CHINA UKPACT

CARBON TRUST

October 2020

How to anticipate a Green Swan event

Preparing Chinese financial markets for climate transition risk

Project background - Capacity building for chinese financial institutions on climate transition risk methodologies

As financial policymakers realise the importance of climate change risks, Chinese financial institutions are expected to put climate risk assessments on the agenda. With the support of the UK Department of Business, Energy and Industry Strategy (BEIS) UK Partnering for Accelerated Climate Transition's (UK PACT)-China Green Finance Program, the Carbon Trust is conducting a project to review existing methodologies and tools for financial institutions to carry out climate transition risk assessment, provide content support to NGFS on climate risk assessment, and provide capacity building for Chinese financial institutions.

This report is part of the project deliverables, which aims to transfer knowledge and enhance the capacity of key Chinese financial institutions and policymakers to understand climate transition risk assessment and tools that exist to integrate this into future investment and policy decision-making.

Who we are

Established in 2001, the Carbon Trust works with businesses, governments and institutions around the world, helping them contribute to, and benefit from, a more sustainable future through carbon reduction, resource efficiency strategies, and commercialising low carbon businesses, systems and technologies.

The Carbon Trust:

- works with corporates and governments, helping them to align their strategies with climate science and meet the goals of the Paris Agreement;
- provides expert advice and assurance, giving investors and financial institutions the confidence that green finance will have genuinely green outcomes; and
- supports the development of low carbon technologies and solutions, building the foundations for the energy system of the future.

Headquartered in London, the Carbon Trust has a global team of over 200 staff, representing over 30 nationalities, based across five continents.

Acknowledgements

We would like to express our sincere gratitude to UK Department of Business, Energy and Industry Strategy (BEIS) UK Partnering for Accelerated Climate Transition (UK PACT)- China Green Finance Program for its financial support. We also want to thank everyone in the UK PACT team, especially Ms. Shadi Fathizadeh, Mr Guan-Tar Ong, Ms. Beibei JIANG, Ms. Jialing SI, and Ms. Joyce GUO, who provided great support to the project and report.

We would also like to thank experts listed below who provided valuable advice and insights to this report. The views in this report do not necessarily reflect the views of the acknowledged individuals, their organizations, or the UK PACT, and Carbon Trust authors will take full responsibility for any errors in this report.

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Disclaimer

Published in the UK: 2020.

The Carbon Trust's mission is to accelerate the move to a sustainable, low carbon economy. It is a world leading expert on carbon reduction and clean technology. As a not-for-dividend group, it advises governments and leading companies around the world, reinvesting profits into its low carbon mission.

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Abbreviations

AIGCC	Asia Investor Group on Climate Change
A4S	The Prince's Accounting for Sustainability Project
BAU	Business As Usual
CapEx	Capital Expenditure
CDB	China Development Bank
CDP	Carbon Disclosure Project
CEXIM	Export-Import Bank of China
CliTRAM	The Climate Transition Risk Assessment Model
CUFE	Central University of Finance and Economics
DCF	Discounted Cash Flow
EBITDA	Earnings Before Interest, Tax, Depreciation and Amortization
ESG	Environment, Social and Governance
EU	European Union
FCA	Financial Conduct Authority
FI	Financial Institution
GHG	Greenhouse Gas
IAMs	Integrated Assessment Models
ICBC	Industrial and Commercial Bank of China
IIASA	International Institute for Applied Systems Analysis
IIGCC	Institutional Investors Group on Climate Change
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
ISIN	International Securities Identification Number
MEE	Ministry of Ecology and Environment of the People's Republic of China
MOEP	Ministry of Environmental Protection
MOF	Ministry of Finance
NDCs	Nationally Determined Contributions
NDRC	National Development and Reform Commission
NFRD	Non-Financial Reporting Directive
NGFS	The Central Banks and Supervisors Network for Greening the Financial System
OpEx	Operating Expenditure
PBOC	People's Bank of China
PRA	Prudential Regulation Authority
PRB	Principles for Responsible Banking
PSI	Principles for Sustainable Insurance
RCGFD	Research Center for Green Finance Development
R&D	Research and Development
ROI	Return on Investment
SSPs	Shared Socioeconomic Pathways
TCFD	Task Force on Climate-related Financial Disclosures
TEG	Technical Expert Group on sustainable finance
UNEP FI	United Nations Environment Programme Finance Initiative
UNPRI	United National Principle for Responsible Investment
VaR	Value at Risk

How to anticipate a Green Swan event

Executive summary

To avoid the most disruptive outcomes of climate change, nearly 200 countries have agreed – through the 2015 Paris Agreement—to strengthen the global response to climate change in order to limit "the increase in the global average temperature to well below 2°C above pre-industrial levels". To achieve this objective, a transition to a low carbon global economy is required. From the market perspective, this response to the threat of climate change will have systemic impacts on corporate value chains, resulting in material financial outcomes. There are clear opportunities in the climate transition to shift markets in favour of low-carbon assets. From the regulatory perspective, understanding and quantifying climate risk is increasingly important as the recovery from the COVID-19 pandemic has been linked to the need for green stimulus including the need to incorporate climate-related disclosure to ensure that the economy is built back in a more resilient way.

Financial markets and climate change are two topics which were traditionally seen by some as only vaguely related. However, the truth is finance, as an enabler, is and will continue to be profoundly affected by climate change. Since the financial sector is exposed to the economy as a whole, the systemic shocks that climate change brings about will inevitably propagate throughout financial systems. Besides, the transition to net zero brings opportunity as well as risk, which encourages financial institutions to identify companies with business models set for the future and not rooted in the past, in turn facilitating a domino effect across the economy. If the financial system fails to recognise the scale of transition required then we run the risk that we will avoid a smooth route to change and instead open markets up to a so-called 'Green Swan'. As stated in The green swan: central banking and financial stability in the age of climate change by the Bank for International Settlements, green swans, or 'climate black swans' risks refer to potentially extremely financially disruptive events that could be behind the next systemic financial crisis. It is a new type of systemic risk that involves interacting, nonlinear, fundamentally unpredictable, environmental, social, economic and geopolitical dynamics, which are irreversibly transformed by the growing concentration of greenhouse gases in the atmosphere.

In response to this attention, a number of international initiatives have been established by regulators, listed companies and financial institutions. Led out of Europe, and on to Asia Pacific, disclosing climate-related information and encouragement of conducting climate risk analysis have gradually become mainstream for many central banks. At the same time, businesses are gradually realising the substantial impacts of climate change and taking action, communicating this though voluntary disclosure of climate-related information aligned with the TCFD framework.

Climate-related transition risks, as well as their potential impacts, differ significantly across sectors, regions and time horizons. Internationally, over 50 tools for climate risk assessment have been developed by global financial institutions and third parties in response to the challenge of pricing and addressing increasingly material transition risks that drive demand from end users and regulators. Therefore, it is crucial for end users to identify their objectives for risk assessment, and prioritise their requirements, given the diversity of methodological approaches. This report will also outline the key, high-level criteria for different financial institutions to consider when selecting an appropriate methodology.

Generally, commonly used methods that focus on integrating climate risk into existing risk models, such as climate-related stress testing and value-at-risk analysis, are mostly applied by banks, asset owners and asset managers. In addition, insurance companies may prefer integration with actuarial models, focusing on physical risk assessment for future liabilities. In terms of transition risk methodologies, two main scenario sets - temperature-based scenario and event-based scenario - are commonly used to translate transition climate-related risk into financial risk.

[1] Bank for International Settlements (2020). The green swan: central banking and financial stability in the age of climate change

Despite the pandemic, China is quietly opening up its domestic financial markets to foreign players, many of whom may require a higher standard of climate-related disclosure to be made. FFrom 2016, PBOC and other regulators jointly issued the first national green finance policy in China, Guidelines for Establishing China's Green Financial System, which addressed the importance of conducting stress testing to assess the impact of environmental and climate factors on invested assets. In 2019, Chen Yulu, the Vice Governor of PBOC, emphasized the financial risks caused by climate change in his speech at the Annual Meeting of the Chinese Finance Association and Chinese Financial Forum, which is a milestone of awakening the awareness of Chinese financial institutions to climate risks. A working paper, named *Climate-related Financial Risks – An Analysis based on the Function of the Central Bank*, published by PBOC followed. Apart from the policy-making level, China has also played an important role in cooperating in global initiatives, such as NGFS, UK-China Climate and Environmental Information Disclosure Pilot, and the G20 Green Finance Research Group.

After interviewing 6 Chinese financial institutions and 8 industry experts, Carbon Trust found out that the overall awareness of climate-related risk was still at an initial stage, regardless of whether they were regulators or financial institutions. However, with the global push for environmental risk assessment, some pioneer Chinese financial institutions have joined the march. Regarding the tools and methodologies, most of the internationally developed tools haven't been used in China and some pioneers have made progress in developing local tools. The following Table 1 presents Carbon Trust's findings in terms of China's challenges and recommendations on climate risk assessment. More detail about these recommendations is available in Chapter 4.

Table 1 - Carbon Trust's findings regarding China's challenges and recommendations on climate risk assessment

Dimen-sions:	Challenges:	Recommendations:
Policy level	• Limited actions from regulators • Coordination and cooperation between national departments is yet to be improved	• Include climate risk into the Comprehensive Risk Management Guidelines • Plan Climate Risk Assessment Pilot • Strengthen policy coordination and cooperation to deal with climate-related financial risks • Introduce incentive mechanism to encourage more FIs joining the march • Encourage climate-related information disclosure • Reinforce climate data collection and sharing system
FIs level	• Lack of understanding of climate risk assessment • Lack of research capacity • Information asymmetry at the organisational level • Insufficient internal motivation	• Recommended roadmap to conduct climate risk assessment • Encourage participation in climate risk capacity building activities • Boost engagement with portfolio companies to conduct climate risk assessment aligning with TCFD style framework • Promote cross-departmental collaboration within the organisation
Tools and	• Lack of high quality public climate-related data; Limited availability of localised tools for Chinese financial institutions • Limited availability of localised tool for Chinese financial institutions	• Harmonise and standardise international tools • Use proxy data to solve issues around data disclosure • Unite developers to engage and coordinate with regulators to develop China specific tools

1. Introduction and background

1.1 What is climate-related risk?

The TCFD recommendations urge banks to use scenario analysis to disclose the "actual and potential impacts" of climate-related risk and opportunities on their business as well as how they identify, assess and manage climate risk. In this framework, climate risk falls into two categories: physical risk and transition risk[2].

Physical risks result from climate variability caused by increasing concentrations of Greenhouse gases in the atmosphere. Impacts include more frequent and extreme weather-related events and longer-term shifts in climate patterns. It may differentially affect the financial health of business and impact the financial performance of sectors, creating risks and opportunities for those financing or investing in them. Their impact is directly linked to climate change, as compared with transition risks, and are especially important for climate-sensitive sectors like agriculture, energy and real estate.

Transition risks are risks related to our societal response to climate change and the transition to a low carbon economy as opposed to the physical impacts of climate change. The TCFD notes that "Transitioning to a lower-carbon economy may entail extensive policy, legal, technology, and market changes to address mitigation and adaptation requirements related to climate change. Depending on the nature, speed, and focus of these changes, transition risks may pose varying levels of financial and reputational risk to organizations"[2]. As such, most transition risks are associated with existing economic forces and consider how these would evolve to achieve our climate goals. See Figure 1 for a summary of TCFD's description on climate transition risk.

Figure 1 - Types of climate-related transition risks
Source: adapted from TCFD (2017)[2]

[2] TCFD (2017). Implementing the Recommendations of the Task Force on Climate-related Financial Disclosures

Policy and legal risks cover a range of different policy, regulatory and legal risk types that are inherent levers for governments to use at the national and international level to support the transition to a low carbon economy and phase out carbon, resource and energy intensive activities. A few well-known regulations or policies governments might take include carbon pricing, minimum energy efficiency performance standards on technologies and specific product quotas for new low carbon technologies. Climate litigation is another emerging area and we have started to see a number of cases come to court that have been driven by climate change considerations.

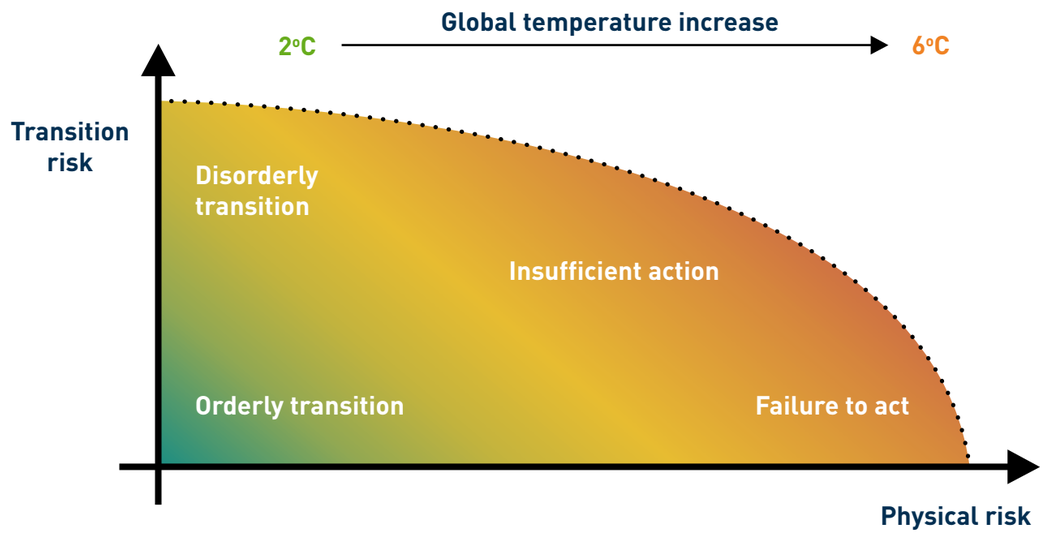
Technology risks exist in relation to the fast development of low carbon technologies and the lower costs that these products may achieve. This can include competition resulting in assets not being able to perform as anticipated leading to the possibility of stranded assets as technology shifts take place. There can also be impacts associated with the timing of companies uptake of these new technologies as it may be more costly to have to suddenly shift the technology profile of an organisation to keep pace with the market. In addition, as markets respond we will see carbon intensive technologies increasingly being out competed.

Market risk: To keep temperature rises to below 2 degrees there will need to be large shifts in the way in which citizens consume and use resources. To meet this goal emissions will have to fall to net zero and uses of other resources will have to fall within the planetary boundary of what can be sustainably extracted while not depleting our natural capital. Market risks are typically systemic in nature as they affect the fundamental structure of many value chains and business models. Increasingly this will mean that markets will have to move away from a linear model in which resources are extracted, processed, manufactured, sold and then go to waste. Instead, far more circularity would need to exist in the way that resources are used such that they are recycled, reused, re-manufactured. Some of this is likely to be driven by consumer behaviour but as the way in which supply chains are set up changes, the market signals that are currently relied upon will start to change as well. Current linear business models will be at risk of competition as they become misaligned with the competitive dynamics in lower carbon markets.

Reputation risk: from a reputation standpoint, climate change can be an increasingly important factor in how companies are viewed by their stakeholders, not only in terms of their ambitions but also their actions. These stakeholders will include customers, investors, employees and wider civil society. As temperatures continue to rise and climate change impacts worsen, this will create tighter restrictions on the societal licence to operate, particularly for those companies that are most associated with contributing to the problem rather than looking to the solution.

The threat of climate risk is imminent. In order to transition the world into a low carbon economy with a maximum temperature rise of 2°C above pre-industrial temperatures, global governments and organisations need to take actions immediately to form an orderly transition. Insufficient responses and actions in the early stage will lead to a physical degradation and accelerated deterioration of climate environment and eventually reaching tipping points after which it is too late to take action. Physical and transition risks are not independent, instead existing as a counterpoint to one another (Figure 2). Either we will act to decarbonise the global economy resulting in transition risks or we will fail to act and lock in physical risks. What is certain is that climate-related risks will definitely increase from this point on, it is the balance between transition and physical risk that is uncertain. This certainty of increased risk underpins the urgency for action for financial institutions to better understand how these risks will impact them.

Figure 2 - The relation between transition risk and physical risk



1.2 Why is it critical to assess climate risk?

One objective of conducting climate risk assessment is to determine the material impact of climate change to corporates.

A corporation's vulnerability to climate impacts goes well beyond the risk exposure of its assets - its supply chains, operations, distribution networks, customers and markets might all lead to corporates' failure in transition. Despite various vulnerability levels, a corporate's resilience to climate impact depends on its business plan, risk management ability, as well as its governance strategy. Finally, the climate-related risks can be directly or indirectly reflected in the financial outcomes including company revenues and costs, asset values, liabilities and cash flows. Therefore, a comprehensive assessment following the framework below (Figure 3) often unveils risks that a company had not anticipated.

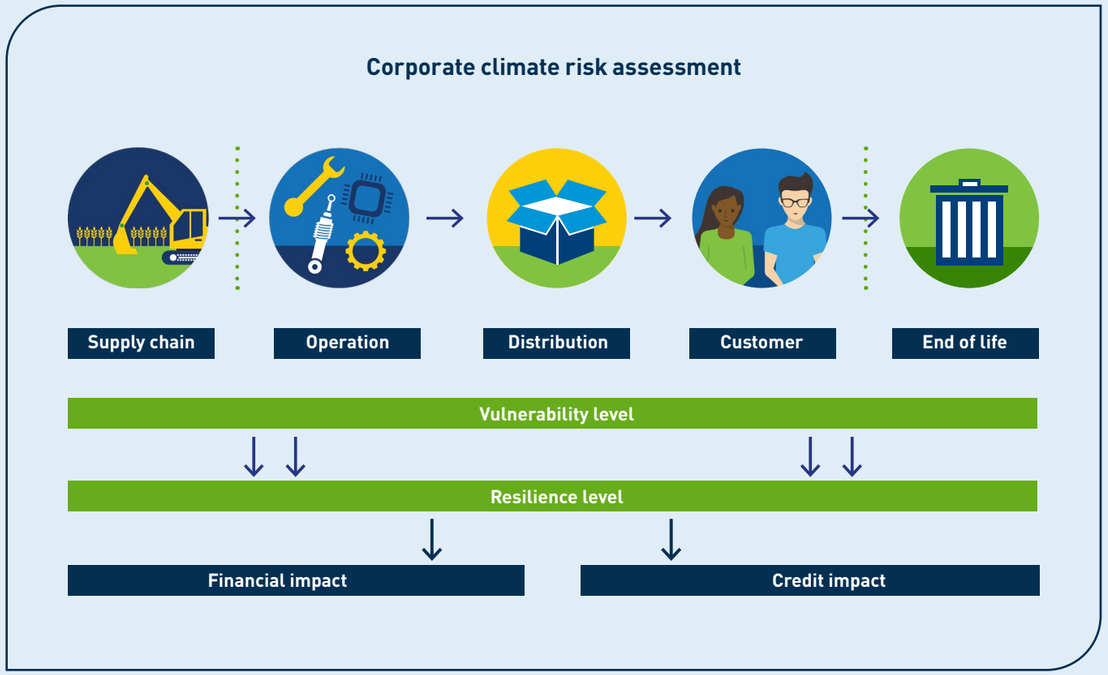
There are clear challenges in predicting climate impacts on corporates through their value chains. The first stage in improving understanding is taking a sectoral lens to see where hotspots of exposure exist. For example, companies whose production processes consume high volumes of water may be particularly sensitive to the likelihood of drought and the availability of water. Similarly, companies with high-energy consumption or reliance on fossil fuels in production, will be sensitive to both energy costs and restrictions on the use of fossil fuels.

Understanding and quantifying climate risk is also becoming a regulatory requirement that corporates need to respond to in some countries.

The Financial Stability Board's Task Force on Climate-related Financial Disclosures (TCFD) published its recommendations in 2017 for the voluntary disclosure of climate-related risk and opportunities by financial institutions and other entities (see Figure 4's inner square for the TCFD recommendations). These have provided the impetus for many organizations to progress climate risk and opportunity assessment. This voluntary disclosure framework is now proposed by the Financial Conduct Authority (FCA) to be applied to all companies that have their main listing in London as a mandatory climate-related disclosure framework, or explain the reason why they cannot. Recently, many governments announced economic responses to the COVID-19 pandemic and some of them have incorporated climate-related disclosure into the criteria of receiving a stimulus package to ensure the economy would be stimulated in a green way. Canada, for example, requires businesses with revenues above $300 million to publish TCFD-aligned Annual Climate Disclosure Reports while applying for the corporate relief programme.[3] To build further resilience, more governments will enhance their requirements to companies' climate responses and encourage more businesses to transition into more sustainable models – the COVID-19 recovery package is a good opportunity to strengthen the link between long-term financial resiliency and climate change responses. Clear parallels can be seen in the impact of COVID-19 as a similarly systemic risk that has impacted the real economy and sent shockwaves through the financial system. Leaving economies exposed to a known systemic risk such as climate change is clearly something governments are trying to avoid as they plan for a recovery.

[3] It is referring to the corporate relief issued by Canadian Prime Minister Justin Trudeau. The programme includes providing bridge loan of up to $60 million and guarantees of up to $80 million for companies who earns more than $300 million a year. Companies who receive such loans will then need to follow the guidance on climate-related issues. https://www.france24.com/en/20200511-canada-ties-coronavirus-help-to-climate-goals]

Figure 3 - How climate change affects corporate value chains



Lastly, investors are raising awareness on how non-financial performance impacts a corporate's financial potential, further pushing climate disclosure forward.

A recent study shows that 51% of surveyed institutional investors believe that climate risk reporting is as important as traditional financial reporting and one-third consider it to be more important.[4] In particular, the investors value climate risk assessment and disclosure as the most important channel to understand the financial consequences for their portfolio corporates.

In addition to financial performance, the regulatory requirements in the previous section applies well to investors themselves too – they are also under pressure to report on climate issues from either regulatory agencies or clients' (asset owners) requirements. The sector is evolving rapidly to meet investors' need: credit rating agencies are racing to incorporate the costs of carbon and broader ESG risks into their strategies; a series of investor initiatives have been launched to unite the world's investors' joint effort in moving investees from tough transition sectors onto a Paris-aligned pathway. Please see Section 1.3 for more details.

As a summary, assessing climate-related risks and opportunities can work as a tool to further raise awareness and inform decision-making within a company and deliver key messages to external investors and financiers. This report lists a few positive results that climate risk assessment could bring to listed companies and financial institutions.

[4] Frankfurt School of Finance & Management (2019). Institutional investors' views and preferences on climate risk disclosure

Listed companies	• Better understanding of the exposure of a company's operations to physical and transition risks related to climate change • Improve credit ratings for bond issuance and credit worthiness assessment for bank loans • Improved access to capital and lower cost of capital • Better ESG performance leading to better stock performance
Financial institutions	• Better understanding of loan/investment portfolios' exposure to climate-related risks • Better risk evaluation for calculation of capital charges • More informed investment and lending decisions (including asset management) • Improved attractiveness to climate-aware clients • Evidence of risk control for financial regulators (stress testing) and control over amount of technical provisions that could be affected by climate-related risk

Table 2 – The potential benefits of climate risk assessment

1.3 International trend on climate risk assessment

1.3.1 Regulators

Table 3 - Regulators' key actions and impacts on climate risk assessment

Regulators	Action	Impact
Bank of England[5]	• Conducted a general insurance stress test in 2019 and collected the exposure of physical and transition risks of major insurance companies under the Prudential Regulation Authority (PRA) monitoring system • Lenders are to be tested against three different environmental scenarios under the Bank's agenda, but the launch of the test will be postponed until at least mid-2021 in order to prioritise the response to COVID-19	• Informs the Bank's view of risks on lenders' and insurers' balance sheets • Creates baseline to the lenders' and insurers' responses to climate sector risks and could be benchmarked in the future to assist in the supervision of individual firms
European Commission	• Published an Action Plan on Financial Sustainable Growth in 2018 • Set up a Technical Expert Group on sustainable finance (TEG) in 2018 to assist in four key areas of the Action Plan through the development, including guidance to improve corporate disclosure of climate-related information • European Commission's Technical Expert Group (TEG) on sustainable finance has created a link between the Task Force on Climate-related Financial Disclosures (TCFD) and the wider guidance on the Non-Financial Reporting Directive (NFRD)	• Sets out a comprehensive strategy to further connect finance with sustainability • Highlights the importance of financial institutions to assess climate risk consistent with disclosure frameworks
The Taskforce for Climate-related Financial Disclosures (TCFD)	• Founded in 2015 and chaired by Michael Bloomberg, the TCFD published its first recommendation in 2017 on what constitutes effective climate-related financial disclosures	• Over 850 organisations have expressed their support for TCFD as of September 2019
The Central Banks and Supervisors Network for Greening the Financial System (NGFS)	• Acknowledged "climate-related risks are a source of financial risk, it is therefore within the mandates of central banks and supervisors to ensure the financial system is resilient to these risks" in a progress report in 2018 • Recommended to integrate climate-related risks into financial stability monitoring and micro-supervision • Published report in 2019 on the financial implication of climate change and provided an overview of existing quantitative methodologies for assessing climate-related risks • Issued three climate scenarios for central banks, which each cover one of the following dimensions – orderly, disorderly and hot house world[6]	• Integrates international central banks and supervisors' joint effort to understand the macroeconomic and financial stability impacts from climate change
The Hong Kong Stock Exchange	• In 2019, issued its new ESG reporting requirements for Hong Kong listed companies from July 2020. A new category of disclosure on climate change has been added on a comply or explain basis, requiring disclosure of policies on identifying and mitigating significant climate-related issues impacting the company	• Policy level thrust has been added, making climate-related information disclosure mandatory

[5]Bank of England (2020). Stress testing and climate change
[6] Environmental Finance (2020). NGFS issues three climate scenarios for central banks

1.3.2 Listed companies

Businesses are gradually realising the substantial financial impacts of climate change. 215 of the world's largest companies have collectively reported their business value at risk as just under US$1 trillion, according to their disclosure to the CDP (formerly the Carbon Disclosure Project) in 2018. In the meantime, this exercise also unveils positive financial impact from climate-related opportunities at over US$2 trillion. As of 2019, 785 public- and private-sector organizations have announced their support for the TCFD and its work, including global financial firms responsible for assets in excess of $118 trillion.[7]

Two-thirds (67%) of UK corporates will be disclosing climate-related risks and opportunities in their 2019 annual reporting, according to the Carbon Trust's research in January 2019. Looking across a time frame of the next three years, the most commonly expected advantage from climate change disclosure in line with the TCFD recommendations is reputational, with seven in ten (72%) believing that this reporting would increase brand value. At an aggregate level, one third (31%) of respondents see financial benefits, which is composed of improved access to capital (12%), lower cost of capital (10%), and strengthened credit rating (9%). Other perceived benefits include reduced shareholder pressure or activism (37%), as well as attracting an increased diversity of investors (29%). And one-fifth (21%) of business leaders think that improved climate change reporting will directly result in an increased company valuation.

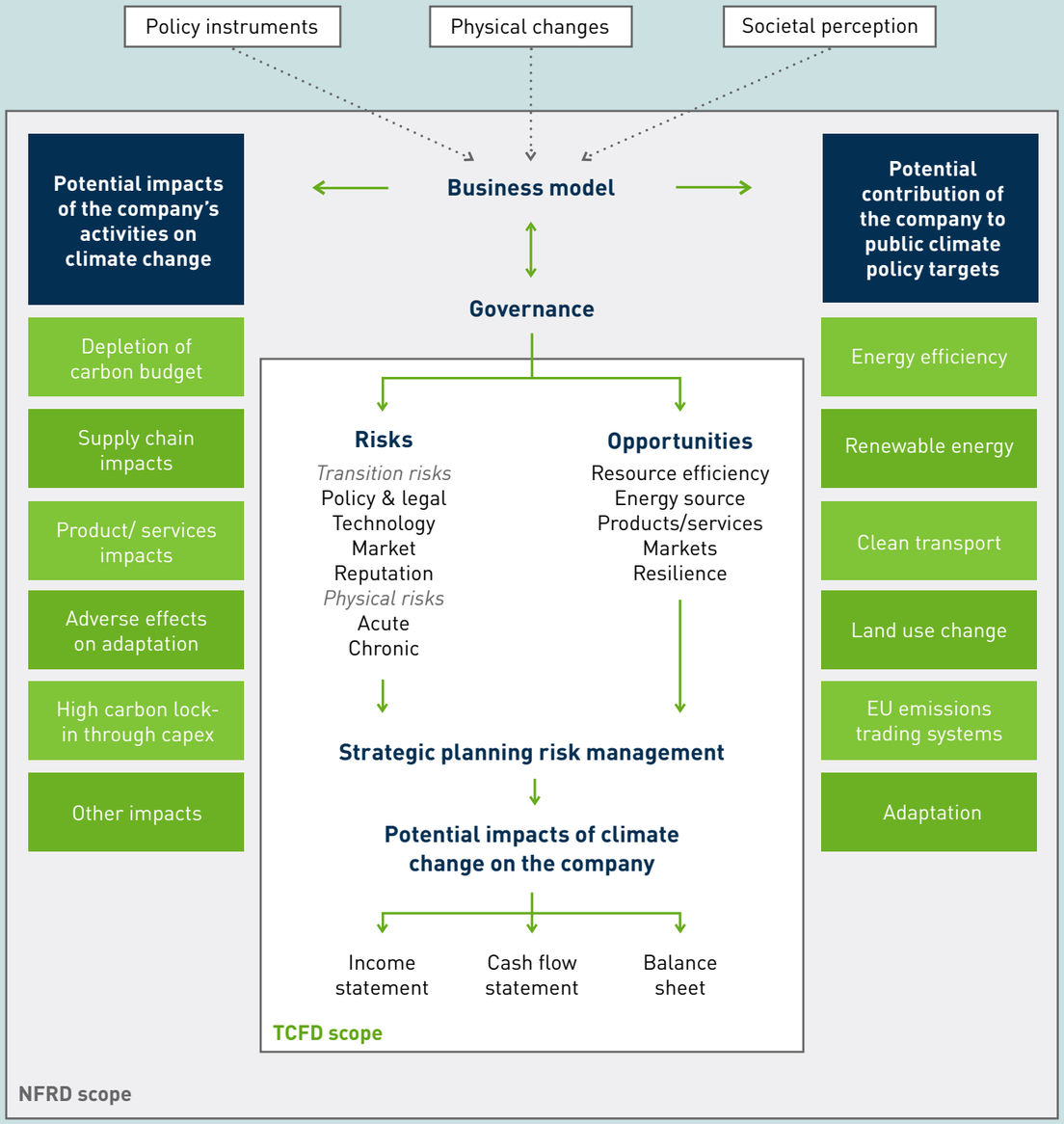
As the reporting process gets more streamlined, disclosures from listed companies are transforming from being voluntary to becoming mandatory. Besides the newly proposed plan by the FCA to require the UK's top listed companies to disclose climate change risks and opportunity, the quality of disclosure is under evaluation too. The Financial Reporting Council announced in February 2020 that "a major review" will be launched to evaluate climate risk disclosure by UK businesses, in which auditors' work would also be reviewed to ensure the climate impact assessment is appropriately reflected to investors.

The EU law also requires large companies to disclose the way they operate and manage social and environmental challenges. The Non-financial Reporting Directive (NFRD) provides rules on disclosure of non-financial information by large companies.[8] The figure below (Figure 4) further elaborates how NFRD responds to the TCFD recommendations.

[7]TCFD (2019). 2019 Status Report

[8]Large companies are defined as "large public-interest companies with more than 500 employees. This covers approximately 6,000 large companies and groups across the EU". More information to retrieve from https://ec.europa.eu/info/business-economy-euro/company-reporting-and-auditing/company-reporting/non-financial-reporting_en.

Figure 4 - TCFD & NFRD scope: Linking climate change impacts and a company's business model
Source - adapted from TCFD (2017)[9]



[9]TCFD (2017). Implementing the Recommendations of the Task Force on Climate-related Financial Disclosures

1.3.3 Financial institutions (FIs) initiatives

Table 4 – Financial institutions' key actions on climate risk assessment

Initiatives	Action
United National Principle for Responsible Investment (UN PRI)	• Investor-led organisation that requires **asset owners and managers** to disclose and report • Over 3000 signatories, including more than 480 investors representing US$42 trillion responding to its mandatory reporting requirements • Introduced TCFD-aligned reporting framework to its existing questionnaire in 2018 and will make TCFD-based reporting mandatory in 2020
Net Zero Asset Owner Alliance	• An asset owner-led alliance representing over US$ 4.6 trillion and counting with all members (**asset owners and managers**) committing to transitioning their investment portfolios to net-zero GHG emissions by 2050
Institutional Investors Group on Climate Change (IIGCC)	• As the European membership body for **institutional investor** collaboration, it currently has 240+ members across **asset owners and managers**, with €33 trillion assets under management. No mandatory requirements for its members so far
Asia Investor Group on Climate Change (AIGCC)	• AIGCC members represent over US$3.5 trillion of funds under management, aiming to create awareness among **Asia's asset owners and financial institutions** about the risks and opportunities associated with climate change and low carbon investing
United Nations Environment Programme Finance Initiative (UNEP FI)	• As a partnership between UNEP and the global financial sector, UNEP FI works with more than 300 members across **banks, insurers and investors** • Three frameworks have been established or co-created by UNEP FI: 1. Principles for Responsible Banking (PRB) launched with more than 130 banks collectively holding US$47 trillion in assets, or one third of the global banking sector, on 22 September 2019; 2. Principles for Sustainable Insurance (PSI), established 2012 by UNEP FI and today applied by one-quarter of the world's insurers (25% of world premium); 3. Principles for Responsible Investment (PRI), established in 2006 by UNEP FI and the UN Global Compact, now applied by half the world's institutional investors (US$83 trillion)
The Investor Agenda	• The Investor Agenda has been developed to encourage **investors** to make low carbon investments and commitments including phasing out investments in thermal coal by seven Founding Partners: AIGCC, CDP, Ceres, Investor Group on Climate Change, IIGCC, UN PRI and UNEP FI
CDP Non-Disclosure Campaign	• As of 2019, 88 investors with nearly US$10 trillion assets are targeting **companies** that are not transparent enough about their environmental impact, and pushing them to disclose this information through CDP
Climate Action 100+	• Investor-led organisation that ensures the **world's largest corporate** greenhouse gas emitters take necessary action on climate change • More than 450 investors with over US$40 trillion in assets collectively under management are engaging companies to strengthen climate-related financial disclosures
The Transition Pathway Initiative	• Asset owner-led initiative that assesses preparedness of **companies in high carbon sectors** for transition to a low carbon economy
The Alliance of CEO Climate Leaders	• Facilitated by the World Economic Forum, it builds a global network of **CEOs from the world's 1000 leading companies** to catalyse transitions from all industry sectors
The Prince's Accounting for Sustainability Project (A4S)	• Established by HRH The Prince of Wales in 2004, it aims to inspire action by finance leaders to drive a fundamental shift towards resilient business models and a sustainable economy, including networks for **CFOs, accounting bodies and asset owners**

In additional to the stakeholders mentioned above, rating agencies and investment information providers are racing to incorporate ESG risk assessment into credit rating analysis or material investment decisions.

- S&P acquired Trucost in 2016 in response to its clients' needs of ESG analysis
- Moody's Corporation bought a majority share in Four Twenty Seven in 2019 in order to incorporate climate change risk into investment decisions
- MSCI acquired Carbon Delta in 2019 in order to strengthen its climate risk assessment capability
- Morningstar acquired Sustainalytics in April 2020

1.4 Why should financial institutions assess climate risk?

Climate change will affect the global economy and financial stability, which puts great stress on financial institutions. Climate risks are systemic in nature and financial institutions are uniquely exposed to the system as a whole.

Financial institutions are no doubt at the crossroad of all economic activities and therefore financial market development has a strong positive relationship with economic growth.

In Chapter 1 of Financial Structure and Economic Growth (2001), editors Demirgüç-Kunt and Levine concluded:

> *In particular, researchers have provided additional findings on the finance-growth nexus and have offered a much bolder appraisal of the causal relationship; firm-level, industry-level, and cross-country studies all suggest that the level of financial development exerts a large, positive impact on economic growth.*

Therefore, an economy under climate risks will certainly bring negative impact to financial systems and financial contagion will feed back to the economy.

A recent NGFS report elaborates how the macroeconomic impact of climate change propagates through direct or indirect channels to transmit economy disruptions into financial system's instability (Figure 5).

Climate impact involves risks and opportunities. A good understanding of climate impact could help financial institutions to avoid risks and seize investment opportunities in the low carbon transition, which could generate the chain effect across the economy.

With a rising awareness from global investors, governments and consumers, fixed assets such as a plant might face early retirement or re-pricing due to more strict regulations and corporates might have lower profit due to an increasing operational cost and reduced demand for high-carbon and high-pollution products. In the UK, the Bank of England admits the loan exposures to fossil fuel producers and other brown assets amount to about 70 per cent of the bank's so-called safest kind of capital.[10]

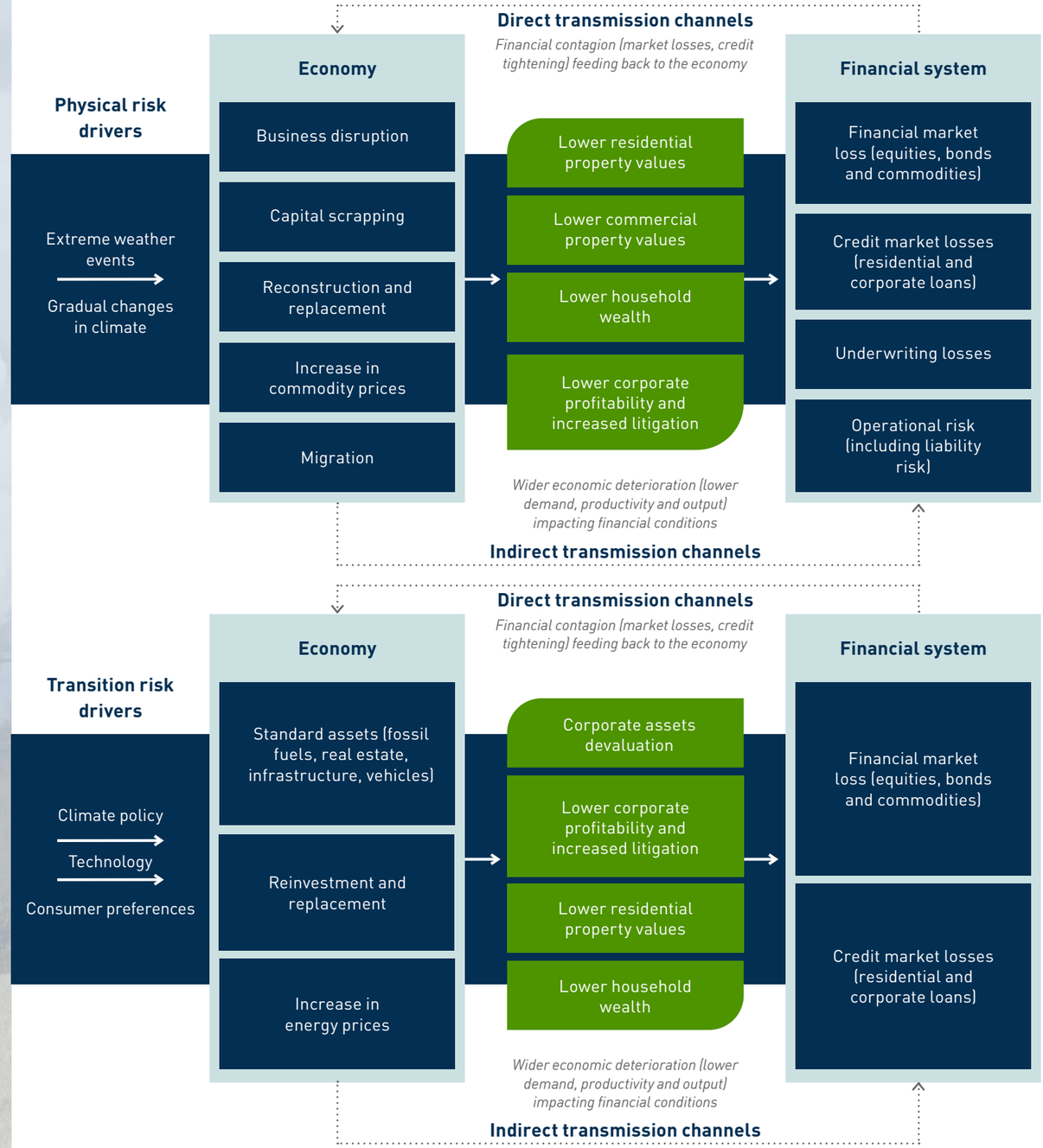
Financial institutions, especially the lenders and insurers, are directly connected with such assets at risk. Assessing and quantifying the size of climate risk is as important as assessing other mainstream types of risk. Beyond risk assessment, effectively managing and responding to climate change also includes mitigating the risks and seizing the opportunities from the decarbonisation of the economy. The global financial industry therefore has created various tools and methods to respond to climate change in a holistic manner in order to achieve the goal.[11]

In addition to a financial institution itself, the report hopes to leverage financial institution's broad connections with the economy to deliver the Climate Emergency message to all players in the society, ranging from retail customers to institutions investors or corporates, instead of a costly government's push.

[10]Financial Times (2020). Bank of England to set up tough climate stress tests
[11]UNEP Finance Initiative (2018). Navigating A New Climate: Assessing credit risk and opportunity in a changing climate – outputs of a working group of 16 banks piloting the TCFD recommendations

Figure 5 - From climate physical and transition risk to financial stability risks

Source: adapted from NGFS (2019)[12]



[12]NGFS (2019). A call for action: Climate change as a source of financial risk

2. Tools and Methodologies

2.1 Key principles in conducting transition risk assessment

Various tools and methods have been developed by the global financial industry to prepare financial institutions for climate risk. This section will introduce general approaches of transition risk assessment, followed by step-by-step guidance of converting climate transition risks into financial risks.

2.1.1 General approaches to conducting transition risk assessment

Internationally, leading financial institutions have tested many methods to carry out quantitative analysis of climate risk. For banks, asset managers and asset owners, the focus is on understanding the risk to financial performance of their counterparts and the impact this has on credit risk or market losses respectively. Commonly used methods focus on integrating climate risk into existing risk models, which includes climate-related stress testing and value-at-risk analysis.

From the perspective of financial institutions, a number of transition risks (such as a significant increase in carbon prices; changes in energy demand caused by nationally determined contributions as part of the Paris Agreement; cost of renewable energy), will have an impact on the asset valuation, changes in the rate of return on investment, or changes in the probability of default on loans. Tools and methods will support the estimation of these impacts under different transition scenarios. These portfolio-level changes can be analysed from a top-down method, or more commonly used across tools, is as a sum of asset-level risks such as listed equity's change in cost, profit, capital and business sustainability.

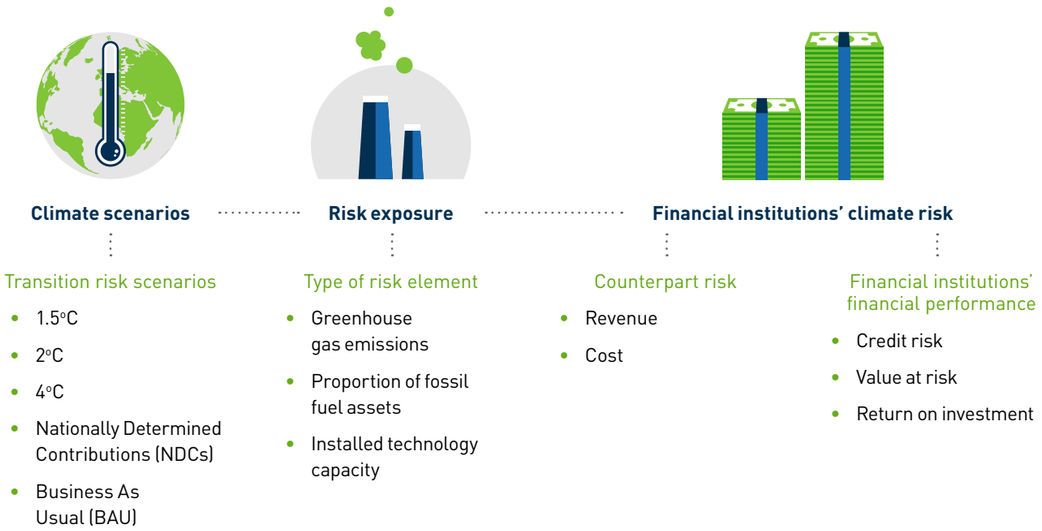
2.1.2 Translating transition risk into financial risk

There are two main scenario sets used to translate transition risk into financial risk, which are temperature-based and event-based.

Temperature-based scenario

The general principle of translating transition risk into financial risk from a temperature-based scenario is shown below:

Figure 6 – General principle of translating transition risk into financial risk on temperature-based scenario
Source: Carbon Trust research



In terms of the risk exposure, this will be highly dependent on which risk categories are measured and included. For example, if a financial institution is looking to measure the risk exposure of emerging low carbon technology, which has potential to replace conventional technology, the input data should be types of technology that is being used now and the future shift in technology cost and deployment as part of a low carbon transition. If the company wants to measure the risk exposure of exceeding committed emission, then the input data used for the tools should be company's carbon intensity.

In order to make it easier to understand, this section will split this general principle into four detailed steps to explain the general principles.

Step 1: setting climate scenarios

Financial institutions can select from a set of different climate scenarios according to their needs. Scenarios could be 1.5 degrees, 2 degrees, 4 degrees, *Business As Usual* (BAU) scenario and *National Determined Contributions* (NDCs) scenario. BAU scenario means no additional mitigation measures will be taken beyond those already announced.

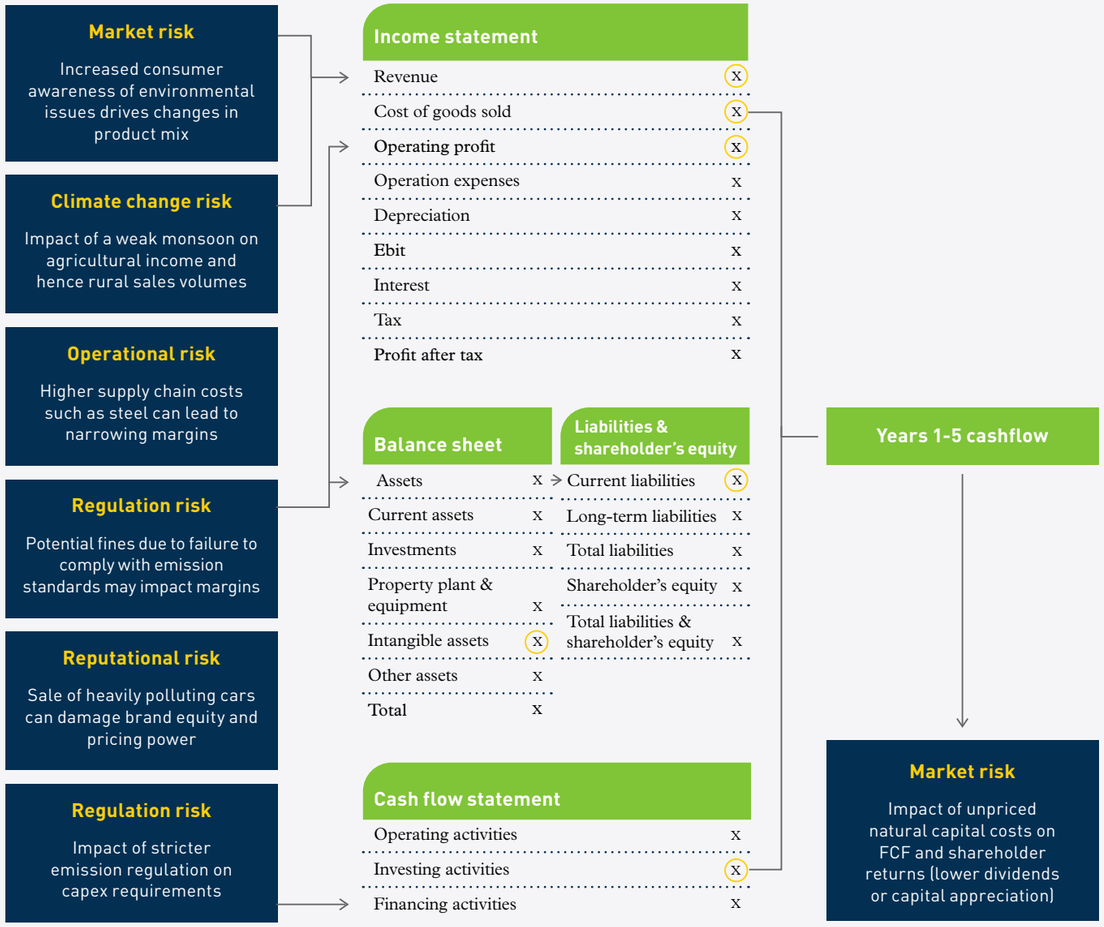
Step 2: transition impact evaluation

Under different scenarios, tools like sector-specific models, Macroeconomic models and Integrated Assessment Models (IAMs) will be used to translate a climate target and temperature goal into necessary and optimised mitigation efforts. These models include a variety of indicators, often including major sector and regional development pathways as a result of the combined impact of policy and technology drivers. The output will include specific sector demand, carbon costs and renewable energy deployment or growth rate.

Step 3: Corporate impact analysis

This part will convert sector and country level macro indicators into corporate financial performance under the transition scenario based on the impacts in previous step. Inputs from these transition scenarios are combined with both financial and operational data available from counterparts. The output is then designed to provide a view of the financial performance of a single counterpart under different transition scenarios. An example that can be used to illustrate this is Figure 7, which shows how within the five-year explicit forecast period of a discounted cash-flow model, climate issues might affect the fundamentals and valuation of a company in the Indian automotive sector, based on a study conducted by Trucost and German Government's GIZ.

Figure 7 - Illustrative example of how climate-risk issues can materialise as financial impacts for an Indian automotive company
Source - adapted from Trucost (2015)[13]



Step 4: Financial risk assessment

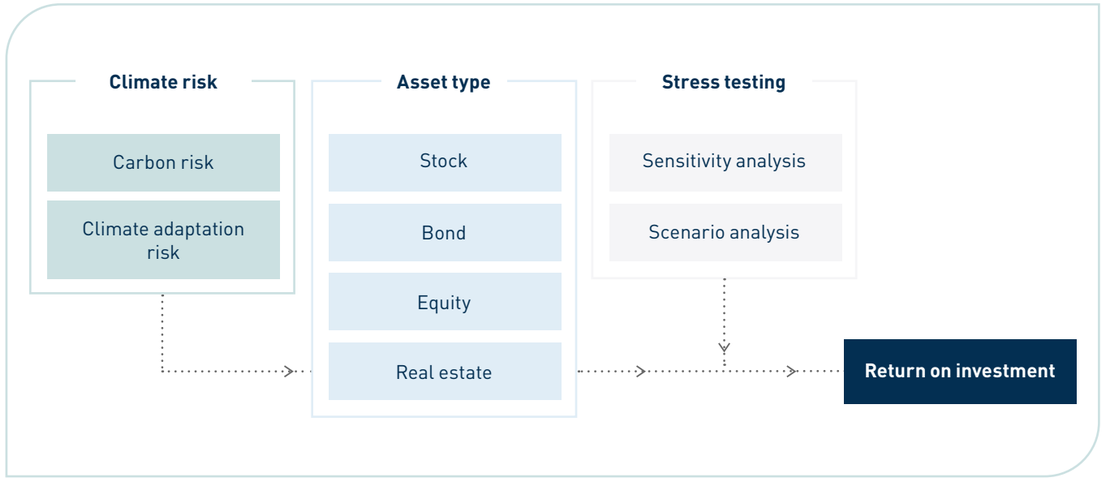
The output produced in step 3 will be converted into models used by different types of financial institutions. For example, banks will insert the data into their PD models to determine the impact on default rate. Asset management companies will look at valuation model and insert these data into their DCF model to see the total asset value change. Asset owners including insurers will look at models like VAR model to analyse the impact of expected ROI after considering transition risks.

Event-based scenario

Under the premise that climate risk has been determined, based on these established risk factors, scenario analysis and sensitivity analysis of stocks, bonds, equity investments and real estate held by financial institutions are conducted to analyse their impact on investment income. Figure 8 shows how this will work for an asset management company.

[13] Trucost (2015). Natural Capital Risk Exposure of the Financial Sector in India

Figure 8 - General principle of translating transition risk into financial risk on event-based scenario



2.1.3 Methodology limitations in current tools

For all the tools currently existing in the market, they will typically focus on only policy risk and technology risk, with limited focus on market risk or reputation risk. In particular on policy risk, the main focus is carbon pricing and the technology risk is often isolated to the direct operations of high carbon sectors, to consider the need for investment in low carbon energy infrastructure or renewable assets. As such, policy risk on carbon pricing would assess the potential increase in OpEx due to paying a carbon price. A technology risk is more likely to assess the CapEx risk associated with the need for investment. Many tools will focus on looking at the value at risks associated with the impact on these two financial metrics.

*For carbon price the implicit formula would be something along the lines of: 'carbon emission * carbon price per tonne = total carbon price spend'.*

Limitations in coverage of these tools to the full range of transition risks is most commonly a result of the availability of data in markets, which is an issue across sustainable investment strategies and not limited to climate risk assessment alone.

For market risks that are typically not covered by tools, the impact can be on revenues or costs. For example, if you were to look at changing market demand under different scenarios for certain commodities then this could impact potential revenues for extractive companies. Alternatively, if you were to look at the costs of commodities then this would impact the OpEx of processing companies. These considerations of the value chain of companies and the exposures upstream and downstream of their operations, are a priority for further development but remain under development currently.

For reputation risks, there are no typical measures for assessing the financial impact as it somewhat relates to the license to operate for the business. An example could be the cost of capital for a business if it is in a sector that becomes viewed as having 'sin' status. So, you could draw comparisons with the coal industry which is exposed to divestment activity due to its contribution to worsening climate change.

2.2 Introduction of the tools

Climate-related transition risks, as well as their potential impacts, differ significantly across sectors, regions and time horizons. Various transition risk assessment methodologies have been developed in response to the challenge of pricing and addressing increasingly material transition risks. It is crucial for financial institutions as users to identify their objectives for risk assessment, and prioritise their requirements, given the diversity of methodological approaches. This section presents a discussion of the characteristics of available transition risk assessment methodologies as applicable to a variety of financial institutions, based on a rigorous assessment of a sample of methodologies carried out by the Carbon Trust. Table 5 shows transition risk assessment tools that are available in the market.

Table 5 - Transition risk assessment tools long list (updated June 2020)

Developer	Title	Description/ purpose of methodology	Type	Portfolio vs asset risk	Risk type	Instruments covered
2° Investing Initiative	2° Scenario Analysis for Corporate Lending Portfolios	Project to extend 2°C scenario analysis framework to corporate lending portfolios	Tool	Portfolio Risk	Transition Risk	Debt
2° Investing Initiative	Energy Transition Risk Project	Toolbox of energy transition risk assessment for specific companies	Tool	Portfolio Risk	Transition Risk	Unclear
2° Investing Initiative	SEI Metrics Project	Free and open-source portfolio test for listed equity portfolios to assess 2° alignment	Tool	Portfolio Risk	Unclear/ N.A.	Equity
Acclimatise	Acclimatise AwareTM	Platform to screen a company or project for climate risk	Tool	Asset Risk	Physical Risk	Unclear
Acclimatise	Climate-related disclosure services	Help clients analyse and understand the climate risks and opportunities in their portfolios or operations and guide them through their disclosure process	Tool	Portfolio Risk	Physical Risk	Multiple
ADEME	Odyssee Project	Database, key indicators and data facilities on energy efficiency across different markets, sectors and countries	Database/ Index	Unclear/ N.A.	Unclear/ N.A.	Unclear
ADEME/CDP	ACT Project	The ACT (Assessing low Carbon Transition) initiative assesses how ready an organization is to transition to this new low carbon world using a future-oriented, sector specific methodology	Methodology guide	Portfolio Risk	Transition Risk	Unclear
Andra AP Fonden	Andra AP Fonden	AP2 is developing an interactive business intelligence (BI) tool that is intended to provide portfolio managers and analysts with these metrics/indicators in real time for both the portfolio as a whole and for each mandate. Data in this tool is divided up into climate-related risks, transition risks, physical climate-related risks and opportunities	Tool	Portfolio Risk	Transition & Physical Risk	Multiple
Asset Owners Disclosure Project	Asset Owners Disclosure Project	Publicly rate and rank institutional investors and assess their response to climate-related risks and opportunities	Database/ Index	Portfolio Risk	Unclear/ N.A.	Unclear
Beyond Ratings	CLAIM© and NC-TIP	Assess, monitor and benchmark the carbon exposure of your equity and fixed income portfolios	Tool	Portfolio Risk	Transition & Physical Risk	Multiple
Bloomberg LP	Water Risk Valuation Tool	It illustrates how water risk can be incorporated into a standard discounted cash flow model to inform the valuation of companies in the mining sector	Tool	Asset Risk	Physical Risk	Multiple
Carbon Delta	Climate Value-at-Risk (VAR)	Risk measurement tool to assess future costs related to climate change and understand what those future costs could mean towards the current valuation of securities	Tool	Portfolio Risk	Transition & Physical Risk	Multiple
Carbon Tracker Initiative	2˚C Compliant Scenario Analysis Tool	Bloomberg Terminal subscribers can access the Carbon Tracker Initiative's research that provides investors in the energy sector and commodities markets, or those with a focus on sustainable investments, insight into oil and gas companies' upstream portfolios. The app includes various indicators for select listed oil and gas companies, that users can incorporate into their assessments of resilience under carbon constrained scenarios	Tool	Portfolio Risk	Transition Risk	Multiple
Carbone 4	Carbon Impact Analytics (CIA)	Transition risk: Carbon Impact Analytics (CIA) is a methodology for assessing the climate impact of portfolios through the measurement of GHG emissions directly and indirectly induced and saved by companies	Methodology guide	Portfolio Risk	Transition & Physical Risk	Multiple
Carbone 4	Mycris	Mycris provides preliminary climate risk scores based on your company's exposure and vulnerability towards climate hazards	Tool	Portfolio Risk	Physical Risk	Unclear
CARIMA	CARIMA project	A capital market based procedure that allows for the quantification, management, and reporting of carbon risks for companies and respective financial securities and portfolios	Methodology guide	Portfolio Risk	Unclear/ N.A.	Multiple

How to anticipate a Green Swan event

Developer	Title	Description/ purpose of methodology	Type	Portfolio vs asset risk	Risk type	Instruments covered
CDP	CDP Data and Tools	Possibility to access CDP data including other companies' responses, companies' scorecards, visual analytics	Database/ Index	Unclear/ N.A.	Unclear/ N.A.	Unclear
CICERO	Shades of Climate Risk	Shades of risk covers physical, policy, liability and technology risks and categorizes these risks by region, timeframe and probability. It points to useful information sources, and provides context for climate scenario stress testing	Tool	Portfolio Risk	Transition & Physical Risk	Unclear
ClimateWise	Transition Risk Framework	Open-source framework to support investors and regulators in assessing how the transition to a low carbon economy will impact the financial performance of infrastructure investments	Methodology guide	Portfolio Risk	Transition Risk	Unclear
Ecofys/ Triple-A Risk Finance/ Deltares	Climate Risk for the Financial Sector (Case Study)	Ecofys, a Navigant company, together with Deltares and Triple-A Risk Finance, supported De Nederlandsche Bank (DNB), the Dutch central bank, with a high-level assessment of the key potential future physical impacts related to climate change (i.e. flooding, droughts, storm surges, etc.) and the impact on the balance sheet of Dutch financial institutions (banks, insurance companies and pension funds). The assessment contributed to a larger project carried out by the DNB, also focusing on climate transition risks for the Dutch financial sector	Methodology guide	Portfolio Risk	Physical Risk	Unclear
ERM	Low Carbon Transition, Climate Change and the TCFD: Top Down Portfolio Screening of Climate-Related Financial Risk and Opportunity	Suite of internal proprietary tools which are used to analyse financial opportunities and risks related to the low carbon transition, and translate these into financial drivers and impacts	Tool	Portfolio Risk	Transition & Physical Risk	Multiple
FINEXUS	CLIMAFIN Toolbox	Tool providing risk and impact metrics to integrate climate physical and policy risk into standard financial risk measures, and classify banks' individual projects and derive overall portfolio's contribution to climate adaptation/mitigation as opposed to portfolio's contribution to climate vulnerability	Tool	Portfolio Risk	Transition & Physical Risk	Unclear
Four Twenty Seven	Equities and Fixed Income	Provide physical climate risk scores for corporate equities and fixed income instruments, based on location	Tool	Asset Risk	Physical Risk	Multiple
Four Twenty Seven	Credit Portfolio Analysis	Evaluate physical climate risk for each credit instrument in a client's portfolio	Tool	Portfolio Risk	Physical Risk	Debt
Four Twenty Seven	Climate Vulnerability Assessment	Company-level risk assessment tailored to strategy and geography	Tool	Asset Risk	Physical Risk	Unclear
ING	Terra	Approach to measure portfolio risk using science-based scenarios. Sector-based analysis	Tool	Portfolio Risk	Transition Risk	Multiple
ISS	Carbon Risk Rating	Carbon Risk Rating assesses the climate-related performance of companies, taking into account not only industry-specific challenges and risk profiles, but also considers companies positive impact. It provides investors with a central instrument for the future-oriented analysis of CO2-related risks both at issuer and portfolio level	Tool	Portfolio Risk	Transition & Physical Risk	Unclear
ISS/CDP	Climetrics	Climetrics assessed a range of funds according to their climate risks and opportunities, giving a score of 1-5	Database/ Index	Portfolio Risk	Transition Risk	Unclear
Mercer	"TRIP" framework	Mercer did an analysis on the potential impact of climate change on industry sectors, asset classes, and total portfolio returns. As a result, it developed the TRIP framework	Methodology guide	Portfolio Risk	Transition & Physical Risk	Multiple
Moody's	Moody's leverages data from its affiliates 427 and VE	Moody's leverages data from its affiliates 427 and VE to provide climate-adjusted PDs/LGDs and quantify the financial impacts of transition risk and physical risk on asset valuation, cash flow, volatility, credit risk, spread	Tool	Portfolio and Asset Risk	Transition & Physical Risk	Equity
MSCI	MSCI ESG Manager	MSCI ESG Manager is an online ESG research and analytics platform designed to provide asset managers and owners with an integrated suite of tools to efficiently manage research, analysis and compliance tasks across the spectrum of environmental, social and governance (ESG) factors	Tool	Portfolio Risk	Unclear/ N.A.	Multiple
Ortec Finance	Climate-savvy scenarios set	The approach consists of a unique combination of climate, economics and finance	Tool	Unclear/ N.A.	Transition & Physical Risk	Unclear
S&P	S&P Carbon Scorecard	Report assessing carbon risk and opportunities of major global equities indices	Database/ Index	N/A	Transition & Physical Risk	Unclear
South Pole	Scenario Analysis & Investment Risks	Analysis of investments' climate risks against a range of climate scenarios	Tool	Portfolio Risk	Transition & Physical Risk	Unclear

How to anticipate a Green Swan event

Developer	Title	Description/ purpose of methodology	Type	Portfolio vs asset risk	Risk type	Instruments covered
South Pole	Sovereign Risks	Indicator of climate risk of sovereign bonds, to be used to assess portfolio risk according to geography	Database/ Index	Unclear/ N.A.	Transition & Physical Risk	Debt
The CO-Firm	ClimateXcellence	Systematic, scenario-based assessment tool of climate transition risks for a range of industries	Tool	Portfolio Risk	Transition Risk	Unclear
Morningstar	Portfolio Carbon Risk Score	Tools are based on a set of company carbon-risk ratings from Sustainalytics, covering more than 4000 companies	Database/ Index	Portfolio Risk	Transition Risk	Multiple
Trucost	Carbon Earnings at Risk analytics	This tool reflects regulatory transition risks by evaluating the impact of rising carbon prices on corporate and portfolio earnings	Tool	Asset Risk	Transition Risk	Unclear
Trucost	Climate Change Physical Risk analytics	This tool evaluates corporate exposure to seven climate change hazards at the asset level, based on a database of over 500,000 corporate assets linked to ultimate parent entities.	Tool	Asset Risk	Physical Risk	Unclear
Trucost	Energy Transition Toolkit	Trucost's energy transition toolkit provides new metrics and interactive charting tools alongside Eboard's traditional carbon metrics, enabling investors to assess company transition pathways	Tool	Portfolio Risk	Transition Risk	Unclear
Tsinghua University	CliTRAM	The Climate Transition Risk Assessment Model (CliTRAM) was developed by the Research Center for Green Finance Development (RCCFD), Tsinghua University. The tool is able to incorporate varied climate scenarios, including those from IEA and IPCC endorsed IAM models, as well as customized scenarios. Different from most of the existing models, the tool also takes into account price competition induced by new alternative technology and the rise of financial cost from degraded rating, to estimate credit-based risk metrics and valuation-based metrics	Tool	Portfolio and Asset Risk	Transition Risk	Multiple
UN PRI	Transition Pathway Initiative - TPI Tool	Tool to assess companies' carbon management quality and carbon performance within a selected sector, and reports the information publicly	Database/ Index	Asset Risk	Unclear/ N.A.	Unclear
UN PRI	2 Degrees of Separation	In-depth sector and company-level analysis of oil and gas companies' upstream exposure to climate transition risks	Database/ Index	Asset Risk	Transition Risk	Unclear
UN PRI	PACTA	Online tool which allows users to measure the alignment of their listed equity and corporate bonds portfolios across key transition sectors and technologies	Tool	Portfolio Risk	Transition Risk	Multiple
UNEP FI / Oliver Wyman	Extending our Horizons	Report outlining a methodology for assessing climate risks and opportunities following TCFD guidelines. Not a tool, but the report paper describes the methodology in detail	Tool	Portfolio Risk	Transition Risk	Debt
Vigeo Eiris	Vigeo Eiris Climate Risk Assessment products	Vigeo Eiris Climate Risk Assessment products have been designed to provide investors with a comprehensive set of tools that can be used to effectively identify risks and opportunities associated with climate change and the transition to a low carbon economy	Tool	Portfolio Risk	Transition & Physical Risk	Multiple
Vivid Economics Climate Risk Toolkit	Vivid's Climate Risk Toolkit	Vivid's Climate Risk Toolkit uses a scenario-driven approach to assess the impact of climate risks on financial assets.	Tool	Portfolio Risk	Transition & Physical Risk	Unclear

Note: For more details of representative tool, please see Appendix. Please also note that not all tools are included in the Appendix.

In general, methodologies of these tools are seeking to link together two sets of information: counterparty specific information and climate risk data. In order to do so, appropriate indicators need to be identified in relation to the counterparties to map across to the risk data. This process allows for an understanding of climate risk based on these counterparties' current exposure and the development of this exposure under different risk scenarios.

Overall, these tools available have the following characteristics:

- To avoid the need for tool users (i.e. individual financial institutions) to individually collect data on these company indicators, tool providers will typically use existing datasets available (e.g. listed companies' disclosure).
- The tools often have defined their climate risk element(s) and other background data. A common data requirement for financial institutions is a list of their portfolios' underlying assets, typically in the form of ISINs.
- The indicator data (e.g. emissions/water usage) available on counterparties is typically backward-looking, self-reported data such as on their emissions, production and energy use.
  - Some tools will include the use of sector averages to fill in data gaps.
  - Beyond backward-looking data, some tools also consider the investment plans of companies to account for their expected degree of transition in the coming years.
- The risk data often comes in the form of carbon prices but can also look at specific transitions required in energy technologies.
- In terms of the approach used to source indicators there tends to be two main types:
  - For those tools considering physical risk and focused on carbon intensive sectors analysis, these will often use asset level data considering site level production statistics and location data. The risk at the asset level can then be summed up to the company level.
  - As asset level data is less available publicly in most sectors, many tools will instead focus on the company level reported data which is disclosed more consistently.
- Areas where tool developers are looking to improve their capabilities include determining indicators that are relevant for consideration of the value chain of companies, such as Scope 3 emissions.
- Most models produce outputs that look to quantify the financial exposure of counterparts and portfolios to climate risk but this does not directly tell financial institutions how this impact factors such as credit risk. As such, much of the work for financial institutions comes in how to interpret the financial exposure of their portfolio counterparts.

It is possible to distribute these tools in various positions on one axis according to the different user objects when the tools are developed (See Figure 9).

Figure 9 - Characters of tools across a spectrum from bespoke to generic
Source: Carbon Trust research

Bespoke tools for specific purpose → **Designed for multiple purposes**

- ✓ Assess specific type of risks
- ✓ Pre-determined scenario based on users' needs
- ✓ Cover bespoke sector, asset class or geography responding to users' needs
- ✓ Provide detailed outputs specific to defined development objectives

- ✓ Allow users to assess physical and transition risks at the same time
- ✓ Run more than one scenario
- ✓ Consider more aspects of the transition risks, such as the risks from market or reputation
- ✓ Cover more and different granularity of setor, asset classes and geographies
- ✓ Provide flexible results

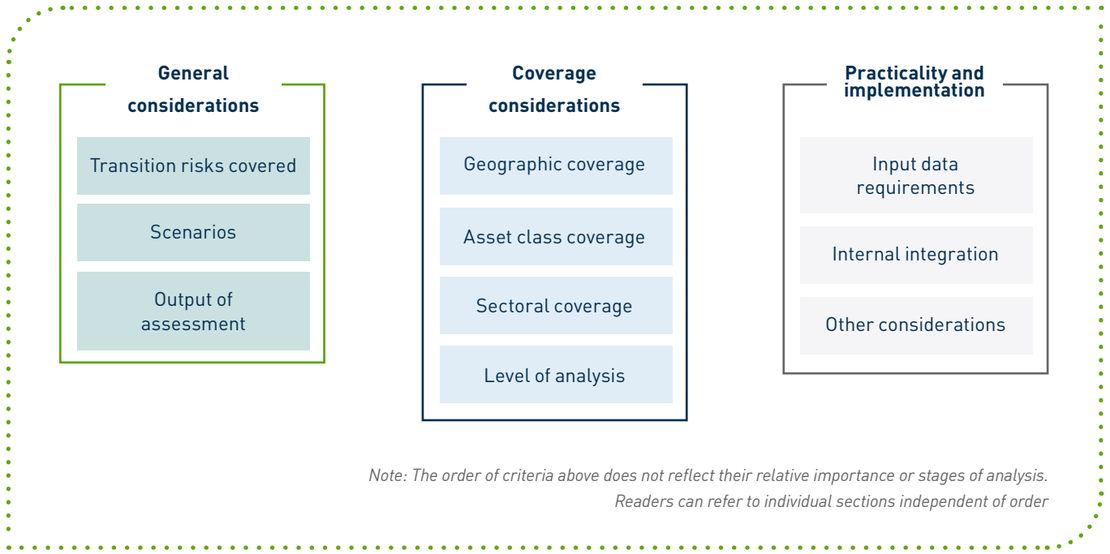
ClimateWise Insuring a sustainable future · THE-CO FIRM · 2° Investing Initiative · ING

TRUCOST · south pole · UNEP FINANCE INITIATIVE · CARBON DELTA · FINEXUS · OLIVER WYMAN

2.3 Methodology selection criteria for transition risk assessment

This section outlines the key and high-level criteria for different financial institutions to consider when selecting an appropriate methodology. A conceptual framework of the criteria is summarised in Figure 10 below:

Figure 10 - Summary of the key criteria to consider when selecting a transition risk methodology



Note: The order of criteria above does not reflect their relative importance or stages of analysis. Readers can refer to individual sections independent of order

General considerations are the key factors that financial institutions should consider when determining their objectives for a risk assessment exercise.

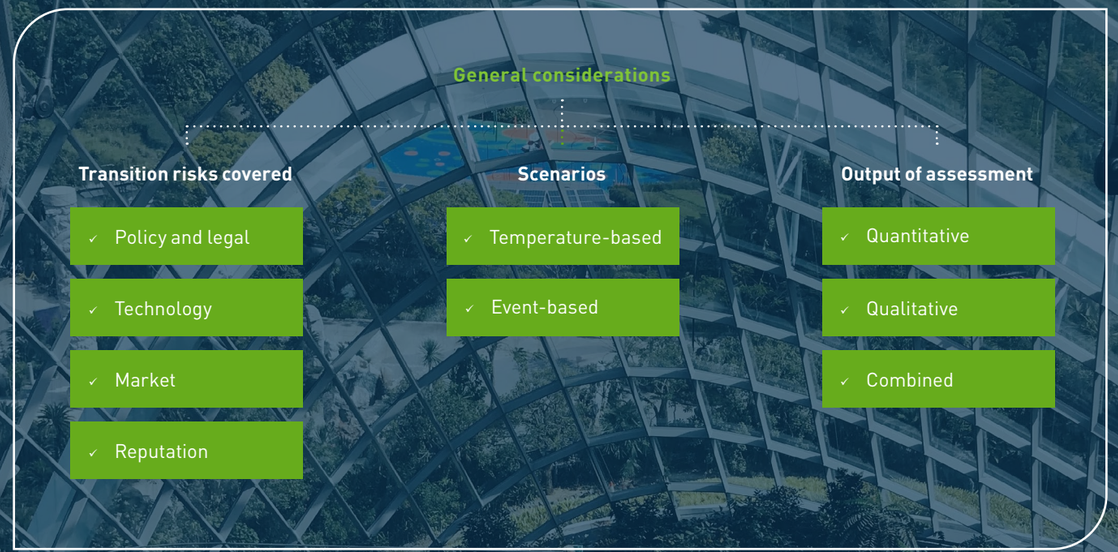
Coverage considerations refer to the applicability of different methodologies based on a financial institution's needs and portfolios.

Practicality and implementation refer to the ease of implementation (cost, time and effort, systems requirements etc.) of a given methodology.

2.3.1 General considerations and alignment with needs

As outlined in Figure 11, the high-level characteristics of any given methodology include three main criteria: a) types of transition risks covered, b) types of scenarios used, c) types of outputs produced. While these characteristics might not always be the primary considerations for all financial institutions when considering the risk assessment implementation, they tackle some of the main aspects of the exercise. Specially, these criteria help the reader to navigate the general landscape of transition risks, better understand available climate scenarios, and types of assessment outcomes.

Figure 11 - Criteria for general consideration



Types of transition risks

The TCFD has identified four overarching categories for transition risk that all companies, including financial institutions, should consider. However, not all methodologies cover all types of transition risks. The most common transition risks assessed are policy risk (often via an assumed carbon price) and technology risk (often via assumed technology cost trajectories). Impacts from legal risk and reputation risk are likely omitted from methodologies because they are harder to quantify,[14] however this is not to say they cannot and will not be integrated into future iterations of risk assessments.

One thing that requires attention is that financial institutions should select methodologies that best cover risks that are most material to their counterparties and portfolios, as well as in meeting their objectives for undertaking this assessment in the first place. For example, whether it is for reporting their transition risks to regulators, or simply understanding which of their counterparties are most exposed to transition risks.

According to TCFD's recommendation, banks are suggested to consider characterising their climate-related risks in the context of traditional banking industry risk categories such as credit risk, market risk, liquidity risk, and operational risk.[15] Similarly, insurance companies were advised to assess transition risks resulting from a reduction in insurable interest due to a decline in value, changing energy costs, implementation of carbon regulation, and liability risks from a possible increase in litigation.

[14]UNEP FI (2019). Changing Course: A comprehensive Investor Guide to Scenario-based Methods for Climate Risk Assessment, in Response to the TCFD
[15]TCFD (2017). Implementing the Recommendations of the Task Force on Climate-related Financial Disclosures

Types of scenarios used

The type of scenario used will depend on whether the financial institution is trying to understand its vulnerability to gradual policy and market shifts caused by climate change (temperature-based), or whether it's trying to understand the impact from a single occurrence (event-based). The number of scenarios available in the risk assessment vary by methodology.

According to Oliver Wyman (2019), financial institutions should consider two types of scenarios when selecting an appropriate methodology, which are:

1. **Temperature-based scenarios:** these often describe a smooth and orderly transition to a low carbon economy, and have a long-term view. However, they can also describe a disorderly transition where stringent policies kick off at a later date to meet climate commitments. Temperature-based scenarios are comprehensive and holistic scenarios analysing how the world might develop, and the corresponding impacts that these pathways have on average global temperature and climate change.
2. **Event-based scenarios:** these are often used to illustrate aspects of an abrupt or a disorderly transition to a low carbon economy, and take a short-term outlook when compared to temperature-based scenarios. Event-based scenarios focus on the potential impacts of one triggering event, such as a sudden change in government policy or the introduction of a disruptive energy technology.

Currently, industry at large is increasingly looking into longer-term, orderly, temperature-based scenarios.

This is in-line with the TCFD's recommendation that organisations use a 2°C or lower scenario in addition to two or three other scenarios most relevant to their circumstances.[16] Though event-based scenarios are not common in transition risk assessment methodologies at the moment, they may be relevant to consider as supervisors are interested in abrupt and disorderly transition scenarios, which are likely to result in higher stress for financial entities as they do not provide the time horizon for a planned movement out of exposed sectors to lower carbon assets.

Multiple methodologies look at a range of temperature-based scenarios

– from a smooth and orderly transition keeping global temperature rise to 1.5°C, to overshooting 2-3°C warming through the implementation of current national pledges and objectives, or even 'no-additional policy' scenarios exceeding 4°C of warming. In addition, some methodologies can also compute implied temperature alignment of portfolios according to the collated total emissions and/or future decarbonisation plans.

Output of assessments

The types of outputs produced by existing transition risk assessment tools can vary considerably. In the broadest sense, risk assessment outputs can be separated into:

- **Quantitative outputs:** these include metrics such as projected changes in EBITDA, VaR, as well as CapEx and OpEx impacts.
- **Qualitative outputs:** these can be graphical, such as risk prioritisation heat-maps, as well as descriptive or numerical, such as discrete scale risk scores.
- **Combined outputs:** some methodology providers can use a combination of the two formats, e.g. producing an initial qualitative screening with a subsequent quantitative deep dive.

As highlighted previously, transition risk is not affecting portfolios and counterparties in a uniform way. A commercial bank, for instance, might be primarily interested in quantifying medium-term risks to its utility sector loans, and would therefore look for a methodology that produces a climate-related Probability of Default, or Expected Shortfall metric. On the other hand, a pension fund in the initial stages of risk assessment might favour a qualitative mapping of their total portfolio by asset class, in order to identify potential risk hotspots for subsequent quantitative analysis, or identify sectors for direct investee engagement. In line with these various user demands, risk assessment tools by design produce various outcomes: some can act as screening tools whereas others quantify the financial impacts of transition risks. Per TCFD guidance, effective disclosures on implications of transition risk can be both quantitative and qualitative, depending on the institution and economic sector in question.

[16]TCFD (2017). Recommendations of the Task Force on Climate-related Financial Disclosures

Box 1 - Tool output demonstration

ClimateWise Climate Transition Framework

Following ClimateWise's Climate Transition Framework, financial institutions would ideally generate qualitative and quantitative results illustrated as below. The quantitative results could include but may not be limited to assets' revenues, costs or net present values.

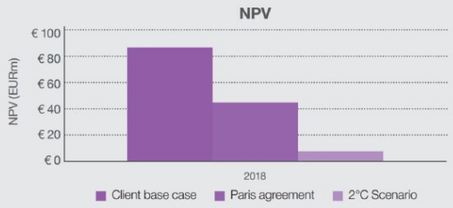


Figure 14: Effect of transition risk on asset net present values

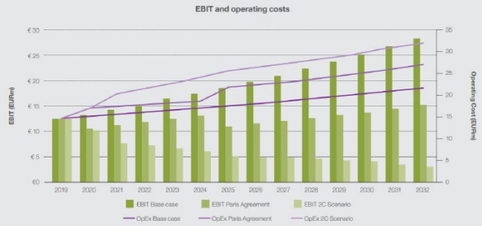


Figure 11: Effect of transition risk on asset returns and costs

Source: ClimateWise website

FINEXUS Climafin tool box

The FINEXUS Climafin tool box produces both qualitative and quantitative results. The two figures below illustrate the outlook of its qualitative results, which focus on the overall portfolio's contribution to climate adaptation/mitigation as opposed to the portfolio's contribution to climate vulnerability. On the quantitative side, the tool uses revenue as a proxy for sector performance and the impact of events are translated into this metric but not others, such as operating costs or capital expenditures.

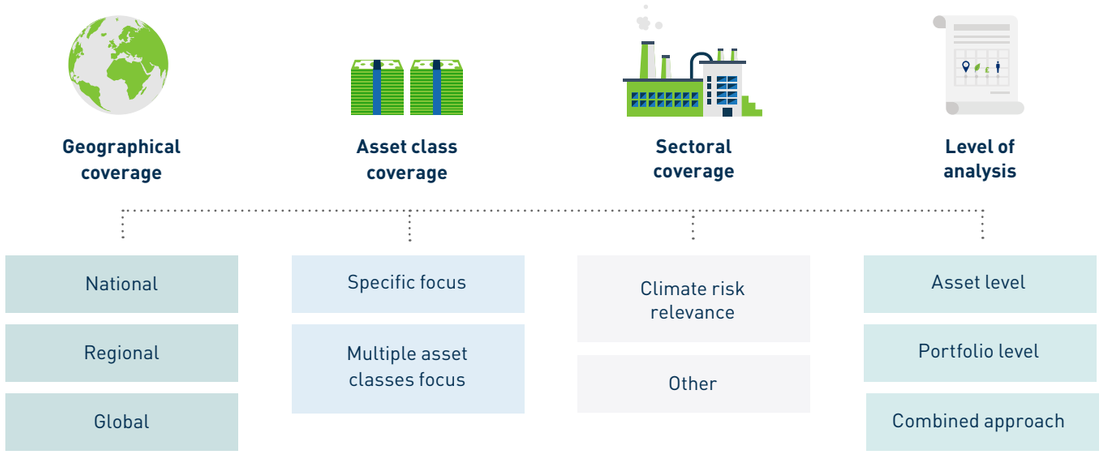
Funding	Description	Economic sector & geographic location	Country vulnerability	Project Climate Physical Risk	Project Climate Policy Risk	Contribution to (CA) vs vulnerability (CV)
20M$	Power plant	Brown utilities, Belize	H	H	H	CV
10M$	Power plant	Green utilities, Trinidad	L	L	L	CA

Source: FINEXUS website

2.3.2 Coverage considerations

Despite the existence of more than 40 methodologies on assessing climate-related transition risks, many of them are designed for specific target portfolios and users. No one methodology covers all regions, all types of financial instruments, and all industry sectors exhaustively. These considerations are summarised in Figure 12 below:

Figure 12 - Criteria for coverage considerations



Geographic coverage

Location matters to transition risk analysis because each location has unique policy requirements, technology development level, market traits and trends, as well as specific consumer and investor behaviours. For example, certain technologyies that are still regarded as "clean" in South-east Asia region might not be acceptable or bankable in the European Union ("EU"). Therefore, for financial institutions with international asset exposure, choosing a tool developed for the right geography is fundamental.

Different tools' geographic risk coverage provides various levels of granularity and generally varies in three ways: risks at global level, regional level (e.g. EU) or country-specific level. Often, a methodology will offer a mix of two levels, and some methodologies provide analysis on all three. When a financial institution selects a methodology, it is critical to answer the following four questions:

1. Where are your counterparties' activities predominantly located?
2. Where will their future activities be located?
3. Are key sectors driven by global trends or local trends?
4. Does it matter for your portfolio to differentiate risks at a country-specific level?

Asset class coverage

Given the wide range of financial instruments across financial institutions' portfolios, asset class applicability is an important practical consideration for selecting an appropriate methodology. Some methodologies were designed specifically for certain end user portfolios, e.g. bank loan portfolios focusing on credit risk, or project finance, focusing on market risk. Others offer a broader range of instrument coverage. As such, financial institutions need to be mindful of each methodology's asset class coverage in relation to their specific needs.

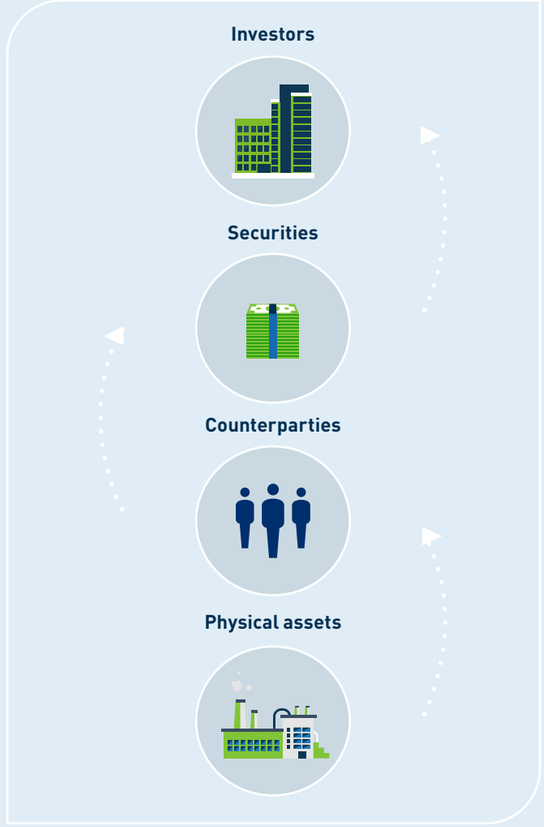
Sectoral coverage

Climate-related transition risks vary across economic sectors. For example, high risk energy and resource intensive sectors, such as power, transport and industry (cement, iron and steel in particular) have traditionally received the most attention from tool developers. Other sectors widely covered include, but are not limited to, real estate and other infrastructure. Some tools can be adapted to almost all sectors after bespoke collaboration with tool developers.

It is also noteworthy that different methodologies cover sectors at different levels of granularity. For example, while two methodologies might both cover transport, one might analyse at the whole transport sector level, while the other breaks the sector down into automotive, aviation and shipping sub-sectors.

Level of analysis

Figure 13 - Investor risk exposure



Transition risk exposure can manifest at various levels, from total portfolio, through to the individual physical assets of a counterparty (as shown in Figure 13). The UNEP FI's Investor Guide in response to TCFD recommendations,[17] notes that risks tend to materialise at the physical asset level, subsequently translating to a counterparty and later portfolio impact. Nevertheless, aggregating risk exposure on a portfolio level can be a desired output for financial institutions, allowing informed strategic decision-making and disclosure.

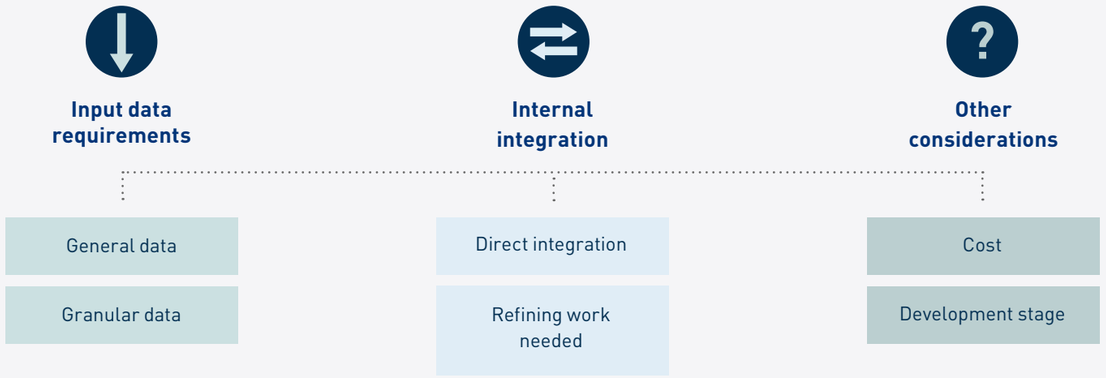
Existing tool providers often offer a combined approach, for example informing portfolio level analysis with asset level data, or executing asset level quantitative analysis after portfolio level risk hotspot identification. The results of different scopes of analysis vary in their applicability among financial institutions. For instance, identifying drivers of transition risks at a physical asset level could help active asset owners inform their engagement strategies with investee companies, while portfolio level insights would enable shareholder disclosure. Assessment granularity also has practical implications, such as data requirements and costs, further addressed in section 2.3.3.

[17] UNEP FI (2019). Changing Course: A comprehensive Investor Guide to Scenario-based Methods for Climate Risk Assessment, in Response to the TCFD

2.3.3 Practicality and implementation

This section deals with the practicality and ease of implementation of risk assessment methodologies. These criteria are important primarily at the implementation stage of the risk assessment process and have direct implications for the exercise's feasibility. Figure 14 below summarises the criteria:

Figure 14 - Practicality and implementation criteria



Input data requirements

The level of input data required depends on the depth of analysis and would normally include financial asset level or portfolio level data. There is a trade-off between the amount of input data and the level of insights gleaned from the analysis. The less data financial institutions input into the tool (either due to the lack of internal data system consolidation, or simply because of lack of reporting from the counterparty), the more generic the output analysis will be. Therefore, financial institutions can opt to provide less data if they simply want a snapshot view of portfolio transition risks, or alternatively, provide granular data for bespoke in-depth analysis.

Typically, general data requirements include portfolio breakdown, such as security names, International Securities Identification Number (ISIN), total asset value, and currency. However, the data required will vary by asset class. For example, in addition to the above inputs, equity portfolios may require portfolio weights.

More granular data (such as asset geography, carbon emissions data, and technology data) may be required for a project finance portfolio, or in the case of a deep-dive analysis of transition risks. This could also include detailed balance sheet data, as well as profit and loss data at the individual counterparty or asset level. When granular data is not available, top-down, rather than bottom-up, approaches can be applied and insights gleaned from the analysis.

Internal integration

The ideal tool would be easily incorporated into end user's risk management systems and general decision-making procedures. This is relatively challenging, given the diverse levels of internal process complexity across financial institutions. There are two common trade-offs to consider in terms of implementation complexity.

Trade-off 1: Time efficiency vs. depth of analysis

The time frame of an assessment process will depend on portfolio composition, data availability and complexity of results expected. Some tools are available online, which makes it possible to assess portfolios relatively quickly. However, this type of general tool likely offers less flexibility for users to include tailored variables. Some tools, on the other hand, might take up to six months to analyse an institution's portfolio in detail, but once the screening session is completed, the assessment is less time intensive and the result is more detailed.

Trade-off 2: Tool feasibility vs. applicability to internal stakeholders

A specific tool may not produce easy to use outcomes for a range of internal divisions within an institution. For example, certain tools are explicitly targeted at commercial banking risk management, while others cater to the needs of equity portfolio managers. This may make results less helpful for another type of financial institution, or even different internal divisions, requiring additional work for refining data and output types. It is critical to ensure the outputs are 'translatable' and can be used broadly across an organisation.

In general, it is in the interest of the end user to select a tool that aligns the best to their goal, while also requiring relatively less additional effort in implementation (e.g., a tool that can produce the most flexible output, which can be used across a financial institution's various business units and with a range of stakeholders.

Other considerations

Other factors that need to be considered are mainly cost structure and development stage. For cost structure, different types of outcome required and methodologies might have different cost of assessment tools on market. Normally, their cost structure could be divided into the following categories:

- Free: some tools are free to use and may be hosted online or may be available as open-source spreadsheet models. However, it is important to note that these are often in a pilot phase, or when a provider is looking to attract initial customers. Therefore, the cost of the tool during this development stage may not be representative of its full cost when it is eventually rolled out to a wider client base.

- Licensing fee: licensing a tool will scale in price depending on the assessment undertaken. The cost of licensing depends on a variety of factors such as: number and size of assets/portfolios, number of sectors, frequency of analysis, granularity of the financial risk, and number of metrics used. Moreover, there may be additional costs related to the level of customisation required, quality assurance, and data updates.

- Consulting services: some bespoke tools cannot be licensed and the cost will be structured as a consulting fee for implementation, with a scaling cost similar to that of licensing models.

For the **development stage**, the current market for transition risk assessment is relatively young, but nevertheless a rapidly growing one. Tools and methods will have various maturity levels, from research and pilot stage to established commercial offerings. The development stage is therefore important for practical implementation of a given methodology in the context of immediate applicability for financial institutions' portfolios. End users are also advised to monitor the space and contribute to tool and method development through pilot participation. Similarly, the use of climate scenarios by the private sector and financial institutions is a relatively new phenomenon. Scenarios are continuously adjusted and developed to adjust to the needs of the sector, given that their initial audience has historically been scientists and policymakers.

How to anticipate a Green Swan event

3. China's status and challenges for Climate Risk assessment

Despite the pandemic, China is quietly opening up its domestic financial markets to foreign players – on 27 March 2020, China approved Goldman Sachs and Morgan Stanley to take majority (51%) ownership stakes in their Chinese securities company subsidiaries. As a summary, the new rules allow majority foreign ownership in securities businesses, fund management, futures businesses, life insurance companies, and currency brokerage companies. Foreign players are additionally allowed to participate for the first time in pension fund management, credit rating agencies and domestic bond underwriting. With more foreign investors playing a role on the Chinese market, higher requirements on climate-related risk assessment and disclosure could be expected.

At the same time, Chinese banks are trying to find new business models as interest income alone is not satisfactory anymore. With an increasingly aging population and growing leverage ratio of the residential sector, the overall saving of households will shrink in the future and the competition for commercial banks will continue to intensify. One potential way for banks to diversify their offering is developing green products. Similarly, climate risk analysis can bring attention to climate-related financing opportunities, helping Chinese financial institutions to innovate and design more diversified products for clients.

The Chinese financial market is dominated by banking, which provides three fifths of total credit to the private sector.[18] This chapter will therefore primarily focus on banks, with additional coverage on asset management companies and insurances companies. In this project, we interviewed 6 Chinese financial institutions and 8 industry experts on their views about climate transition risks and how to further promote climate transition risk assessment in the Chinese market. Their suggestions and feedbacks have been incorporated in our research result as below.

[18] John L. Thornton China Center at Brookings (2016). The Chinese Financial System.

3.1 Policy level

3.1.1 Overall status for Chinese regulators

In China, the government's appetite on climate risk is not very clear, although climate risk is often covered as a subset of environmental risk in the existing published policy. At present, domestic financial institutions carry out this type of assessment with a focus on risks related to local environmental pollution. This focus results in a climate risk blind spot, as it ignores the forward-looking, systemic changes associated with the national and global response to climate change. Table 6 below elaborates the Chinese regulator's current key actions on enhancing awareness of climate risk.

Table 6 - Chinese regulators' key actions on enhancing awareness of climate risk

Regulator	Date	Action
PBOC, MOF, NDRC, MOEP, China Banking Regulatory Commission, China Securities Regulatory Commission, China Insurance Regulatory Commission	2016	Jointly issued Guidelines for Establishing China's Green Financial System. It explicitly indicated that "supporting banks and other financial institutions to use environmental and social risks as important influencing factors when conducting credit asset quality stress testing, and improving investors' ability to conduct stress testing on the impact of environmental and climate factors to invested assets.[19]
PBOC	2019 December	Chen Yulu, the Vice Governor of the People's Bank of China, emphasized the potential climate-related financial risks in his speech at the annual meeting of the Chinese Finance Association and Chinese Financial Forum. He described climate change as one of the major factors leading to structural changes in the economic and financial system, bringing a long-term, structural and global impact. Furthermore, market signals may amplify the severity of climate-related risks, making their impact on individual financial institutions systemic.[20]
PBOC	2020 May	PBOC published a working paper on "Climate-related Financial Risks – An Analysis based on the Function of the Central Bank", which suggested to build up risk assessment methodologies and tools for regulatory purpose and to encourage Chinese financial institutions to incorporate climate-related financial risks into mainstream risk management practice.[21]

[19]PBOC (2016). Guidelines for Establishing China's Green Financial System
[20]More information to retrieve from: http://www.cff.org.cn/zgjrlt/139824/139838/140094/index.html
[21]PBOC (2020). Climate-related Financial Risks – An Analysis based on the Function of the Central Bank

Meanwhile, China has been actively participating in the global cooperation of sustainable finance supervision:

- **NGFS**

As a steering committee and a founding member of NGFS, People's Bank of China has attached great importance to the construction of a green financial system and has continued to pay attention to the financial risks related to climate change. In 2019, China cooperated with the Regulatory Working Group to compile the *Handbook on Environmental Risk Analysis for Financial Institutions.*

- **UK-China Climate and Environmental information Disclosure Pilot**

Under the partnership of the City of London Green Finance Initiative and China Green Finance Committee, 13 financial institutions have agreed to set up a pilot to report against the TCFD recommendations and, where financially material, wider environmental risks. The pilot will involve representatives from the People's Bank of China and the Bank of England and was endorsed by the UK & Chinese governments at the 9th UK-China Economic and Financial Dialogue on 15th December 2017. The pilot will seek to support enhanced information disclosure market practice in both countries, providing a platform for experience sharing and information exchange amongst financial institutions and market regulators.

- **G20 Green Finance Research Group**

In 2017, the G20 Green Finance Research Group proposed an initiative to encourage global financial institutions to carry out environmental risk analysis. In 2016, during China's presidency, the G20 incorporated green finance into the topic of financial channels and launched the G20 Green Finance Research Group, co-chaired by the People's Bank of China and the Bank of England. In 2016, the seven initiatives proposed by the G20 Green Finance Research Group were all included in the G20 Hangzhou Summit Leader's Declaration, one of which was to promote international exchanges on environmental risk analysis issues. In 2017, during Germany's presidency of the G20, the G20 Green Finance Research Group formally took environmental risk analysis and environmental data availability as two main research topics. The Group's initiative on encouraging financial institutions to carry out environmental risk analysis and improving the availability of public environmental data was written in the *G20 Hamburg Action Plan.*

3.1.2 Challenges at the policy level

Limited actions from the regulatory level

It is clear that Chinese regulators are aware of the rising concern around climate risk. However, no immediate actions have been taken by the China mainland's regulatory agencies to address climate change risk directly. Despite the fact that China's 13th five-year plan delivered a clear message to encourage capital flows for sustainable development, which includes low carbon projects, the definition of "green" in China is relatively broad, covering projects that are low pollution mainly.

Hong Kong Stock Exchange, as the first mover in the region, has required all Hong Kong listed companies to disclose information according to TCFD framework. Addressing information barriers could serve as a key first-step to pave the way for enforcing regulation requirements.

Coordination and cooperation between national departments is yet to be improved

From the green finance strategy experience of Bank of England, we noticed the importance of complementary actions between national departments. For example, in order to act on UK's green finance strategy, the Bank of England started developing climate-related stress tests for insurers and banks, and the PRA was tasked to implement these actions. No corresponding actions can currently be found in China.

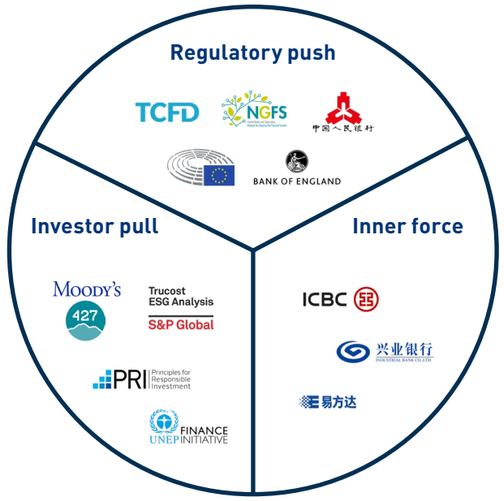
3.2 Financial institution level

3.2.1 Overall status for Chinese financial institutions

In general, most Chinese financial institutions' awareness of climate-related risks is at the initial stage. In the banking industry, the traditional risk management system mainly focuses on credit risk, market risk, operational risk, etc., and rarely incorporates climate risk into the scope of risk management. Even though a few financial institutions have started conducting relevant research, the majority of banks, including local commercial banks, rural credit cooperatives and town banks have not heard of climate risk analysis. In terms of asset management companies, a few of them, like China Asset Management, have begun to participate in climate risk assessment. However, at least more than 100 public funds and private equity funds haven't followed suit yet, given the fact that there are currently 143 public funds and 24584 private equity funds in China.[22]

With the global encouragement for environmental risk assessment, some pioneering Chinese financial institutions have joined the march. Figure 15 shows the participation status for Chinese financial institutions.

Figure 15 - Chinese financial institutions' participation in international initiatives
Source - Carbon Trust research



TCFD

AVIC Trust
Bank of Huzhou
Bank of Jiangsu
China Asset Management (CAMC)
EFund
ICBC
CIB
PICC Property
Casualty Company Limited (PICC)
Ping An Insurance

These companies listed here participated in the UK-China Climate and Environmental Information Disclosure Pilot.

UNEP FINANCE INITIATIVE

Bank of Longjiang
Bank of Taizhou
CDB
CIB
CMB
ICBC
Ping An Bank

PRI Principles for Responsible Investment

34 asset management firms and 2 asset owners, includes:
CAMC
China Merchants Fund
PICC
Ping An Insurance Group, etc.

PSI Principles for Sustainable Insurance

Ping An Insurance
Peak Capital

UNEP FINANCE INITIATIVE PRINCIPLES FOR RESPONSIBLE BANKING

CIB
ICBC
Bank of Huaxia

[22] More information to retrieve from http://www.amac.org.cn/researchstatistics/datastatistics/mutualfundindustrydata and http://www.amac.org.cn/researchstatistics/datastatistics/privategravefundindustrydata/

3.2.2 Challenges at the financial institution level

Internal Challenges

- Lack of understanding of climate risk assessment

Despite the rising number of banks joining climate-related global initiatives, their understanding of climate risk is still nascent. Among interviewed banks, most of them are often combining the discussion of climate risk with environmental risks. While both of them are critical to accelerate China's sustainable economy transition, they do have a big difference and the solutions of addressing two issues are not the same.

We found that Chinese banks' current environment-related risk assessment approach could potentially support the integration of climate-related risk analysis. An example is below:

The Chinese government introduced a green credit policy in 2007, aiming to lower emissions from highly polluting companies through improving information disclosure quality during the loan process. Many Chinese researchers suggest that this policy has been effective by restraining the investment to energy intensive industries by increasing the loan interest.[23] The green credit policy mainly collects corporates environmental performance data (e.g. pollutant level, etc.). This type of environmental disclosure process could be relatively easily extended to include climate information and collect climate-risk related information without adding more bureaucratic stages.

Box 2 - Environmental Risk and Climate Risk

Environmental risk

1. Natural environment risk: Risk of heavy damages due to material damage and personal injury caused by companies releasing pollutants into the air or processing industrial waste on land or waterways.
2. Social environmental risk: Enterprise encounter legal, social, political, and economic risks from their operating environment. For example, changes in policies and laws have affected the production and operation of firms, eventually reducing the profits of enterprises.

Climate risk

1. Physical risk: Climate variability caused by increasing concentrations of greenhouse gases in the atmosphere.
2. Transition risk: Risks related to our societal response to climate change and the transition to a low carbon economy.

Relationship

At present, environmental risk can theoretically include climate risk, but the domestic financial institutions who carry out such assessments focus on risks related to local environmental pollution, rather than climate-related issues.

[23] FINEXUS (2018). Climate-finance and climate transition risk: an assessment of China's overseas energy investments portfolio

- Lack of research capacity

Among the financial institutions who have a reasonable level of understanding, including knowledge of different types of climate risks, it is often challenging to conduct in-depth quantitative analysis due to a lack of research capacity. A key challenge to the mainstream consideration of climate risk is being able to take the step to quantify impacts in financial terms.

- Information asymmetry at the organisational level

During the interview process, identifying key staff who were in charge of climate-related issues was not difficult. For commercial banks, most interviewees had established a dedicated green finance department to handle environmental and climate-related product design, policy review and client engagement. However, climate transition risks, as an overlapping area between climate and risk management, sometimes fall into the gap. For state-owned banks however, environmental and climate-related risk assessments are normally the responsibility of the back office, such as the risk control department. On the other side of the coin, due to the lack of understanding of green finance and the low carbon transition, climate-related risk is normally overlooked.

External Challenges

- Insufficient internal motivation

For cutting-edge research, such as climate risk assessment, Chinese financial institutions have insufficient internal motivation to proactively invest additional resources. This is partly due to their insufficient awareness on the urgency and importance of climate change. Unlike development banks who have a long-term mindset, commercial banks often have only a short-term exposure to their clients, which to some extent will help them to manage risks flexibly.

An external nudge is therefore essential to send a signal to the market that despite climate change being a long-term issue, policy shocks could arrive in the short-term. Such an external nudge could be as light-touch as issuing guidance on encouraging internal research or communication of the central bank (PBOC)'s strategy in this area.

3.3 Tools and methodologies level

3.3.1 Overall status at the tools and methodologies level

Most of the internationally developed tools have not been used in China

Currently, the FINEXUS CLIMAFIN Toolbox has only been applied to the energy portfolio loans of two major Chinese policy banks: China Development Bank (CDB) and Export-Import Bank of China (CEXIM).[24] No other leading internationally developed tools have been found and used in China.

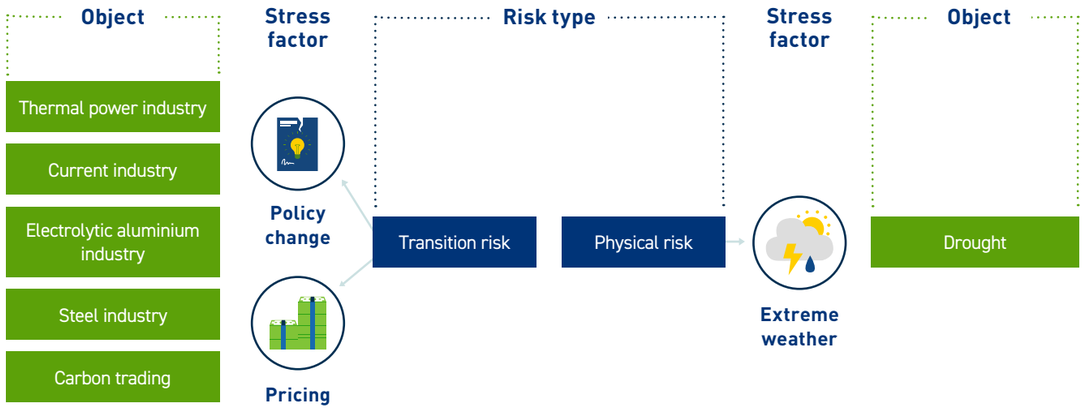
Some pioneers have made progress in developing local tools

There has been some initial progress in the research and development of climate risk assessment tools and methodologies for Chinese financial institutions. From 2016 to 2017, the financial sector cooperated with research institutions to carry out a series of climate risk analysis studies, with subjects covering credit, asset management, insurance, bonds, and the stock market. Among them, climate stress testing has begun to be incorporated into the investment practices of enterprises and financial institutions.

Industrial and Commercial Bank of China (ICBC) stress testing practice

From 2016, ICBC has successively conducted stress testing on physical risk and transition risk. In the physical risk analysis, ICBC analysed the impact of drought on credit risk. In the transition risk analysis, ICBC analysed the impact of environmental policy change and carbon price. (Figure 16).

Figure 16 - Process of ICBC's stress test



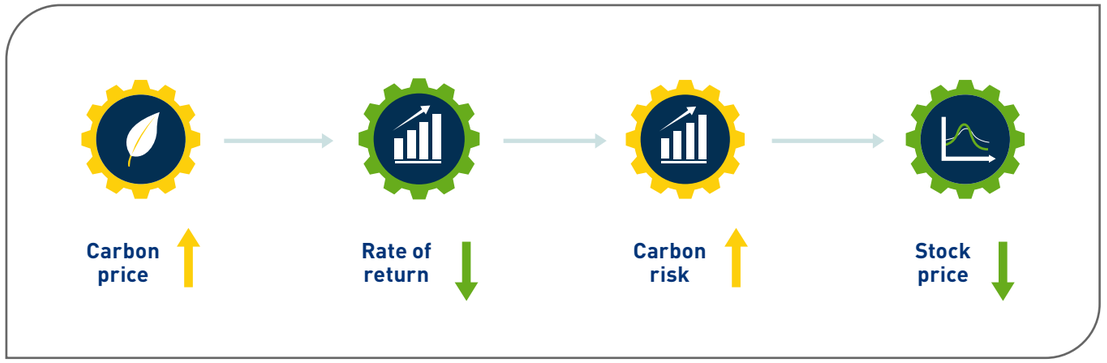
[24] More information to retrieve from https://www.google.com/url?sa=t&source=web&cd=&ved=2ahUKEwiLwZre9abqAhUCd98KHTthBLcQFjAGegQIBxAB&url=https%3A%2F%2Fwww.essdi.it%2Fsites%2Fdefault%2Ffiles%2Fmonasterolo2018climate.pdf&usg=AOvVaw1h0EO3dnpX99sHxBg_kUUA

CUFE's carbon risk assessment on Shanghai and Shenzhen 300 asset portfolio

The International Institute of Green Finance, CUFE, took Shanghai and Shenzhen 300 as an asset portfolio, and conducted environmental stress tests on asset portfolio losses due to carbon risk, water risk, air pollution risk, and environmental penalty risk.

The basic principle is illustrated in Figure 17: If the carbon standards become stricter and the price of carbon rises, then the cost for companies to purchase carbon emission permits will increase, resulting in reduced profits for companies and therefore increased carbon risks. The greater the carbon risk coefficient and the higher the carbon price, the higher the risk premium, resulting in a decline in the stock price and a decline in the actual rate of return.

Figure 17 - Process of CUFE's carbon risk assessment



The Climate Transition Risk Assessment Model (CliTRAM) developed by the Research Center for Green Finance Development (RCGFD), Tsinghua University

This tool was developed by the Research Center for Green Finance Development (RCGFD), Tsinghua University, a university-based think tank focused on facilitating and promoting the development of green finance in China, but with an extensive outreach to the globe. The model aims to measure financial impact induced by transition risks including market demand change, rising carbon cost and declines in renewable energy prices as well as the associated deteriorating credit rating. For more details about this tool, please see the Appendix.

3.3.2 Challenges on the level of tools and methodologies

Lack of high quality public climate-related data

Although the financial industry and academia are actively carrying out research on climate risk analysis and management frameworks, their use within investment practices still faces some obstacles and difficulties. The quality and availability of publicly disclosed environmental data is low, which seriously restricts the quality and credibility of risk analysis across diversified portfolios.

Limited availability of localised tools for Chinese financial institutions

Currently, there are only three locally representative-developed Chinese tools according to the Carbon Trust's research as of June 2020. Internationally, only the FINEXUS CLIMAFIN Toolbox has explicitly mentioned its test with the China Development Bank (CDB) and Export-Import Bank of China (CEXIM). In order to allow Chinese banks to assess the risks effectively and finally incorporate the results in their long-term strategy and risk management process, it is critical to ensure tools are adapted and aligned to the local context.

4. Recommendations

After analysing China's status and challenges for climate risk assessment, the following recommendations reflect the best practices identified so far by the Carbon Trust as an informative first step for further refinement of climate risk assessment in China.

4.1 Recommendations to regulators

Include climate risk into the Comprehensive Risk Management Guidelines

- Due to the fact that Chinese financial institutions lack motivation to conduct climate risk analysis, external policy pressure is necessary. China Banking and Insurance Regulatory Commission could include climate risk into the *Comprehensive Risk Management Guidelines*, as a way to force them to integrate climate risk into their overall risk management system.

- Clarifying existing policy requirements for climate risk analysis, including physical risk and transition risk, is necessary. Currently, there is no clear distinction between policy requirements for environmental risk assessment and climate risk assessment, causing confusion among Chinese financial institutions. Therefore, a distinctive climate risk assessment policy guidance should be a necessity.

- The central bank (PBOC) could consider increasing requirements of collateral quality and refinancing rates for financial institutions with higher levels of climate risk.

Plan Climate Risk Assessment Pilot

- The central bank (PBOC) could take the lead to organise a climate risk assessment pilot for relevant Chinese financial institutions. From the experience of central banks of the UK and the Netherlands, their priority is to require specific financial institutions to conduct stress testing to examine their resilience to financial losses under different climate scenarios. This initial exercise can be helpful for the central bank (PBOC) to understand how to adjust reserve standards.

- Relevant regulators (e.g. PBOC, China Banking and Insurance Regulatory Commission) should publish specific climate risk assessment guidelines, defining key dimensions and criteria for FIs to consider.

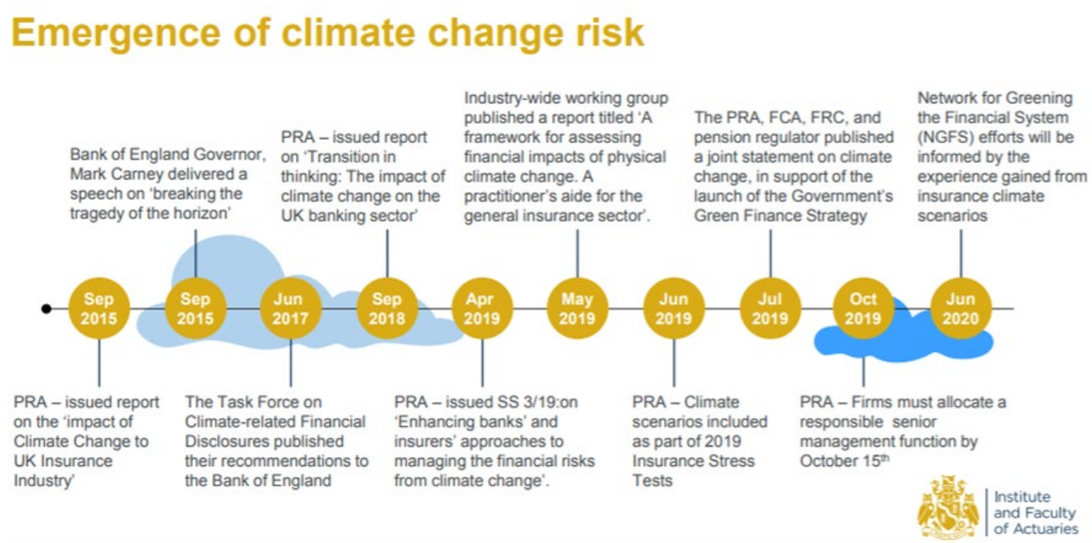
Strengthen policy coordination and cooperation to deal with climate-related financial risks

Climate change has a wide range of impacts, and its response requires coordination and cooperation from the central bank (PBOC), the National Development and Reform Commission, the Ministry of Ecology and Environment, and the Ministry of Finance. At the same time, in order to quickly and effectively deal with financial risks and maintain financial stability, the establishment of a special committee for financial risk identification and response is necessary. One of the main tasks of this special committee is to conduct in-depth research and provide guidance on the timely mitigation of climate-related financial risks.

Introduce incentive mechanism

An example of a successful incentive mechanisms is the Ganjiang New District. As one of the China Green Finance Pilot Zones, Ganjiang New District encourages local financial institutions to conduct stress testing on environmental risks, providing a plus point in their year-end evaluation system for implementing organisations.

Figure 18 - How climate risk was included into the UK's regulatory sada[25]



Encourage climate-related information disclosure

- The central bank (PBOC) may require financial institutions to disclose the results of stress tests, forcing them to improve their climate data and risk management systems.
- Regulators could promote an equivalent level of climate risk disclosure for corporates. First, encouraging listed companies to understand climate-related risk, followed by voluntary disclosure of climate-related data, and alignment to the requirements of the TCFD disclosure framework. Over time, mandatory climate data disclosure for listed companies could subsequently be introduced.
- Relevant regulators (e.g. China Securities Regulatory Commission, MEE) should publish climate-related information and disclosure guidelines to instruct listed companies and financial institutions on how to achieve best practice in disclosure.

Reinforce climate data collection and sharing system

The government can continue to promote the construction of public environmental data systems, including climate data. The government needs to pay attention to the construction of public environmental data publishing platforms and provide the necessary guidelines and technical support to the environmental data sharing platforms of non-governmental organizations. The platform could be organised at the industry level, so companies in the same industry could use climate data to conduct relevant research, in an efficient and transparent manner.

[25]Institute and Faculty of Actuaries (2019). Climate change risk for insurers

4.2 Recommendations to financial institutions

Recommended roadmap to conduct climate risk assessment

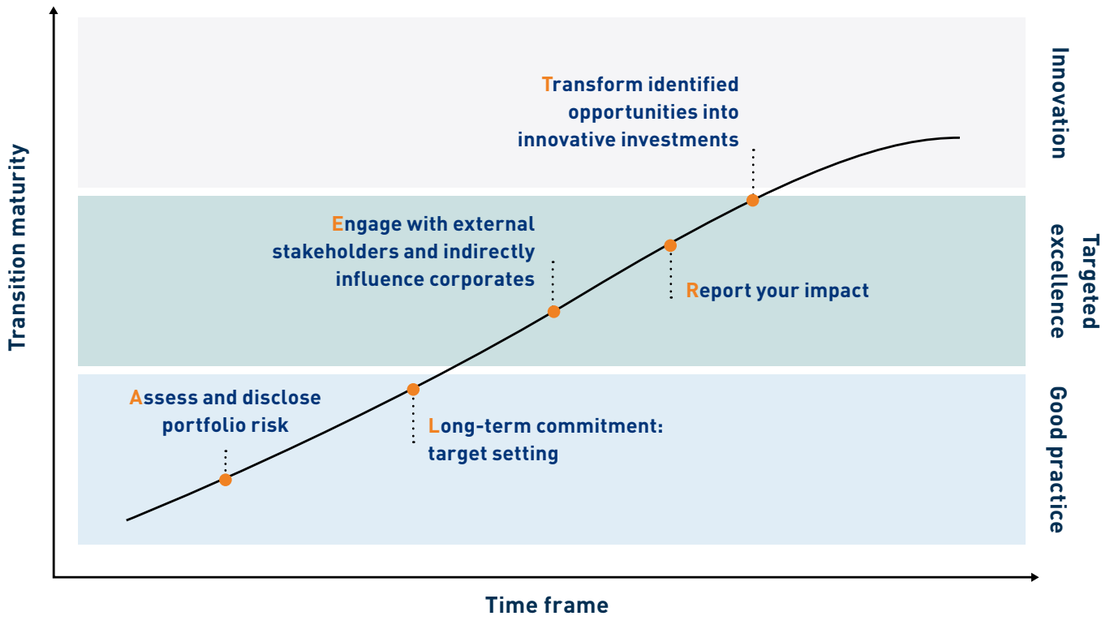
To mitigate potential risk and identify opportunities in the process of climate risk assessment, this five-step approach is recommended for financial institutions.

1. Assess and disclose portfolio risk
2. Long-term commitment: target setting
3. Engage with external stakeholders and indirectly influence corporates
4. Report your impact
5. Transform identified opportunities into innovative investments

Encourage participation in climate risk capacity building activities

Upon the introduction of a series of policies on environmental risks in China, it's a good time to conduct capacity building for Chinese financial institutions, which will deepen their understanding of climate risks and encourage them to make a first move. Being more proactive for financial institutions will further raise awareness and inform decision-making within a company and deliver key messages to external investors and financiers.

Figure 19 - Five-step approach recommended for financial institutions to conduct climate risk assessment



Boost engagement with portfolio companies to conduct climate risk assessment aligning with TCFD style framework

Financial institutions play a key role in mitigating and transferring risk. Should Chinese financial institutions engage consistently with portfolio companies to conduct climate risk assessments aligned with TCFD style, this will cascade the pricing of climate risk beyond listed companies, to even small or medium companies. This would ensure climate risk is priced appropriately across the economy, leading to more capital invested in low carbon industries and greater financial stability. This is the ultimate goal for the TCFD and leverage the position of financial institutions in the economy is an efficient mechanism to the mainstreaming of climate risk.

Promote cross-departmental collaboration within the organisation

In order to solve the issue of information asymmetry, Chinese financial institutions should form cross-department teams to tackle climate risk assessment. Such teams should have staff from different departments, including risk control, information management, green finance and legal compliance. The collaborative results of research activities undertaken could then be incorporated into the business' operation, reflecting the combined knowledge of each of these departments. Table 7 outlines suggestions on the roles of different departments when conducting climate risk assessment.

Table 7 – Suggestions on the roles of different departments when conducting climate risk assessment

FIs category	Department	Expertise	Advice
Bank	Green finance department	• Deep understanding of green finance • More involved with international initiatives	Include climate risk as part of criteria when designing new products
	Risk control department	• Deep understanding of risk models and integration	Include climate risk as part of risk management system
	Credit department	• Directly engage with projects or companies they are providing finance to	Set collateral qualification and mortgage interest rate requirements in the operation of refinancing financial institutions based on climate risk indicators
Asset owners and managers; Insurers	Sustainability-related team	• Some firms may appoint an independent team to focus on sustainability or a previous team (e.g. Innovative department or Strategy department) to fully take responsibility of sustainability issues • In either case, this team is dedicated to the research and the topic but have less control in how the investment team could fully incorporate the result into decision-making process	Build strong governance structure between two teams to ensure the research result could build into investment decisions
	ESG investment manager	• This kind of team structure is often the case of a mature investor with good understanding of ESG issues • It will be easier to fully integrate the climate-risk analysis into the investment process, as the team themselves are responsible for the investment return	Ensure the scope and depth of climate risk analysis is appropriately developed and considered

4.3 Recommendations to tool developers

Harmonise and standardise international tools

There are many mature tools and international methodologies available in the world that allow Chinese financial institutions to learn about and communicate on climate risk. Initially, Chinese tool developers could learn from international methodologies and localise according to the recommended criteria set by regulators. This could greatly increase standardization and comparability among tools, which helps solve the applicability challenge of international tools.

Use proxy data to solve issues around data disclosure

Tools often rely on companies disclosing their data to provide useful outputs and while the level of disclosure is low for the time being, it may be necessary for the tool developers to find work around options which could involve using proxy data instead of the ideal data they would typically use when drawing from company disclosure.

Unite developers to engage and coordinate with regulators to develop China specific tools

Developers looking to be proactive in engaging the central bank (PBOC) or other government bodies to coordinate the development of China specific tools. This links to our recommendation for the central bank (PBOC) to set up this type of research but is aimed at the developers to push for this.

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6. Appendix: Representative tools introduction

The tools are selected by their representativeness in certain perspectives. The selection does not imply these tools outperform others.

2° Investing Initiative – PACTA

The Paris Agreement Capital Transition Assessment (PACTA) tool was developed by the 2° Investing Initiative (2oii), a think tank focused on aligning financial markets with climate goals. Many of the organisation's tools and methodologies arise out of specific projects and funding designed to meet a defined need. PACTA received funding from the Horizon 2020 Sustainable Energy Investing (SEI) Metrics project.

Key Features:

- Rather than measuring transition risk, the tool informs the user on portfolio alignment to a specific scenario
- Outputs are graphical and do not include financial metrics. Additionally, the analysis is based on a five-year outlook, which is not suitable for the long-term nature investments
- As a scenario analysis tool, it has some use for TCFD compliant reporting
- The tool is free and available online and therefore quick and simple to use

Table 8 – 2° Investing Initiative PACTA Ranking & Assessment

	Criteria	Justification
General	**2°C transition**	The tool is generally focused around alignment to 2°C but is not restricted to this and includes other scenarios.
	Existing users	Typical users are involved in capital markets and the early version of the tool was used by over 250 investors and 4 regulators. The tool has a free online version available to all users.
	TCFD alignment	The tool is a scenario analysis tool, and as such it can be used to respond to the TCFD recommendations. It however does not provide outputs in terms of Value-at-Risk metrics.
Nature of Risk	**Asset/portfolio risk**	The tool measures alignment of a portfolio to a scenario at a portfolio level but has some limited use for asset specific analysis, such as the top 10 companies. 2°ii is currently developing a complementary tool focused on company scenario analysis.
	Country risk	Limited applicability to considering sovereign risk due to the focus on companies and the nature of their physical assets or outputs.
	Physical risk	The tool only considers transition risk.
	Reputation/ litigation risk	While not covered by this tool, the ability to identify alignment to a 2°C scenario through the use of the tool may be an implicit way of mitigating reputational risks.
	Types of transition risk	Beyond technology risk, the tool does not provide users with the nature of other risks arising from the transition. Policy considerations are considered to be implicitly embedded within the underlying IEA scenarios.

Applicability	**Geographic coverage**	While the analysis includes considerations specific to different geographies, the output does not show portfolio risk exposure by geography.
	Instrument tailoring	The PACTA tool covers public equity and corporate bond portfolios. The analysis for corporate bonds portfolios is being piloted by a working group of commercial banks.
	Sector tailoring	The tool covers energy (fossil fuels), power, transport (light-heavy duty vehicles, aviation, shipping), and industrial sectors (cement, steel). The intention is to expand to additional sectors in the future.
Implementation	**Cost**	The tool is hosted online to improve the number of users and improve usability. Currently there is not a cost associated with use of the tool.
	Data requirements	For the online tool, inputs will require knowledge of all counterparties' International Securities Identification Number (ISIN) codes in the portfolio, their market value and currency, which is matched against the databases used in the tool. However, this is not possible for SMEs and other non-listed entities. This is only possible in the corporate loans' application.
	Difficulty	The online tool offers the possibility to easily check portfolio alignment with commitments under the Paris Agreement, without excessive time and resource requirements by the user.
	Outputs	Outputs are mainly given in terms of a comparison of the existing portfolio's technology mix or CO_2 intensity to a 2°C scenario as well as its trajectory in the next five years.
	Top down/ bottom up	The tool gives a portfolio alignment viewpoint, built from sector assessment using mitigation scenarios as well as a bottom up assessment using physical asset level data, which draws from market intelligence data and companies' disclosure.

Beyond Ratings – NC-TIP

Beyond Ratings is a financial services provider that focuses on risk assessment and integrates ESG principles into investment decisions. They are developing a risk-assessment methodology for corporate portfolios, which is currently in the piloting phase, called NC-TIP. Beyond Ratings also have a parallel service offering focused on sovereign risk, financed by Climate-KIC, called Climate Liabilities Assessment Integrated Methodology (CLAIM©).

Key Features:

- Rather than measuring transition risk, Beyond Ratings' offering informs the user on portfolio alignment to a specific scenario.
- NC-TIP is not a tool per se but rather a set of metrics that can be used to assess portfolio risk based on the relative weight of bonds and equities. This results into a more complicated implementation process.
- Beyond Ratings are experts in country-level risk assessment and their tools include specific sovereign risk-assessment services for over 170 countries. As such, the methodology could be useful to complement portfolio risk assessment exercises with other tools.

Table 9 – Beyond Ratings NC-TIP

	Criteria	Justification
General	2°C transition	Portfolio alignment can be determined for a number of different transition scenarios – 2°C, 1.5°C, NDC targets etc. Or, reversely, temperatures of portfolio can be computed according to the collated total emissions.
	Existing users	The outputs have been piloted by pension funds, insurers, asset managers and commercial banks.
	TCFD alignment	Beyond Ratings did not wait for the TCFD to develop their own methodologies, which are nonetheless consistent with the recommendations.
Nature of Risk	Asset/portfolio risk	The CLAIM© methodology allows for an assessment both at the asset and portfolio level. Once a country has been assessed, a portfolio made of sovereign bonds can be assessed.
	Country risk	Beyond ratings has a separate tool/ service offering that focuses on sovereign risks. This risk framework assessment methodology combines traditional macro-financial analysis with the integration of ESG factors that present material to sovereign solvency.
	Physical risk	The tool implicitly assesses physical climate risk, as physical risk considerations are included in carbon footprinting and energy transition risk. In addition, some physical risks factors can also be covered as such.
	Reputation/ litigation risk	These types of risk are not explicitly considered within the methodology.
	Types of transition risk	As the tool provides portfolio alignment with different climate scenarios, it does not provide specific assessments of different transition risks.
Applicability	Geographic coverage	A total of 170 countries are covered as part of the sovereign risk coverage and data on 12,000 companies in 50 countries is present as part of the corporate offering.
	Instrument tailoring	The risk assessment methodologies focus on corporate equity and corporate bond portfolios. Over €500bn of sovereign and equity/ corporate credit investments have already been measured.
	Sector tailoring	While CLAIM© computes carbon budgets for countries, the corporate risk methodology covers sectors using various taxonomies (ICB, GICS, NAICS), at different levels of granularity. The new research project actually in progress (NC-TIP) will facilitate a smooth transition between equity taxonomies and macro-sectors taken at country level.
Implementation	Cost	Cost depends on the number of portfolios, the frequency of analysis and the level of customization.
	Data requirements	NC-TIP is not a tool per se but rather a set of metrics that can be used to assess portfolio risk based on the relative weight of bonds and equities. While asset geolocation will not be relevant, asset class and investment value will.
	Difficulty	Based on the relative weighting of bonds and equities, results can be interpreted in a quantitative way.
	Outputs	Both financial outputs, such as assets' EBIT margin and multiples, and non-financial outputs, such as overall portfolio footprint.
	Top down/ bottom up	The tool gives a portfolio alignment viewpoint and is built from a bottom up assessment, specifically a variety of ESG data sources at a sovereign level as well as Scope 1, 2 and sometimes 3 data at a corporate level.

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Carbon Delta – Climate Value-at-Risk

Carbon Delta is a climate change data analytics firm. Its Climate Value-at-Risk (Climate VaR) model provides a forward-looking risk measurement for investors to analyse climate-related risks and opportunities across their investments. The model assesses more than 22,000 companies and 300,000 securities along numerous climate change scenarios to measure future climate change risks and understand what these risks could mean for the current valuation of securities.

Key Features:

- Climate VaR is a forward-looking risk assessment tool that measures Climate Value-at-Risk for portfolios.
- Used by several institutional investors, as well as by working groups such as the UNEP FI pilot project on TCFD disclosure for investors, the tool has a good reputation and can produce outputs comparable to those used by other banks.
- The tool appears quick and easy to use, with minimal data requirements.
- The tool assesses regulatory risks and low carbon technology opportunities arising through a patent analysis to drive the financial outputs.
- At the moment, the tool only works for equity and corporate bonds, with a methodology for loans and sovereign debt currently being developed.

Table 10 – Carbon Delta Climate Value-at-Risk Ranking & Assessment

	Criteria	Justification
General	**2°C transition**	The model currently analyses BAU, 3°C, 2°C, and 1.5°C scenarios, each including emission reduction prices from integrated assessment models, including REMIND, IMAGE and GCAM.
	Existing users	The tool is designed for institutional investors such as asset managers and pension funds. Current clients include Aviva, AXA Investment Managers, Norges Bank Investment Managers and MN Pension Fund.
	TCFD alignment	The methodology is fully aligned with TCFD, and Carbon Delta provides optional additional services for TCFD reporting.
Nature of Risk	**Asset/portfolio risk**	The tool allows for the analysis of Climate Value-at-Risk data both in the context of a portfolio and for individual companies and related investible securities such as equities and corporate bonds. In addition, Carbon Delta provides analysis for real estate assets.
	Country risk	The tool does not currently take into account sovereign risk, this is planned for release in 2019.
	Physical risk	The methodology assesses seven extreme weather hazards such as extreme heat, precipitation and coastal flooding and tropical cyclones within the physical risk analysis. For this analysis, Carbon Delta is collaborating with the Potsdam Institute for Climate Impact Research. The methodology covers both average and aggressive physical climate change risk values.
	Reputation/ litigation risk	The tool does not currently assess reputational or litigation risk.
	Types of transition risk	The tool assesses regulatory risks and low carbon technology opportunities arising through a patent analysis.

Applicability	**Geographic coverage**	Carbon Delta provides global coverage of 22,000 public companies and 600,000 facilities. The tool looks at country emission reduction targets, which are then broken down into sector level targets based on details within 190 country NDCs as well as recently proposed individual national climate policies. This enables the tool to calculate emission reduction costs for each portfolio company, per country.
	Instrument tailoring	The tool can be used for the analysis of equities, corporate bonds, and real estate assets. Carbon Delta are currently developing a methodology for loans and sovereign debt.
	Sector tailoring	The data model covers 31 distinct emission sectors, and 34 extreme weather sectors to assess future cost and green revenue potential for the companies being assessed. In addition, the mode provides 400 low carbon patent families.
Implementation	**Cost**	Costs range depending on the offering. Offerings range from a 'basic' analysis of a portfolio of up to 1,000 securities to a 'premium' analysis of a portfolio of up to 25,000 securities. A 'basic' analysis includes setup, data access and scenario access. A 'premium' analysis includes additional supporting services, such as TCFD reporting, a workshop with senior management, model customisation and data dissemination via FTP enterprise feed.
	Data requirements	The methodology includes a portfolio tool where the user inputs relevant information. Data requirements depend on asset class. For equity portfolios this includes security names, ISIN codes and weights. For bond portfolios this includes, in addition to the above inputs, ultimate parent ISIN and bond maturity dates.
	Difficulty	The analysis can be used for strategic and tactical asset allocation, stock selection, engagement, disclosure, sector specific climate risk analysis, monitoring, compliance and reporting (TCFD and Article 173).
	Outputs	Climate Value-at-Risk, policy costs and green profits as well as warming potential for each portfolio company. The main output is climate Value-at-Risk (Climate VaR). This metric can be calculated for single companies, for the equity and debt portions and for the entire portfolio, and as such it could be used to assess each investment's contribution to climate-related portfolio risk and /or opportunities.
	Top down/ bottom up	The data model employs a top-down and bottom-up hybrid methodology. VaR calculations are based on a database of 22,000 companies, 300,000 investible securities and 600,000 company facilities.

ClimateWise – Transition Risk Framework

ClimateWise operates as part of the Cambridge Institute for Sustainability Leadership (CISL). ClimateWise represents a global network of insurance companies with an aim to better the understanding of climate-related risks and opportunities. The Transition Risk Framework was primarily designed to support infrastructure investors and regulators. The framework was formally launched on the 22nd of February 2019, and has already been tested with a number of investors and lenders. The Framework is intended to be flexible so that it can be back-ended into relevant decision-making.

Key Features:

- The framework is financially grounded allowing for outputs in terms of project change in EBIT, OpEx and CapEx. Outputs can be viewed at a sectoral level and ClimateWise see the data underpinning the model as potentially be used for stress-testing
- The framework looks at specific infrastructure assets rather than assessing counterparties
- The framework quantifies the transition impact on financial drivers and summarises the results in terms of financial outputs. The used underlying scenarios integrate considerations of policy, technology, market and reputational risks, but these are not explicitly differentiated in the outputs of the framework
- The framework does not require separate software and is contained within an Excel spreadsheet

Table 11 – ClimateWise Transition Risk Framework Ranking & Assessment

	Criteria	Justification
General	**2°C transition**	The framework currently utilises Business as usual (3.7°C), Paris Agreement (NDCs, 2.7°C) and 2°C scenarios for both specific and comparative analysis. The developers are investigating the possibility of integrating a 1.5°C scenario.
	Existing users	During the design phase the Framework had been tested on a number of investors' and lenders' portfolios. Typical users the framework is designed for are predominately insurance companies and asset managers, infrastructure investors, lenders (project finance and commercial) and government departments for the purpose of infrastructure plans.
	TCFD alignment	TCFD has been a consideration in the development of the framework but is not a primary aim. The framework is aligned with most of the requirements of scenario analysis included as part of TCFD.
Nature of Risk	**Asset/portfolio risk**	Framework allows for both portfolio exposure analysis and asset specific impact identification. At a portfolio level the focus is on screening for risk on a low, medium, high basis. At an asset level the framework allows for quantitative analysis of main risk drivers as they relate to future costs and revenues of the asset and as such it can be incorporated into financial accounting models fairly easily.
	Country risk	Sovereign risk can be considered if impact for specific assets and infrastructure is identified and incorporated in to the risk matrix. However this would require performing the analysis on the whole of the asset fleet of a country which this framework has not been explicitly designed for.
	Physical risk	The framework is focused on transition risk only. A parallel exercise is ongoing to collaborate with insurance companies to use their catastrophe models to develop a framework for assessing impact of physical risks.
	Reputation/ litigation risk	Litigation risks are not considered within the framework. The impact of reputational risks are considered, for example on capital expenditure.
	Types of transition risk	Underlying scenarios used transition risks defined in line with the TCFD transition risk categories: market and technology shifts, emerging policy and legal requirements, mounting reputational pressures and investor sentiment. The framework quantifies the transition impact on financial drivers and summarises the results in the output. The used underlying scenarios integrate considerations of policy, technology, market and reputational risks, but these are not explicitly differentiated in the outputs of the framework.
Applicability	**Geographic coverage**	The framework generally does not provide country-level data but it covers broader regions. Some country-level analysis is possible, such as Germany and India.
	Instrument tailoring	The framework is highly tailored towards infrastructure investments and investments in the underlying assets themselves. There is potential for this methodology to be expanded in terms of regional geography, and additional data sources if the user has their own in-house view on the underlying risk drivers and/or procures these additional analyses from third parties.
	Sector tailoring	As an infrastructure focused tool it covers power utilities, oil & gas, transport, telecoms, buildings and water. Sub-sectors within each of these are then available.
Implementation	**Cost**	The framework is an open-source excel model.
	Data requirements	Outputs would require knowledge of asset classes, value of the assets and geolocation of the assets. Some matching would be required between internal sector classifications and those of the framework.
	Difficulty	The methodology is flexible and outputs could be used in a variety of ways. The financial outputs could potentially be translated into risk metrics.
	Outputs	Outputs are all considered on a financial basis, at the detailed level this includes breakdown of EBIT, CapEx and OpEx impacts year-on-year. Qualitative High/Medium/Low outputs are also generated.
	Top down/ bottom up	The first stage of adoption would be a top down screening of the portfolio to identify hotspots, followed by bottom up asset assessment, leading to quantification of financial risk.

The CO-Firm – ClimateXcellence

The CO-Firm is a boutique consultancy and modelling firm specialising in climate and energy-related risk and opportunity analyses for industry, utilities, buildings, and the financial sector. They developed the ClimateXcellence Toolset, a systematic, scenario-based assessment tool of climate transition risks for a range of industries, with partners such as Allianz Climate Solutions, Allianz Global Investors, the Investment Leaders Group hosted by the Cambridge Institute for Sustainability Leadership (CISL), and WWF Germany.

Key Features:

- Developed by a small consultancy firm, the tool has gained traction in the market and has been piloted by a number of high-profile institutions, mainly insurers and corporates
- Ease of implementation varies, as users can access the toolset for a high-level analysis on some key sectors or carry out a detailed analysis through the CO-Firm's consulting services
- The tool only focuses on equity portfolios for the time being, and cannot be applied to loans
- Outputs can be quantitative and financial and are determined dynamically according to the needs of the client
- Table 12 – The CO-Firm ClimateXcellence Ranking & Assessment

Table 12 – The CO-Firm ClimateXcellence Ranking & Assessment

	Criteria	Justification
General	**2°C transition**	Multiple transition scenarios are included in the assessment, including the IEA Paris Climate Transition (PCT), Ambitious Climate Transition (ACT) and Limited Climate Transition (LCT).
	Existing users	A variety of users have piloted and validated the tool, including Allianz, Aviva, Zurich Insurance, Natixis and Nordea. Overall, over 260 investor and bank analysts have been trained on applying the tool.
	TCFD alignment	The offer explicitly focuses on embedding scenario-analyses in an organization to assess climate risks and opportunities in line with the TCFD.
Nature of Risk	**Asset/portfolio risk**	The CO-Firms models margins and cash flows based on data for more than 200,000 physical assets of companies (such as production sites), and it also integrates scenario-analyses into the portfolio impact assessment.
	Country risk	The tool has not yet been applied to assess sovereign risk, but this is currently under development.
	Physical risk	The framework is focused on transition risk only, but the CO-Firm is working with (unnamed) partners to cover physical risk in line with the ClimateXcellence approach.
	Reputation/ litigation risk	While the risk outcomes depend on the sector in question, the quantitative outputs do not explicitly differentiate between different types of risks.
	Types of transition risk	The used underlying scenarios integrate transition drivers, including regulation, technology, market and reputational and litigation risks, but these are not explicitly differentiated in the quantitative outputs of the framework.
Applicability	**Geographic coverage**	The assessment currently covers 58 different countries globally and greater country specification is offered in sectors with greater required differentiation.
	Instrument tailoring	Their services focus on equity investments at this stage and have been tested with large asset managers and insurers to date. The CO-Firm has an ambition to extend the approach to debt instruments in the future. The basis for this has been laid in the cooperation with organisations including S&P in the European ET Risk (Energy Transition Risk) project.
	Sector tailoring	The assessment currently covers the following sectors: utilities, auto, steel, cement, oil & gas, plastic, aviation and shipping. More than 15,000 technical adaptation measures are offered across sectors.
Implementation	**Cost**	The CO-Firm's business model focuses on consulting and models cannot yet be licensed. Costs depend on the scope (number and nature of sectors selected), scale of ambition/ level of support.
	Data requirements	As much balance-sheet company/asset-level data as possible, including how companies and sectors are already evaluated to ensure better integration of analysis into existing evaluation procedures. Matching would also be required between internal sector classifications and the tool.
	Difficulty	The whole assessment is implemented over 3 phases. The first phase (materiality analysis on portfolio level) takes 4-6 weeks; the second phase (focused) sector level takes 8-12 weeks per sector and the last phase (at a company level) is highly dependent on the amount of companies to be analysed.
	Outputs	Through ClimateXcellence the CO-Firm provides analyses and services based on a set of data and scenarios. ClimateXcellence is able to produce quantitative outputs measuring the financial impact of climate transition, and the type of metric provided can be tailored to the client's needs. Examples include expected changes in EBITDA margins, earnings and CapEx under different scenarios.
	Top down/ bottom up	The CO-Firm employs a bottom-up approach at a company/asset level and then aggregates data at a sector level. Asset-level data is sourced from the client where possible and otherwise from proprietary and third-party databases.

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FINEXUS – CLIMAFIN Toolbox

FINEXUS is the Center for Financial Networks and Sustainability and is part of the University of Zurich. The centre developed the CLIMAFIN Toolbox in dialogue with international institutions such as the Inter-American Development Bank and the World Bank. The tool aims to integrate physical and transition risk into standard financial risk measures, and derive a portfolio's overall contribution to climate adaptation/mitigation.

Key Features:

- The tool is peer-reviewed, has been piloted with Multi-lateral Development Banks and is ready-to-use
- The CLIMAFIN Toolbox has the capability to assess both physical and transition risk, specifically policy risk
- The tool currently has the capacity to assess a number of different financial instruments, including loans, bonds and equity holdings
- The toolbox focuses on transition risks arising from market responses to climate policies based on economic sector trajectories. Shocks on the market share of firms operating in a country/ sector and the resulting shocks on the revenue streams of securities issued by the firm drive the numerical financial outputs.
- The outputs of the tool are geared towards integration into systemic risk management practices and are numerical, financial metrics, such as standard deviation and value-at-risk

Table 13 – FINEXUS CLIMAFIN Toolbox Ranking & Assessment

	Criteria	Justification
General	**2°C transition**	The tool covers all the main 2°C transition scenarios including the IEA Technological Roadmap as well as the scenarios produced by all the main existing Integrated Assessment Models, e.g. by means of scenarios databases such as LIMITS Database and Socio-Economic Shared Pathways database. It thus allows for an assessment of the portfolio against multiple scenarios for temperature goals, technological trajectories and national contributions.
	Existing users	The toolbox can be customized to target both private and public financial institutions. Existing applications have targeted MDBs (e.g. China Development Bank), National Central Banks (e.g. Austrian National Bank and Banco de Mexico), the European Central Bank (e.g. CSPP under Quantitative Easing) and commercial banks (top 20 European Banks).
	TCFD alignment	The CLIMAFIN toolbox covers the scenarios recommended by the TCFD and it provides numerical values which can be incorporated into TCFD reporting.
Nature of Risk	**Asset/portfolio risk**	The method allows users to price-in the risk deriving from forward-looking 2°C transition scenarios in the present value of individual financial contracts at the firm level. The sectors covered are those included in the IEA technological roadmap and in the EU Reference Scenarios such as: energy, utility, transportation. The risk at the individual firm level can be aggregated at the level of the whole portfolio and incorporated into standard financial risk metrics.
	Country risk	The FINEXUS Center is elaborating a dataset of proprietary trajectories based on country-level and sector specific progress towards NDC targets in order to incorporate country-level transition risk into standard metric of sovereign risk.
	Physical risk	Physical risk is can be assessed at the firm and individual project level by combining information on the sector and the geographical exposure to climate-induced hazards (based on geolocalized disaster risk databases EMDAT and Desinventar) and the quality of adaptation plans in countries' NDCs.
	Reputation/ litigation risk	As the tool focuses on climate policy and technological transition risk, reputation and litigation risk are not included in the assessment.
	Types of transition risk	The toolbox focuses on transition risks arising from market responses to climate policies. Adjustments include gains/losses depending on: i) exposure to high/low carbon assets ii) delayed and disordered alignment to climate targets that investors do not fully anticipate If climate policies are credible and stable, and investors are able to anticipate them, portfolios do not experience additional price volatility and asset revaluation.
Applicability	**Geographic coverage**	The tool can be adapted to all of the geographies.
	Instrument tailoring	The methodology covers: loans, bonds and equity holdings. The team is working to integrate derivatives as well.
	Sector tailoring	The tool can be adapted to all of the sectors.
Implementation	**Cost**	The cost structure of using the tool depends on the number of assets and sectors to be analysed and on the granularity of the financial risk metrics to be computed. The cost will include the analysis of the documentation of individual projects and the cross-matching of asset level information from portfolio with the databases utilised by the tool.
	Data requirements	The level of granularity required depends on the depth of analysis and would normally include project-level and/or counterparty data.
	Difficulty	Delivering the assessment takes between 1 to 6 months depending on the portfolio composition, the data availability and the depth of the required analysis. Once the portfolio screening has been completed, subsequent assessments are likely to be less data and time-intensive.
	Outputs	The workflow aims to mainstream the systematic risk management and impact assessment at every stage of the credit and financial cycle for each development project and for each investment in the financial market. The outputs are numerical financial metrics, such as standard deviation, Climate Value-at-Risk and Climate Spread for sovereign bonds.
	Top down/ bottom up	The toolbox combines top-down data based on transition scenarios at country/sector level with bottom-up data at the asset level to deliver integrated financial risk metrics for the entire portfolio or selected portions of the portfolio.

ISS – Carbon Risk Rating

Institutional Shareholder Services Inc. (ISS) is both a tool developer/provider and advisory services company. In recent years it has expanded its teams through the acquisition of South Pole Group's investment climate data division and oekom research. ISS currently operates eight different tools/approaches that have scenario analysis claims, which could potentially be used jointly. The Carbon Risk Rating tool compares the relative risk of individual sectors and also identifies climate leaders within each sector. While the tool and data can be standalone, ISS does not see its use as a 'one size fits all approach'. The organisation would typically provide bespoke alignment work where a client sends information on their portfolio and ISS then does analysis.

Key Features

- The tool focuses on the CO_2 emissions of companies across the full value chain and their strategies to mitigate impacts in the future and draws upon ISS' own proprietary datasets to rank companies across a range of ESG indicators
- The tool looks not only at the existing impacts of companies but also at their plans for transition and where available assesses winners and losers in a decarbonising economy. 'Transition readiness' is assessed over both generic and sector-specific questions
- Where a counterparty is not in the current database, users would need to engage directly with them to source answers to a series of ESG questions

Table 14 – ISS Carbon Risk Rating Ranking & Assessment

	Criteria	Justification
General	**2°C transition**	ISS provides a range of tools that look across a range of pathways including up to 2°C, 4°C, 6°C and others.
	Existing users	The existing users of the tools are generally institutional investors but some work has been done to adapt the tool to commercial banks' lending portfolios.
	TCFD alignment	The tool is not a dedicated TCFD alignment tool. It emerges from broader ESG related tools which do not look exclusively from a climate risk lens.
Nature of Risk	**Asset/portfolio risk**	The tool can provide a portfolio risk assessment at a high level but is largely designed to provide insight at asset level. The aim is generally to assist in steering portfolio composition towards a climate-friendly scenario rather than assessing risk explicitly.
	Country risk	ISS have incorporated country-level information including subsidies on renewables and fossil fuel regulations. This has been used to develop climate-focused sovereign ratings in other tools.
	Physical risk	Exposure to physical risks is part of ISS' service and feeds into other tools. ISS differentiates between acute and chronic climate risks and does so by assessing sectors and geographies.
	Reputation/ litigation risk	Given the number of individual ESG indicators collected there may be potential to use a subset of these to identify specific reputation or litigation red flags. Particularly the research focussing on violations of international norms is useful for this purpose.
	Types of transition risk	The flagship scenario tool has a focus on emissions and as such would largely be relevant for policy/regulatory risks. Individual market risks are not considered because sector economic growth projections are not adjusted by scenario, but the tool assesses winners and losers in a decarbonising economy. A different tool on disclosure does provide a framework following the four TCFD pillars.
Applicability	**Geographic coverage**	The flagship scenario tool utilises IEA data so provides breakdown at a regional level but does not go beyond this to country level. The country rating, offered separately, does have a climate specific risk rating.
	Instrument tailoring	The tool comes from the listed equity space and provides information on stocks and bonds.
	Sector tailoring	Aligned to the IEA's sector classification, so will cover oil & gas, power, transport, industry (cement, iron & steel), and real estate. Other ISS tools rely on a proprietary sector climate risk classification.
Implementation	**Cost**	If the user is more bespoke, potentially the cost would be associated with the consultancy required to align ISS' tools to user's data rather than the cost of the data use itself.
	Data requirements	Would require knowledge of all counterparties in portfolio but minimal needs beyond this, should all counterparties be covered by the database. Top-down approaches can be applied with the respective limitations on granularity.
	Difficulty	If the current crossover of the tool with the user's portfolio is low, it is expected that consultancy services would be required to ensure alignment between the bank's data and what ISS has available.
	Outputs	Outputs are company scores on zero, weak, moderate, robust and 2°C climate strategy, based on ISS' set of assessment metrics (~100). Some prior experience of adapting tools to align to credit risk assessments and ISS see this as a feasible use of their information.
	Top down/ bottom up	The tool has a bottom-up approach, assessing individual companies' pathways to climate scenarios. The tools can also provide an initial risk heat map for a portfolio but are generally used to provide information at the counterparty specific level to build from the bottom up.

How to anticipate a Green Swan event

South Pole – Arctica

South Pole is a provider of sustainability financing solutions and services. They are currently developing Arctica, a tool to assess portfolios' physical and transition risk. The tool assesses the climate risk exposure of underlying holdings across different climate change scenarios and builds on South Pole's existing Sovereign Risk services and Climate Risk Tools for investors.

Key Features:

- While the physical risk part of the tool is nearly ready, the transition risk component (covering policy, market and technology risk) is still under development and will be launched in 2019.
- Risk assessment can be done at varying levels of depth, and as such the tool can be used for portfolio screening as well as deep-dive analysis.
- While Arctica can theoretically be applied to debt instruments, the tool has so far has only been tested on equity portfolios.
- Outputs consist of an interactive platform with numerical and graphical results that can be tailored to different sectors, geographies and timeframes. Numerical outputs include financial metrics such as Value-at-Risk.

Table 15 – South Pole Arctica Ranking & Assessment

	Criteria	Justification
General	**2°C transition**	South Pole recommends using IEA and SSP scenarios, but the tool can run any scenario.
	Existing users	Existing and expected users include pension funds, private asset managers, commercial banks, multilateral development banks and multinational corporates.
	TCFD alignment	The tool is in line with TCFD.
Nature of Risk	**Asset/portfolio risk**	The tool allows for three levels of depth: top-down portfolio screening, hotspot analysis by sector and/or geography and deep-dive analysis at asset level.
	Country risk	The tool accounts for country specific risk factors. Country risk is defined as country's vulnerability to climate change related risks.
	Physical risk	The tool currently assesses physical risk, and the transition risk component is under development. The tool provides separate quantitative risk measures for physical and transitional risks. For the physical risks, the outputs for various hazards are modelled based on sector/subsector exposure and geographies' vulnerabilities.
	Reputation/ litigation risk	The tool models litigation risks at a top-down level. Reputational risks are not yet modelled at a top-down level, but they can be included in the hotspot analysis.
	Types of transition risk	For the transition risk assessment, outputs are shown for different risks such as policy risk, litigation risk, market risk and technology risk.
Applicability	**Geographic coverage**	The tool has a global coverage, with the possibility to tailor it to different geographies.
	Instrument tailoring	The tool is used for equity portfolio analysis as well as fixed income.
	Sector tailoring	The tool covers all sectors and industries as per the GICS and ISIC industry categorisation. Hotspot analysis tailored towards a specific sector is provided beyond the screening tool service.
Implementation	**Cost**	The cost depends on the size and type of portfolio screened. Main costs relate to consulting fees, quality assurance and data updates. Currently the tool is not available for clients on a licence basis.
	Data requirements	Data requirements consist of a list of portfolio holdings and their weighting. If the client wants a deep-dive analysis, they will need to provide more granular information.
	Difficulty	Unless a deep-dive analysis is being sought, data requirements are manageable, and the outputs are diverse and financial, which should be easily translated into risk metrics.
	Outputs	The output will be an interactive platform, with numerical and graphical results. This includes financial outputs such as Value-at-Risk and liquidity.
	Top down/ bottom up	The tool allows for three levels of depth: top-down portfolio screening, hotspot analysis by sector and/or geography and deep-dive analysis at asset level.

Trucost – Carbon Earnings-at-Risk

Trucost was established as a provider of ESG data and tools. It was acquired by S&P in 2016 and now acts as the rating agency's climate and ESG research centre. Trucost developed two separate climate risk assessment methodologies. The Carbon Earnings-at-Risk methodology measures the climate transition risk of companies and assets with a focus on policy risk. The 2 Degree Alignment metric assesses individual companies' alignment with a 2°C scenario, using the SBTi's SDA approach on applicable sectors, and GEVA scenarios on the other sectors.

Key Features:

- The Carbon Earnings-at-Risk methodology evaluates the impact of environmental policies such as carbon taxes on companies' EBIT and EBITDA
- The methodology uses disclosed information from companies' annual reports and CDP (formerly 'Carbon Disclosure Project') responses, and it estimates data using sector- and country-level information as well as extrapolating from companies' past performance
- Trucost employs country-level considerations on policy risk, such as carbon pricing, to develop the earnings-at-risk output.
- The S&P 500 Carbon Efficient Index is in part based on this methodology

Table 16 – Trucost Carbon Earnings-at-Risk Ranking & Assessment

	Criteria	Justification
General	2°C transition	The methodology for Carbon Earnings-at-Risk is based on multiple scenarios, from sources including: IEA, OECD and IPCC. S&P's own scenario developed by the PLATTS division is not used by Trucost but can be used in the near future.
	Existing users	Existing users include: US, European and Asian banks.
	TCFD alignment	The methodology is fully aligned with the 'Metrics and Targets' category of TCFD, and it strives to align as much as possible with all other categories.
Nature of Risk	Asset/portfolio risk	The methodology evaluates portfolio risk through aggregating information on single assets, making it possible to evaluate risk at both portfolio and asset level.
	Country risk	The methodology for Carbon Earnings-at-Risk looks at country-level risks based on companies production or revenue exposure to countries.
	Physical risk	The methodology for Carbon Earnings-at-Risk focuses only on regulatory transition risk. However, Trucost has previously partnered with other organisations in exercises to assess physical risk.
	Reputation/ litigation risk	These are not covered for Carbon Earnings-at-Risk, as the methodology focuses on policy risk.
	Types of transition risk	With a focus on carbon pricing, the methodology only assesses policy (regulatory) risk.
Applicability	Geographic coverage	The methodology for Carbon Earnings-at-Risk is applicable to assets across all countries.
	Instrument tailoring	Trucost never applied the methodology to guarantees, but all other types of securities can be assessed. The outputs are entity rather than instrument level.
	Sector tailoring	The methodology for Carbon Earnings-at-Risk uses OECD sector (and geo) specific carbon prices (industry, residential and commercial, road- and offroad transport, agriculture and fisheries, electricity) and these sectors are mapped to Trucost's 464 sectors.
Implementation	Cost	Costs will depend on the scope and complexity of the project and whether one of or all the two metrics are used.
	Data requirements	Data requirements include asset-specific information. For infrastructure investments this includes: location, project type, construction year, energy use and generation, technology type and information on the investment such as value owned and total asset value.
	Difficulty	Trucost are currently exploring ways to integrate the methodology's outputs into S&P's practices across various business divisions. At the moment this resulted in a methodology using the data in fundamental credit scorecards and statistical credit risk modelling.
	Outputs	The Earnings-at-Risk ratio is a financial output that measures a company's exposure to potential changes of carbon prices based on 2 degree aligned, NDCs aligned and an in-between scenario.
	Top down/ bottom up	The methodology for Carbon Earnings-at-Risk follows a bottom-up approach. The approach is based on disclosed information from companies' annual reports, CDP responses and where they are not available, Factset's Georev data.

UNEP FI/ Oliver Wyman – Extending Our Horizons

This methodology was developed as part of a collaborative pilot with 16 commercial banks, the UN Environment Finance Initiative (UNEP FI) and Oliver Wyman. The latter two parties hold responsibility for developing the technical aspects of the methodology. The explicit focus of the working group was to consider transition risk as a separate working group in collaboration with Acclimatise who have published a methodology on physical risk.

Key Features:

- The Extending Our Horizons tool was designed to assess transition risk exposures within corporate loan portfolios. Given that the tool was developed alongside commercial banks, the outcome of the tool focused on the credit risk assessments alongside appropriate response strategies based on the short-term nature of commercial bank loans
- In order to function effectively, the tool requires banks to bring together both credit and sustainability experts
- Stress-testing was considered as a potential outcome of the pilot but was ultimately not chosen on account of the time horizons over which transition risks manifest
- The Extending Our Horizons methodology primarily employs carbon pricing assumptions, alongside market risk, to develop scenario-adjusted financial outputs.
- Case studies from the pilot phase implementation have been published and are available to review

Table 17 – UNEP FI/ Oliver Wyman Extending Our Horizons Ranking & Assessment

	Criteria	Justification
General	2°C transition	The methodology lends itself for linkage, in principle, with all scenarios. The scenarios that are most compatible with the methodology, however, are the REMIND and MESSAGE scenarios from PIK and IIASA that include at the very least 1.5, 2 and BAU pathways.
General	Existing users	To date the tool has been piloted with 16 commercial banks.
General	TCFD alignment	Fully TCFD aligned as the working group is focused on piloting the recommendations, specifically those associated with Strategy and scenario analysis.
Nature of Risk	Asset/portfolio risk	The end outcome of the model is a portfolio impact assessment, expressed in the form of climate-adjusted risk metrics like climate-adjusted probability of default, or climate-adjusted loss given default. This output is drawn from specific calibration at an asset level to tailor the assessment to the bank's specific exposures.
Nature of Risk	Country risk	The tool has not currently been used to assess sovereign risks.
Nature of Risk	Physical risk	Not covered by this methodology, but part of wider project to have alignment of both transition and physical methods.
Nature of Risk	Reputation/ litigation risk	Given the credit risk focus, this is not a feature of the tool in its current form and would be an unlikely extension as the main users have shorter term exposures than MDBs.
Nature of Risk	Types of transition risk	Covers a range of transition risks with carbon pricing playing a large role but elements of market risk are also included. Specifically risk areas in relation to electricity price, production/demand given energy mix, carbon and fuel costs, and investments required to current energy mix.
Applicability	Geographic coverage	The methodology is broadly applicable to all geographies, although some niche regions are covered in less detail.
Applicability	Instrument tailoring	Pilot phase has taken place with commercial banks as borrowers to assess risks in the corporate loan portfolio.
Applicability	Sector tailoring	Currently the tool has been used in a number of sectors that were considered the most risk-exposed by the banks in the piloting group. These are high emission intensity sectors such as power generation, industry (oil, cement, steel, coal), transport and more. The group will look at agriculture and residential real estate in the future.
Implementation	Cost	Issues of cost have not yet been resolved as the intellectual property considerations are still under discussion. Outside of data use the costs would largely be associated with engaging with credit risk teams to calibrate the tool to the user's processes.
Implementation	Data requirements	Currently the main inputs into the methodology would be: location data, exposure, ratings, revenues and costs associated with counterparts.
Implementation	Difficulty	The tool is focused on aligning with the needs of credit teams, specifically in terms of expected loss calculations. As such a lower level of disruption is expected as fewer additional processes or changes to process would be required.
Implementation	Outputs	Outputs are designed to feed into credit risk models. The risk factor outputs relate to Probability of Default (PD) analysis using an adapted Merton framework. The model looks at scenario-adjusted projections for revenues, costs and capital expenditures at a borrower level to generate performance metrics such as cash flow/debt or debt/EBITDA.
Implementation	Top down/ bottom up	The methodology utilises both approaches in its implementation as outputs are presented at a sector/sub-sectoral level but require the need to look at the borrower-specific level to adjust the methodology to the bank.

How to anticipate a Green Swan event

Research Center for Green Finance Development, Tsinghua University – CliTRAM

The Climate Transition Risk Assessment Model (CliTRAM) was developed by the Research Center for Green Finance Development (RCGFD), Tsinghua University, a university-based think tank focused on facilitating and promoting the development of green finance in China, but with an extensive outreach to the globe.

Key Features:

- The model aims to measure financial impact induced by transition risks including market demand change, rising carbon cost and declines in renewable energy prices as well as the associated deteriorating credit rating
- Outputs are direct financial metrics, including adjusted probability of defaults for loans and bonds and valuation for enterprises, stocks price and bonds
- The model estimates financial impact by comparing the difference between financial metrics derived from base scenario and an alternative scenario that often refers to 2°C scenario
- Due to its high flexibility, the model is not a stand-along type of tool and involves a considerable level of sophistication for conducting an analysis

Table 18 – UNEP FI/ Oliver Wyman Extending Our Horizons Ranking & Assessment

	Criteria	Justification
General	2°C transition	The tool is generally focused around alignment to a 2°C scenario but it is not restricted to this and includes other scenarios.
	Existing users	The model derives from academic research and now is in its early stage of application. It has been applied by case studies for coal-fired power sector and oil sector. Several branches of the People's Bank of China and Chinese leading commercial banks are in discussion of applying this model to analyse the transition risk they expose.
	TCFD alignment	The tool is a scenario analysis tool, and as such it can be used to respond to the TCFD recommendations. It provides outputs in terms of value-at-risk metrics.
Nature of Risk	Asset/portfolio risk	The focuses on company scenario analysis based on which portfolio risk can be derived too.
	Country risk	Given its high flexibility, the model is able to estimate financial risks for individual assets, portfolios for financial institutions, and can also estimate the impact on key regulatory financial metrics that represent transition risks a country might face, once national asset allocation provided.
	Physical risk	The CliTRAM model only considers transition risk. However, the RCGFD team at Tsinghua has developed another model that specifically focuses on quantifying physical risks.
	Reputation/ litigation risk	While not covered by this tool, the ability to identify alignment gap to a 2°C scenario through the use of this model may be an implicit way of mitigating reputational risks.
	Types of transition risk	Transition risks including market demand change, rising carbon cost and declines in renewable energy prices (which put downward pressure on fossil fuel prices) as well as increases in funding costs (due to credit rating downgrades, and changing regulations and banks' internal credit polices).
Applicability	Geographic coverage	The model is limited to any specific geography, once data are available it is ready to analyse asset and portfolios in any jurisdictions.
	Instrument tailoring	The CliTRAM model is now applied for demonstration purpose for the probability of default of bank loans, but it is fully applicable to valuation of bonds and stocks.
	Sector tailoring	The tool covers energy (fossil fuels) and power. The intention is to expand to additional sectors in the coming future.
Implementation	Cost	The model is tailored-analysis based. Therefore, a customised analysis base normally on a commissioned project.
	Data requirements	For an analysis, inputs will require knowledge of all counterparties' International Securities Identification Number (ISIN) codes in the portfolio, their market value and the related currency, which is matched against the databases used in the tool. However, this might not be possible for SMEs and other non-listed entities.
	Difficulty	At present, an analysis by applying the model can only be conducted by the development team.
	Outputs	Outputs are mainly given in terms of a comparison of financial metrics including probability of defaults, valuations under both base scenario and an alternative climate scenario, for example 2°C scenario.
	Top down/ bottom up	The CliTRAM model is an umbrella for a series of transition risks analysis developed by Tsinghua RCGFD. Depending on customized demand, it can approach an analysis via a bottom-up based method by applying the outputs of integrated assessment models or it can also approach a risk analysis via a to-down based method by integrating the outputs of the marco-econometric method.


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