.

The types of vehicles and transportation systems are likely to change under a low-carbon transition. Rail freight will increasingly be favoured by policymakers over trucks for ground shipping, and public transit systems will be encouraged over private vehicles in urban areas due to lower emissions intensity (AAR 2018).

One of the most notable areas of change within the transportation sector is the shift from internal combustion vehicles to electric vehicles (EVs), as road transport accounts for the majority of emissions from the transport sector. With a growing number of cars sold each year, the emissions impact of the automobile sector is critical to climate goals. The movement to EVs through policy incentives and advancing technologies has the potential to vastly alter the carbon footprint of the global automobile fleet. Major auto makers plan to increase their EV offerings and in some instances even phase out their internal combustion models (Business Insider 2020).

Figure 19: Transportation sector heatmap

Segment	Direct Emissions Cost	Indirect Emissions Cost	Low-Carbon CapEx	Revenue	Overall
Sea-based shipping	Moderately High	Moderately Low	Moderately High	Moderately Low	Moderate
Tankers	Moderately High	Moderately Low	Moderately High	Moderately High	Moderately High
Passenger ships	Moderately High	Moderately Low	Moderately High	Moderate	Moderate
Airlines- commercial	High	Moderate	High	Moderately High	Moderately High
Airlines- cargo	High	Moderate	High	Moderately Low	Moderately High
Autos high-carbon (few EVs, many SUVs)	Moderately High	Moderate	Moderately High	Moderately High	Moderately High
Autos low-carbon (many EVs, few SUVs)	Moderate	Moderate	Moderately High	Positive Impact	Low
Land-based shipping high-carbon (trucks)	Moderately High	Moderately High	Moderate	Moderately High	Moderately High
Land-based shipping low-carbon (rail)	Moderately Low	Moderately Low	Moderately Low	Positive Impact	Low
Transit systems	Moderate	Moderately Low	Moderate	Low	Moderately Low

Segment considerations

- Sea-based shipping- Sea-based shipping is likely to expand, but large investments are needed to reduce the emissions associated with current ships.
- Tankers- Tankers will face significant losses of revenue if oil demand plummets.
- Passenger ships- Cruise ships will face some decreasing demand and more stringent emissions and environmental regulations in a rapid transition.
- Airlines (commercial)- Revenues are likely to be adversely impacted as costs rise and social awareness of impacts grow.
- Airlines (cargo)- Significant emissions costs for cargo planes but increasing global commerce may help to protect revenues.
- Autos (high-carbon)- Municipal regulations are beginning to phase out internal combustion engines and increasing fuel costs will also make consumers more willing to shift away from traditional vehicles.
- Autos (low-carbon)- Electric vehicles (full EVs and hybrids) will benefit from higher consumer demand and government subsidies.
- Land-based shipping (high-carbon)- High emissions costs may also push trucking firms to invest in low-carbon or carbon neutral fleets.
- Land-based shipping (low-carbon)- Rail shipping is likely to expand by relying on already existing infrastructure.
- Transit systems- A rapid transition will likely spur an increase in public transportation funding and construction.

4.3.8. Services and Technology sectors heatmap

While many climate risk heatmaps do not include the Services and Technology sectors, companies in these sectors will still be impacted under an ambitious low-carbon transition. However, much of the impact they will face will be indirect in the form of changing energy prices. Opportunities to shift to greener and more efficient operations will have impacts on the bottom line of companies across these sectors.

Figure 20: Services and Technology sectors heatmap

Segment	Direct Emissions Cost	Indirect Emissions Cost	Low-Carbon CapEx	Revenue	Overall
Financial services	Low	Moderately Low	Moderately Low	Moderate	Moderately Low
Health care	Low	Moderate	Moderately Low	Low	Low
Entertainment & leisure	Moderately Low	Moderate	Moderate	Moderate	Moderate
Technology	Moderately Low	Moderate	Moderate	Moderately Low	Moderately Low

Segment considerations

- Financial services- Financial firms may face a modest decline in revenues from the transition away from major fossil fuel clients, but this could be offset by funding a growing renewables sector.
- Health care- There will be limited direct effects, but given the size of the industry, energy and supply chain costs could have impacts on performance.
- Entertainment & leisure- These discretionary industries may be impacted by changing consumer patterns in a low-carbon economy.
- Technology- The technology industry will continue growing, but associated costs for energy will also rise with rising carbon prices.

This heatmap can provide a starting point for institutions beginning a climate risk identification process. It can also facilitate the assessment of transition risk across a variety of sectors using the transition risk approach in the Transition Check webtool. However, as mentioned in the introduction to this section, sensitivities can change based on the scenario selected and the unique characteristics of an institution's portfolio. Segmentation can also be changed if the firm desires a more granular or less granular approach to a sector.

One area of discussion during the development of the heatmap was how the transition may proceed differently in different regions. At the time it was decided to provide a single heatmap for broader applicability, but there is scope to consider the impacts of these regional differences. Certain policies and technologies may be more prevalent in one region versus another. Additionally, the processes and impacts of decarbonization may vary across regions. At a more fundamental level, some economic activities captured as segments may only be applicable in certain regions. Regional working groups could consider these nuances in a future pilot program.

One advantage of the global heatmap will be the comparable outputs it generates. Using the same set of segments and sectors, anonymous data can be collected from across the industry. There are a variety of promising areas where these data comparisons can be conducted. One would be in assessing the average ratings change that institutions assign to borrowers in a segment under a given scenario. That would reveal information about how severe institutions believe that scenario is. Another assessment would be a comparison of losses for the same sector and same institution under different scenarios. These analyses have the benefit of producing standard outputs (from the Transition Risk tool) which will make it easier to benchmark and evaluate specific aspects of transition risk.

5. Conclusion

The financial sector is increasingly recognising the importance of climate scenario analysis. Regulators such as the Bank of England and DNB have incorporated climate scenarios into their climate stress tests. The NGFS has supported these efforts through the release of their reference scenarios and the corresponding guidance for central banks on climate scenario analysis. Other regulators are moving to make climate risk disclosures mandatory.

The private sector is also driving banks toward producing more detailed scenario-driven climate disclosures. Major asset managers have expressed clear desires for firms to disclose climate risks in a quantitative manner. However, it is not outside pressure alone that is shaping bank TCFD disclosures and climate scenario analysis. Institutions have themselves appreciated the strategic and business value of assessing potential climate risks. Understanding how risks are likely to manifest in a changing world is a fundamental part of any effective risk management function.

5.1. Next steps

Each of the prior sections of this report includes views on the next steps for the specific work discussed. UNEP FI has likewise been considering the appropriate next steps on a programmatic level. The goals of helping the financial sector manage its climate risk and play a positive role in the low-carbon transition remain core to UNEP FI's climate work. As the global carbon budget dwindles, those goals will only grow in urgency.

UNEP FI's theory of change in the financial sector relies on education, application, and action. In Phase II, participating institutions were able to learn from climate experts about potential sectoral risks and the latest climate models and data. The participants were then able to apply the transition risk methodology to evaluate climate risk across a broad range of economic sectors and scenarios (including NGFS reference scenarios). Through plenary sessions on TCFD disclosure and governance, participants developed ways to integrate climate risk management into their decision-making processes.

The vision for the next TCFD pilot is to continue to advance this "hands-on" theory of change by providing participants and the industry at large with the knowledge and tools to confront the climate challenge. However, owing to developments across the financial sector and logistical learnings gained from running the Phase II program, Phase III will look significantly different.

Phase III will leverage the convening power of the UN to bring together leading climate experts and global financial institutions. These collaborations will produce thought leadership on critical issues related to climate risk in the financial sector. In addition, UNEP FI plans to continue to promote the dissemination of climate risk knowledge and the adoption of good climate risk management practices. These aims come together in the hybrid design of Phase III.

Participating institutions will engage with focused modules that are supported by climate modelers, tool providers, financial regulators, and academic institutions. These modules will explore topics such as climate stress testing, sector-specific risks, climate scenario comparisons, and climate risk governance. These modules will allow smaller groups of institutions to dive deeply into the areas of climate risk and disclosure that are most relevant to them.

In addition, Phase III will provide participants with a TCFD roadmap to support institutions at all stages on the TCFD journey. This roadmap will take institutions through the process of identifying, assessing, and managing their climate risks. It will consolidate the extensive set of resources that UNEP FI has built up through the prior TCFD pilot programs. These resources include the transition risk heatmap and Transition Check webtool covered in this report along with a variety of physical risk tools.

UNEP FI recognises the value of dialogue between industry participants and Phase III will provide ample opportunities both in small groups and in plenary sessions for institutions to discuss their practices. Resources such as the heatmap and Transition Check tool will give these participants a common starting point for their discussions and a standardised way of thinking about their climate risks.

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