ENHANCING ENVIRONMENTAL RISK ASSESSMENT IN FINANCIAL DECISION-MAKING

In support of the G20 Green Finance Study Group

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This background paper has been prepared by specialists from the Bank of England, the UN Environment Inquiry and the University of Cambridge Institute for Sustainability Leadership with inputs from 2 Degrees Investing Initiative, ICBC, Natural Capital Finance Alliance and UN Environment Finance Initiative. The views expressed in this paper are those of the authors and do not necessarily represent the views of the GFSG.

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Executive summary

The effective identification, pricing and management of risk is an essential feature of efficient and resilient financial markets. Physical and transition factors (including environmental externalities, trends and events) are resulting in a range of financial risks, with implications for both financial institutions and financial authorities,[1] and are likely to increase in significance in the future.

The G20 Green Finance Study Group (GFSG or "Study Group") aims to develop options "to enhance the ability of the financial system to mobilize private capital for green investments". As recognized by G20 delegates in the Study Group's first year, Environmental Risk Analysis (ERA) is an important and relevant cross-cutting topic that supports the GFSG's overall strategic objective. ERA describes a portfolio of tools and methodologies that enable financial decision-makers to integrate environmental data into the decision-making process from the risk management and asset allocation perspective.

In 2016, the GFSG undertook a stocktake of environmental risk analysis activities in banking, bond markets, among institutional investors and insurance firms as well as financial authorities.[2] The stocktake identified a wide range of international ERA practices. Activity by financial institutions to assess environmental risks has been under way for several decades, but this has been sporadic in nature, confined to specific financial subsectors and far from a mainstream practice. A small percentage of financial institutions currently employ ERA in their investment decision-making processes,[3] hence, strong governance is needed to drive education, identify and obtain relevant data and build capacity within the financial system.

The nascent nature of many approaches and the financial significance of factors such as climate change, pollution and resource degradation led the GFSG to conclude in its 2016 Synthesis Report that "the GFSG/G20 could encourage further dialogue on environmental and financial risk, to facilitate knowledge exchange on methodologies for environmental risk analysis and management within the financial sector."

As a result, in 2017 the GFSG is deepening its approach to how ERA is advancing across five areas of work: i) Understanding practice via case studies; ii) Categorizing existing ERA practices; iii) A desk review evaluation of effectiveness through case analysis; iv) Identifying barriers to effective usage of ERA methodologies; and v) developing options to promote wider adoption of ERA practices. The key lessons and findings from market and policy experts are captured in the ERA Background Paper.

Environmental risk assessment: increasing momentum but not yet systematic

Environmental factors are increasingly recognized as among the most important risk factors for the global economy. The World Economic Forum's 2017 Global Risks Report, for example, concludes that four of the five top risks in terms of impact are environmentally linked: extreme weather events, water crises, major natural disasters and the failure of climate change mitigation and adaptation.[4] These physical risks and the associated transition risks (e.g. policy action to mitigate climate change) are now recognized by some leading insurance companies, asset managers and banks as potential drivers of financial losses, increasing market volatility and sector instability. Examples from practice in several G20 economies show air pollution, water scarcity and natural capital degradation may also act as sources of credit, market and legal risks for financial institutions.

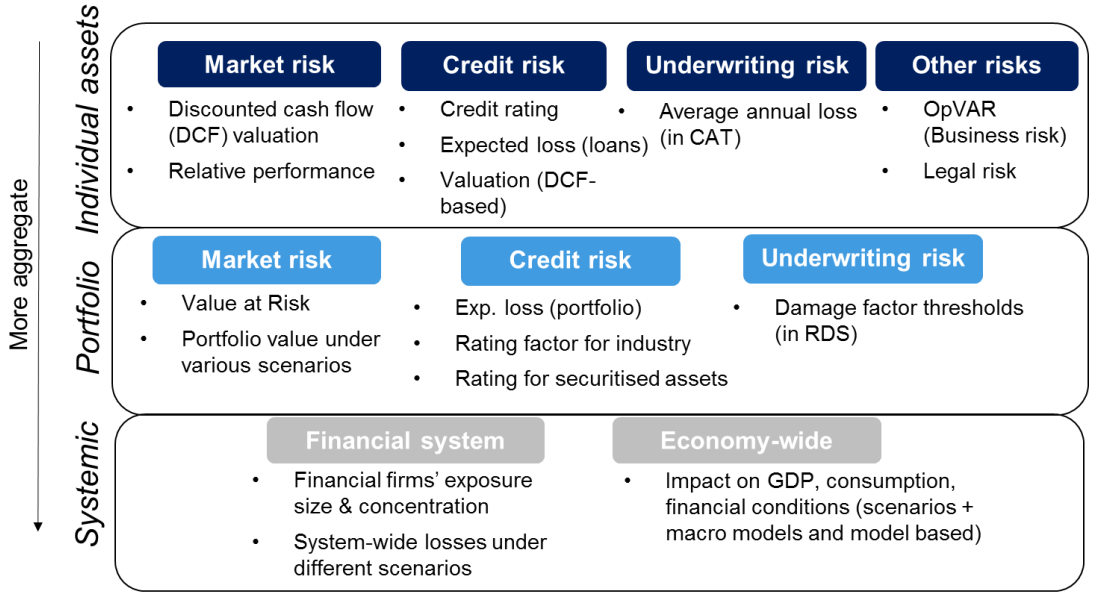
Efforts by financial institutions to assess the financial impacts implied by environmental risks have begun to increase in terms of their analytical scope and sophistication. This includes, for example, considering a wider range of environmental factors, such as those from policy and technological responses (transition risks), as well as considering the impacts of environmental events and physical

risks on a broader range of asset classes (such as sovereign debt). In addition, a growing number of public institutions in G20 member economies – including governments, regulators, supervisors and other bodies – are recognizing that environmental factors may have implications for the resilience and efficiency of financial institutions and potentially the financial system as a whole.[5] Finally, analysis of environmental factors is beginning to reveal that potential financial impacts may be non-linear and disruptive, posing challenges for risk management.[6] These developments, while significant, have not yet lead to widespread changes in financial decision-making and market behaviour, and significant questions remain regarding the most suitable approaches to assess environmental risks, and how to leverage this information for strategic action.

Categorization of Environmental Risk Assessment Tools

Environmental risks can be effectively integrated into financial institutions' decision-making process, using well-tested financial tools that can be adapted to take into account environmental factors. Financial institutions need to combine two types of approaches to assess environmental risks: 1) seeking to understand environment factors that may pose risks to financial assets and liabilities (e.g., wrong pricing of a pollution liability or natural disaster insurance policy could be a risk to liability, if the event probability is underestimated), and how such risks may evolve over time; and 2) translating environmental risk factors into quantitative measures of financial risk that can, in turn, inform firms' risk management and investment decisions. The appropriateness of risk analysis tools and associated metrics primarily depend upon the asset classes and risk types financial institutions are exposed to (e.g. a fixed income analyst may be most interested in credit risk). Similarly, the choice of approach depends on the type of direct and/or indirect exposure to an environmental risk factor. (For example, the probability of physical risks from flooding will have to be incorporated differently than transition risks stemming from the transition to a low-carbon economy). Within a given organization, different levels of analysis will likely be performed: for example, at the individual asset level, portfolio level, and at the macroeconomic or systemic level (Figure 1).

Figure ES1: Categorization of Environmental Risk Tools



Applying the Methodological Tools: Case Study Analysis

The GFSG has assessed practical examples of efforts by financial institutions, regulators, and central banks to assess environmental risks. These studies have been chosen to cover a broad and representative range of environmental risks (physical and transition), methods, time horizons and

regions of the world. Several other methods of comparable quality and focus exist that were not covered here, but could be of relevance to financial investors. A summary of the examples is provided in table 1.

Table ES1: Summary of Case Studies

Environmental Risk Factor	Country	Sector	Activity	Financial Risk Tool	Results
Transition and Physical (impact of air pollution and water risk)	China	Banking	Assessing how government efforts in dealing with pollution (e.g., via higher levies on pollutants, carbon tax and ETS system) may affect borrowers' creditworthiness	Default probability models linking pollution control measures to internal credit ratings of clients	Revision to credit policy based on expected rating migrations and loan losses for bank
Transition (impact of environmental regulation and carbon price)	Germany	Investment	Scenario analysis to assess impact of carbon and energy regulation on margins of carbon intensive firms	ClimateXcellence model	Impact on company margin in terms of € cent per kWh
Transition (impact of carbon price linked to low-carbon scenario	UK	Investment	Analysis of impacts of transition risks on German electricity utilities	SOTP valuation methodology (DCF + EV/EBITDA)	Total and per share firm valuation
Transition (climate scenarios linked to various risk factors)	International	Investment	Examining the effect of transitions risks on strategic asset allocation	Integrated assessment model incorporated in asset allocation investment model	Median additional annual returns to 2050
Transition (energy transition)	Netherlands	System	Regulatory Review of financial sector exposures to the energy transition and macroeconomic implications	Exposure analysis based on survey data disclosed by firms	% total portfolios of major financial institutions held in fossil fuels and carbon-intensive sectors
Physical (Natural Hazards)	International	Insurance	Assessing natural hazard risks to geographic coordinates	CatNet Online natural hazard risk assessment tool	Analysis of natural hazard risks at individual locations and portfolio level
Physical (Climate Change)	International	Investment (Sovereign Debt)	Assessing Physical Effects of Climate Change on Sovereign Issuers	Consideration of climate change factors within Sovereign Rating Model	Assessment of susceptibility of sovereigns to climate change risks
Physical (direct and secondary impacts of water scarcity)	International	Banking	Assessing the impacts of drought on corporate lending portfolios	Drought model (natural catastrophe, input-output model)	Overall expected losses for banking portfolios
Physical and Transition (direct and secondary impacts of natural capital degradation)	India	Banking	Examining natural capital exposure of an Indian commercial bank	Environmentally extended input output model (EEIO), India Natural Capital Model	Estimation of natural capital costs apportioned to the loans and advances, Natural Capital Exposure ratio

Lessons from Practice

Effective environmental risk assessment is integral to an iterative and strategic approach to green finance. A three-phase process can be derived:

1. **Risk Identification:** including strategic reviews using forward looking models
2. **Risk Assessment:** from basic estimation of exposure to detailed analysis of risks to assets and portfolios (stress testing, scenario analysis, modelling techniques)
3. **Risk Management**: Activities to reduce exposure and mitigate or transfer risks and redeploy investments.

In terms of risk management, financial institutions may respond to the results of risk analysis in different ways. Financial institutions may employ basic risk management actions to address near-term risks to asset values. They may also take into consideration mid/longer-term risks to portfolio values and act in a proactive manning to protect long hold investments. Further, some firms are beginning to take a more strategic long term macro response and are adjusting their investment preferences to support an orderly market transition to a low-carbon economy that could ultimately reduce risk and provide superior returns. The range of actions being taken is described further below:

- **Analysis of near-term financial impacts at an individual firm level** through more sophisticated ERA techniques;
- **Embedding ERA practices** by seeking to mainstream ERA practice across all activities;
- **Revising risk management governance**, i.e. amending credit policies, introducing sector limits; establishing board level governance to effect top-down change, thereby reducing firm/investment level environmental risks;
- **Taking action to implement the framework** through risk functions, such as:

  - **Product Innovation**, including development of 'green' products and services;

  - **Reallocating capital**, both away from assets evaluated as high-risk as well as seeking new green investment opportunities; and

  - **Engaging with stakeholders**, including clients, investees, market intermediaries and policymakers, often forming collaborative partnerships address systemic risks that fall outside immediate prudential considerations.

Barriers to effective use of ERA tools

Discussions in the GFSG and the case studies have confirmed that there are a number of challenges to the mainstreaming of ERA practice. Six key issues emerge:

i. **Technical Barriers**: Where environmental risk analysis practice is nascent, barriers can relate to the building blocks underlying ERA approaches. Barriers can include definitions and standards for risk pricing, indicators and data gaps. Where practice is developing, barriers relate to an appropriate balance between granularity, robustness and efforts to drive comparability. Where ERA practice is maturing, barriers relate to defining parameters associated with integrating complex and dynamic risks into existing systems. Overall, there is a lack of comparability in how financial institutions and regulators are seeking to analyse environmental risks. This lack of consistency is true even when applying comparatively similar tools and methodologies.

ii. **Capacity:** Many financial institutions lack knowledge on how to assess environmental risk, as well as facing a lack of understanding of best practice, and a lack of budget, staff and tools to cover all funds, with limited incentives to build such capacity.

iii. **Time Horizons**: Environmental risk factors may crystallize beyond the average time horizon of both most financial institutions and regulators – but with irreversible impacts (the "Tragedy of the Horizon"). Investing in capacity (see above) to understand long-term risk may not be a priority in short-term cost-benefit considerations. However, environmental factors may be perceived to be long-term, when in fact the financial implications can be much more immediate (for example, the penetration of renewable technologies or changes in environmental regulation).

iv. **Financial Norms and Regulations:** Financial institutions may be constrained to address environmental risk factors based on misperceptions of key requirements such as fiduciary duty.

v. **Market Incentives and Behaviour:** The current alignment of performance-linked incentives within the financial sector may act as a major barrier to taking a long-term view. Short-termism could constrain efforts to reallocate capital towards green investment options.

vi. **Policy Signals:** A lack of clear and consistent environmental policy signals, including frameworks for the low-carbon transition, remains a source of deep uncertainty for financial institutions.

From the examples reviewed, and discussions held in GFSG meetings, a number of other barriers that should be priorities for enhancing ERA practice emerged. Six key priorities include:

i. **Integration into core processes:** Environmental risk factors may be relevant to broader governance mechanisms and strategy processes, including controls on risk appetite, regulatory constraints (i.e. on risk capital), or indicators used to monitor and evaluate financial performance.

ii. **Broadening risk scope:** While attention has been concentrated on a specific set of climate and transition-related risks, efforts to assess other environmental factors (such as water and land use) have been limited.

iii. **Linking assessment across scales**: As methodologies advance, there is increasing recognition of the importance of linking risk assessment across scales: from project level, through sectors, institutions and finally financial market and system levels.

iv. **Promoting coherence in scenario analysis:** There is a balance to be struck between accelerating learning through the provision of publicly available reference scenarios, and not facilitating excessive uniformity or acceptance of ready-made scenarios without putting due thought into the assumptions.

v. **Convenience of information:** Data alone, however, has proven to be not enough – rather, the key is to translate this information to something more useful for financial industry.

vi. **Moving from a prudential to systemic view of environmental risks**: While important progress is being made using ERA to consider near-term, firm level prudential implications, the mobilization of private capital for green investments can be supported by institutions taking a wider view of systemic risks, and developing a high level, institution-wide, strategic framework to respond.

Options for promoting more effective adoption of ERA practices

At a **national level,** a range of policy options exist to encourage effective environmental risk assessment:

Encourage mainstreaming of environmental risk analysis by financial institutions. G20 members could encourage the mainstreaming of ERA practice within financial institutions. G20 members could encourage country- and sector-level industrial associations (e.g., banking, insurance and asset management associations) to promote the mainstreaming of environmental risk analysis. Mainstreaming is very much of a governance issue that requires engagement at the top of the executive level and the board level and policymaker level to embed integration and effect change.

Encourage enhanced disclosure of environmental data by corporates and financial institutions. G20 members could identify actions to strengthen disclosure of environmental risks by listed companies and issuers. One possible action in this regard could be to encourage large listed companies and financial institutions to adopt the final recommendations and supplemental guidance of the FSB Taskforce on Climate-related Financial Disclosures, pending its final release.

Encourage longer-term risk analysis. G20 members could identify ways to support longer-term risk analysis, including by stimulating demand for long-term risk analysis in the marketplace through policy frameworks or incentives. G20 members could also seek to review existing financial sector policy frameworks to review potential unintended barriers to the mainstreaming of environmental risks by financial institutions, including considering institutional responsibilities to consider systemic, as well as prudential risks and to develop strategic frameworks to support an orderly market transition.

Support policy alignment relating to environmental factors. G20 members could seek to support alignment between policy, regulatory, and legislative frameworks to generate consistent signals relevant to environmental factors, reducing policy uncertainty for financial institutions. Such efforts could include identifying ways to clarify alignment between economic growth strategies, environmental governance and enforcement, and financial sector strategies.

Encourage public institutions to assess environmental risks and their financial implications. G20 central banks, supervisors and regulators could consider deepening research to advance initial assessments of physical and transition risks and their implications for financial institutions, financial sectors, and ultimately the financial system.

Support capacity-building through engagement and policy frameworks. G20 members could seek to encourage financial institutions to building capacity in environmental risk management. This may include through supervisory engagement with firms and the provision of voluntary guidance, drawing on best practices. G20 members could also seek to support international collaboration among financial institutions to share information on ERA methodologies and lessons from experience.

1. Introduction

This background paper provides inputs to the G20 Green Finance Study Group (GFSG) Research Subject on enhancing Environmental Risk Assessment (ERA) in Financial Sector Decision-making.

1.1. GFSG Work on ERA to date

In 2016, the GFSG considered risk analysis as a cross-cutting issue with relevance for efforts to green the banking system, bond markets and institutional investors.[7] As part of this work, the GFSG considered how and why environmental risks may be relevant to financial institutions, described leading risk assessment practices and identified areas for further work. This included:

i) Development of a background paper[8] taking stock of emerging risk assessment approaches across banking, investment and insurance firms, as well as activities by financial regulators and central banks.[9] From this work, the GFSG set out a framework to clarify how environmental factors may affect financial institutions, mapping physical and transition risks arising from environmental triggers against an established typology of "business" (including operational and reputation risk), "legal" (including liability risk), "credit" (including underwriting and counterparty risk), and "market" risks (Table 1).

Table 1: Taxonomies of Environmental Triggers and Financial Risks

		Financial risks			
		Business	Legal	Credit	Market
Environmental sources	**Physical** - Climatic - Geologic - Ecosystems				
	Transition - Policy - Technology - Sentiment				

Source: GFSG, 2016

ii) Workshop on Modelling and Assessing Environmental Risks, held in Bern in May 2016. At this workshop, the GFSG and external participants identified the need for further work pertaining to risk analysis in several areas, including:

- Making adequate and more granular data or metrics more readily available,
- Developing more commonly accepted methods and models,
- Improving the effectiveness of models, and
- Improving awareness of potential longer-term risks associated with climate and environmental change in the mainstream of the global financial sector.

The novelty of many approaches and the financial significance of factors such as climate change, pollution and resource degradation led the GFSG to conclude in its 2016 Synthesis Report that "the GFSG/G20 could encourage further dialogue on environmental and financial risk, to facilitate

knowledge exchange on methodologies for environmental risk analysis and management within the financial sector."

1.2. Why Focus on ERA?

Environmental factors are increasingly recognized as among the most important risk factors for the global economy. The World Economic Forum's 2017 Global Risks Report, for example, concludes that four of the five top risks in terms of impact are environmentally linked: extreme weather events, water crises, major natural disasters, and the failure of climate change mitigation and adaptation.[10]

The effective identification, pricing and management of risk is an essential feature of efficient and resilient financial markets. Environmental events and externalities resulting in financial risk are increasingly material for both financial institutions and financial authorities and are expected to become more so in the future.

A lack of robust assessment of environmental risks could lead to mispricing of assets, exposure to "stranded assets", and flawed capital allocation, which may result in excessive investment in polluting sectors and underinvestment in green sectors. Currently, only a small fraction of financial market participants integrate environmental risks into their financial decision-making process in a systematic way. A more comprehensive integration of environmental risks is an important first step to ensuring the safety and soundness of financial assets. An informed and forward-looking governance framework that applies this information across a range of strategy and business development imperatives is necessary. Finally, this information can help motivate improved capital allocation decisions, enhancing the capacity to mobilize private capital for green investment.

Efforts to identify, assess and manage environmental risks will require relevant information from market participants and other sources that can be processed in a coherent and comparable manner.[11] Currently, much of the innovation in the design methodologies for environmental risk assessment is being led by major international financial institutions, taking place with the support of boutique-type providers, including specialized NGOs, academic institutions and financial sector spin-offs. In itself, a diversity of methodologies is not a problem. However, a persistent divergence of methods may pose risks for comparability across firms, coherence in responses and strategies, and overall cost-effectiveness.

Efforts to enhance ERA in financial decision-making are critically linked to the broader agenda relating to environmental disclosure at national and international levels (notably with the release of the FSB Task Force on Climate-related Financial Disclosures Recommendations Report in December 2016[12]). Similarly, such efforts are complementary to efforts by the G20 GFSG Publicly Available Environmental Data (PAED) Research Subject in drawing in new sources of information to enhance risk analysis.

1.3. Building Momentum on ERA

Activity by financial institutions to assess environmental risks has been under way for several decades, but this has been sporadic in nature, confined to specific financial subsectors, and far from mainstream practice.[13] During recent years, efforts have significantly accelerated in terms of their analytical scope and sophistication, leading to greater impacts on financial decision-making and market behaviour.

Looking across the financial sector, there is increasing interest in understanding how environmental factors may pose physical and transition risks to assets, firms, and corporate sectors, which in turn may pose risks to financial assets, institutions and sectors. A range of issues are considered, such as air pollution, decarbonization pathways, natural hazards and water stress. Analysis of these factors is

revealing that financial impacts can be non-linear and disruptive. In addition, new classes of assets (such as sovereign bonds) are coming into focus as potentially vulnerable to environmental risks.

At the same time, an increasing number of public institutions in G20 member economies – including governments, regulators, supervisors and other bodies – are recognizing that environmental factors may have implications for the resilience and efficiency of financial institutions and potentially the financial system as a whole. Central banks and financial regulators in several G20 countries have undertaken activities to deepen their understanding of environmental risks at sector and system levels. Collectively, new coalitions between public institutions are emerging to support international collaboration on sector-specific challenges (i.e. Sustainable Insurance Forum[14]).

1.4. GFSG Approach in 2017

In 2016 the GFSG undertook a mapping exercise to identify leading ERA practices; however, it did not seek to evaluate the breadth, depth or impact of these practices. Going into 2017, the GFSG seeks to build on its work to date by deepening the understanding of how ERA practice is advancing across the financial system, including:

- what leading ERA approaches are moving to scale;
- how improved ERA practice is affecting financial decision-making (including risk pricing, risk appetites and capital allocation); and
- how improved ERA practice could stimulate or constrain green investment.

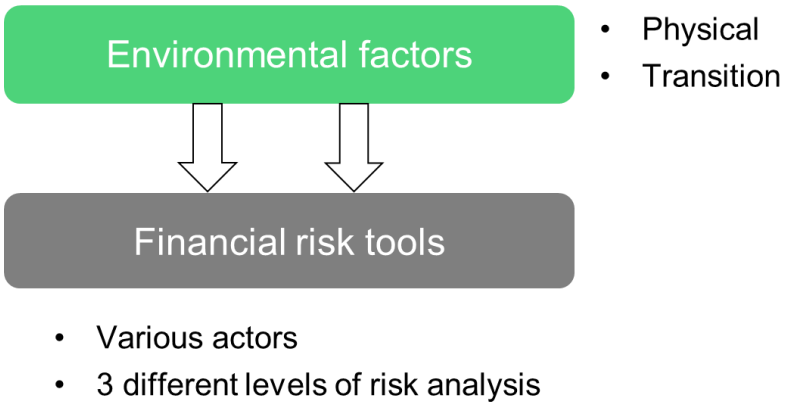
At the first meeting of the GFSG under the 2017 German G20 Presidency in Frankfurt, the GFSG agreed to take forward an approach involving four areas of work: i) Categorizing existing ERA practices; ii) An evaluation of effectiveness through case analysis; iii) Identifying barriers to effective usage of ERA methodologies; and iv) Developing options to promote wider adoption of ERA practices.

2. The Environmental Risk Analysis Toolbox

2.1. How to Price Environmental Risks?

When actors in capital markets, banks and insurers analyse the financial impacts of climate change and other environmental risks, two types of approaches need to be combined (Figure 1).

Figure 1: Two Elements of Environmental Risk Analysis



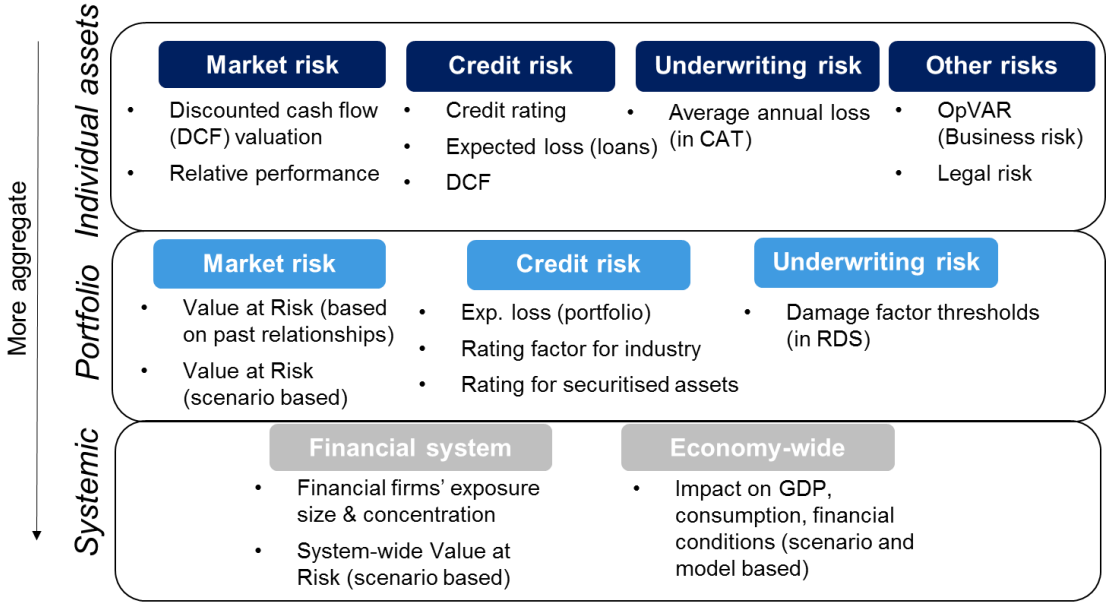
- **Environmental factors:** A first step is seeking to understand how environmental factors may pose risks to financial assets, and how such risks may evolve over time. Such factors may include the direct risks such as physical impacts of climate change to real economy assets, or indirect risks posed by policy and market responses to environmental factors. Notable in this respect are transition scenarios, which simulate how a transition to a low-carbon economy could play out across different sectors and countries.[15] If firms are unprepared for either the physical impacts or for the low-carbon transition, they can be faced with credit, market, business and legal risks.
- **Financial risk analysis tools:** Environmental factors have to be translated into quantitative measures of financial risk that can, in turn, inform risk management. For instance, an investor may not find it very useful to merely know that an area where an asset is located is likely to suffer from droughts. But once this is expressed as the potential impact on the valuations of agricultural producers and water-using electricity generation plants in that region, the investor can take it into account in their capital allocation decisions. The following section provides an overview of these types of financial risk tools and metrics.

2.2. Using Archetypical Financial Tools for Environmental Risk Analysis

The type of financial tools applied to assess environmental risks depend on the needs and constraints of different financial actors, and may vary depending on classes of financial holdings, balance of retail vs. capital markets activities, and the risk analyst's position in the capital allocation chain. Financial regulators and central banks may also seek to assess how environmental risks may affect the safety and soundness of regulated firms through supervision, as well as exploring the potential for environmental factors to pose systemic risks.

Risk tool needs primarily depend on the different assets classes via which financial institutions may be exposed to direct and indirect environmental risk factors. Within a given organization, different levels of analysis will likely be performed: some teams will assess individual assets, while others perform portfolio level risk analysis while still others look at the macroeconomic or systemic level (Figure 2).

Figure 2: A Toolbox for Environmental Risk Assessment



Source: GFSG, 2017

2.2.1. Individual Asset Analysis

- Equity analysts use valuation tools such as discounted cash flow (DCF) models, which take into account the riskiness of an asset. Environmental factors could be taken into account by adjusting either the expected future cash flow or adjusting the risk premium applied to future cash flows, impacting the valuation of an equity security. For example, increased water stress for agricultural producer will result in lower expected future earnings which will decrease the value of its equity valuation today. Equity analysts could use models or *ad hoc* assumptions to project how earnings or the risk premium are affected by environmental risks.
- Analysts that look at the credit risk of bonds are focused on the issuing firm's capacity to repay the borrowed funds, and thus focus more on short-term financial buffers than medium-term cash flows. These are key factors feeding into a bond-rating decision. However, for longer-dated securities, the impacts of environmental factors and impacts on future cash flow analysis receive more attention, including for rating decisions.
- When looking at loans extended by banks, credit risk analysts use tools such as expected loss (based on probability of default and loss given default). Similar to bond analysis, banks will have to judge how environmental factors affect the credit risk of the entities to which they lend, through reduced cash flows, higher costs or degradation of collateral value.
- Insurers have the longest track record in developing and applying models to estimate financial losses arising from environmental hazards, primarily to inform underwriting decisions. Catastrophe Risk Models integrate environmental information.

Table 2: Examples of Individual Asset Analysis Assessed by the GFSG in 2016

Asset type	Market risk	Credit risk (bonds)	Credit risk (loans)
Example	Allianz Global Investors	S&P/SwissRe	Moody's
Environmental factor	Transition: Climate regulation and introduction of carbon price	Physical: Cyclones and floods	Physical: exposure to a range of physical climate risks and economic resilience to them
Financial risk metric	Reduced profit, DCF-based valuation	Impact on sovereign rating	Adjust credit ratings of sovereigns that are highly exposed

2.2.2. Portfolio Level Risk Analysis

Beyond pricing the risk of individual assets, financial sector actors have started to price environmental risk on a more aggregate, portfolio level (Table 3). This could either build on individual asset assessment which is then aggregated (such as done by ICBC) or start with some more aggregate risk factor that affects industries across the board (such as done in the Mercer study). In both cases, the risk metric applies to the *aggregate* exposures.[16] Also, here the distinction between market and credit applies, depending on the assets in the portfolio. And the interpretation of the metric will depend on the approach used to obtain it. For instance, on the market risk side, value at risk (VaR) in its standard form is based on past distributions. But in environmental risk analysis, a forward-looking estimate could also be obtained through scenarios (as in the Mercer study). On the credit risk side, ratings for entire industries or assets in a given country can be impacted by environmental factors. Similarly, on the insurers' liability side (underwriting risk), physical risks may apply to groups of policy owners that are located in the same physical risk area.

Table 3: Examples of Portfolio-level Analysis Assessed by the GFSG in 2016

Type of portfolio	Market risk	Credit risk	Underwriting risk
Example	Mercer	ICBC	Lloyd's
Environmental factor	Identify high-risk factor	Three scenarios of stricter regulation of air and water pollution	Physical: Shock to global food production
Financial risk metric	Relative performance against alternative portfolio	impact on the credit quality of commercial banks' portfolio	RDS: losses based on expert judgement

2.2.3. Systemic Level Risk Analysis

Both private sector actors and regulators have an interest in how physical and transition risks could affect the stability of the system as a whole (Table 4). Given their financial stability mandate, several regulators have started to analyse the exposures to climate-related risks of the institutions they supervise. This includes estimating the total exposure of the system but also analysing whether there are pockets of the financial system in which risks are concentrated. Beyond the direct financial

stability impact, system-level risk analysis can bring out what the risks to the economy as a whole are. This, often, will go beyond looking at exposures and towards estimating potential impacts on GDP, consumption and financial conditions – if risks materialize. Economy-wide risk analysis will require some kind of macroeconomic model that estimates the feedback effects between sectors of the economy. Both approaches though aim to quantify the environmental risks on a systemic level.

Table 4: Examples of System-level Analysis Assessed by the GFSG in 2016

Feedback module	Financial system	Economy wide
Example	DNB	UBS
Environmental factor	Identify key transition risk sectors	Physical risk: flooding in key coastal cities, followed by transition risk: including global carbon pricing agreement
Financial risk metric	Total exposure of financial institutions	Effect of regulation and physical damages on financial market and GDP

Notwithstanding the examples shown above, financial markets' experience with pricing environmental risks is still limited. Progress to date has been concentrated on certain factors – such as risks posed by high-carbon assets to investment portfolios, or physical risks to insurance liabilities. Since the GFSG's initial analysis in 2016, several leading financial institutions and public bodies have taken forward effort to deepen understanding of new risk factors, increase the robustness of approaches and using insights generated through risk assessment activities to inform strategic decisions.

3. Case Studies

This section reviews examples from financial institutions, regulators and central banks seeking to assess different dimensions of environmental risks. These examples are organized into two main sections:

I. Transition Risks

II. Physical Risks

The objective of this case analysis is to learn lessons about the effectiveness of ERA tools in terms of their practical application, identifying any emerging lessons or insights, to substantiate the generation of policy options for consideration by the GFSG. This study is neither a comprehensive nor exhaustive catalogue of efforts by private and public institutions to assess environmental risks. Due to the proprietary nature of most financial risk analysis, we acknowledge that relevant examples or lessons may not be reflected. The following sections are organized to:

- Identify the specific scale and nature of the financial risk challenge relevant to the area (transition or physical risks);
- Profile examples of leading practice by private and public institutions, review initial findings, evaluate impacts, assess gaps and barriers, implications;
- Assess the breadth and depth of ERA relevant to a given transition or physical risk factor within mainstream financial practice; and
- Identify emerging lessons or insights for policy options.

Examples from practice are reviewed in a consistent format to ensure comparability:

A) Summary

- Overview of approach and key findings

B) Evaluation

- Impacts
- Gaps
- Barriers

C) Implications

- Options for improvement and next steps for mainstreaming
- Potential implications of broader uptake/mainstreaming
- Lessons for policy options

3.1. Transition Risks

The transition to low-carbon growth may pose a range of risks to the financial system. At the local and national levels, environmental factors such as local air pollution are inspiring a range of market, policy and social responses, affecting the operations, risk management practices and corporate strategies in energy and industrial sectors. At the international level, the establishment of a global climate agreement sets a clear path for rapid decarbonization. Technological innovations in energy systems, communications and within the financial system itself are disrupting markets and business models, and challenging incumbents. If the transition to a low-carbon economy is unmanaged and

disorderly, this range of interlinked factors is likely to pose significant implications for the value of real assets, firms, and corporate sectors – and the value of securities and financial assets derived from them.

Transition factors may pose complex constellations of risks to financial institutions stemming from interlocking social, policy, market and technology factors, which may have non-linear and compounding relationships across asset classes:

- A key transmission mechanism is the financial system's exposure to high-carbon assets in the real economy and the risk that these could potentially become "stranded" as a result of the low-carbon transition. Tightening air and water pollution regulation, increased energy efficiency and the rising share of renewable energy have already had serious implications for valuations in the coal,[17] oil[18] and gas[19] as well as power generation sectors.[20,21]
- On the upside, the rapid expansion of clean technology (including renewable energy resources) can have non-linear and disruptive impacts on financial performance in both high- and low-carbon sectors, yet may also be characterized by volatility, affecting capital markets.
- Due to their interlinked nature, transition risks may pose a range of primary and secondary impacts within the financial system, potentially leading to cascading financial losses and the disruption of markets. For example, rapid changes in investor sentiment and herding behaviour may exacerbate the impacts of transition risk.

In 2016, the GFSG considered a range of risk assessment case studies relating to air pollution, climate change and transition risks, including stress testing and scenario analysis approaches.[22] This year, we revisit some of these examples to deepen understanding on how risk analysis has led to changes in financial decision-making and market behaviour.

3.1.1. Societal Responses to Air and Water Pollution

Environmental impacts stemming from carbon-intensive economic growth – including air pollution, soot, sulphur and nitrous oxides, and other particulate matter – have long been a critical environmental and public health concern in many G20 economies. Despite efforts to constrain pollutants, the costs of air pollution to society continue to mount – with a human toll of 6.5 million premature deaths every year resulting from energy sector air pollution alone.[23] Social and reputational risks stemming from localized air pollution in G20 countries – such as China – are recognized as potentially disruptive to the credit performance of bank assets, including loans to the heavy industry (i.e. ICBC). Legislation aimed at addressing air pollution – such as the Clean Power Plan in the United States, or Industrial Emissions Directive in the European Union – may affect the financial health of high-polluting sectors and assets, affecting investment portfolios.

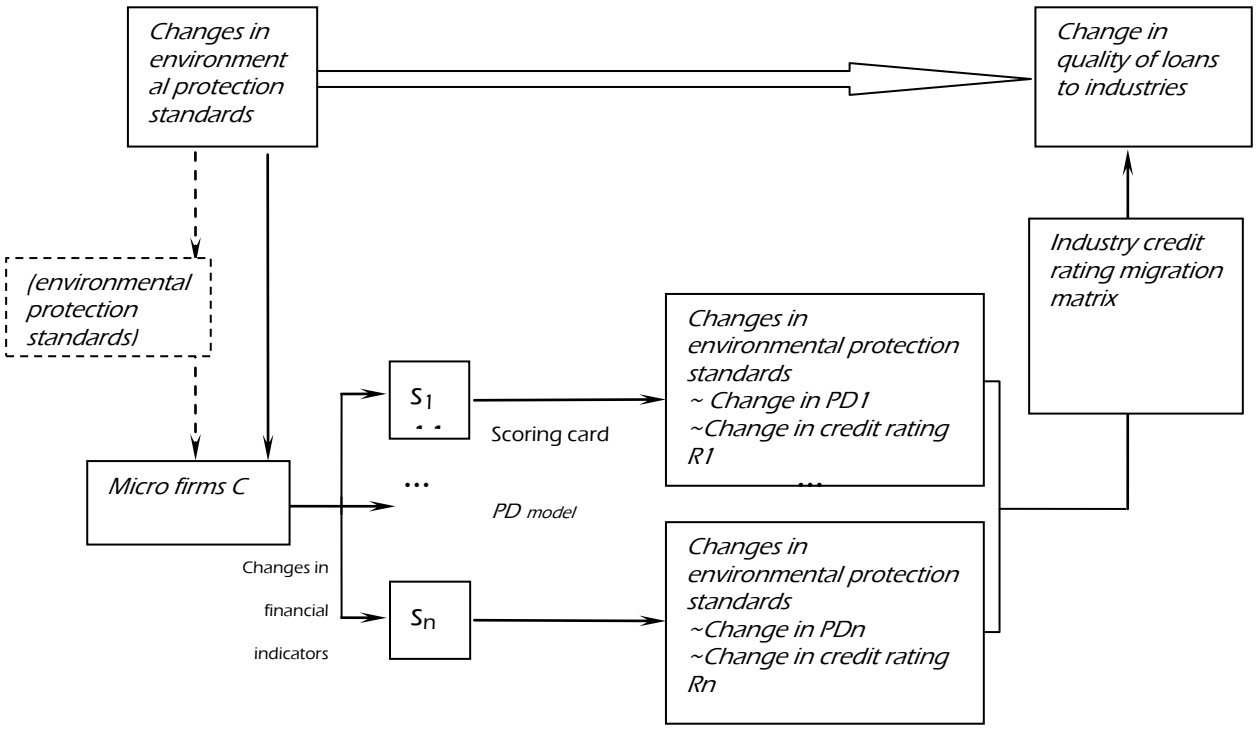
ICBC (China): Stress testing the impact of environmental factors on a Chinese commercial bank's credit risk

A) Summary

Sector	Banking
Environmental Risk Factor	Transition: Impact of air and water pollution regulations
Level of Analysis	Portfolio
Financial Risk Typology	Credit
Financial Risk Tools	Credit rating model
Quantitative Results	Probability of defaults, credit rating migration matrix

Overview of approach and key findings: Motivated by declining air quality and its potential public health impacts, ICBC developed a stress test methodology to analyse the impact of possible environmental standard improvement on the credit rating of thermal power and cement industry clients. In China, the government has a relatively clear timetable of launching a series of health-related environmental policies, which will affect companies' costs and revenues, and therefore have an impact on the credit quality of commercial banks' portfolio. Based on three scenarios for strictness of air and water pollution control, the model estimated the financial effect of near-term impact (up to 2020) of these regulations on key performance indicators such as cost of goods produced and revenue in the income statement and the balance sheet (Figure 3). The model consists of two parts, financial indicators and qualitative evaluation performed by credit analysts – as visualized in Figure 3.

Figure 3: ICBC Stress Testing Model



Source: ICBC, 2016

The recalculated financial indicators were then incorporated into the rating model. When calculating the changes in the probabilities of default, ICBC amended the qualitative indicators in proportion to the decreases in the quantitative indicators. The results showed that under severe scenarios, the thermal power production industry experiences certain cost pressures, but ultimately remains stable given the steady growth of the economy and the huge demand for electricity. Confronted with financial pressures, small- and medium-sized enterprises will be under most stress and experience the most significant credit rating migration. For the cement industry, the analysis finds that raised environmental standards will impose relatively substantial financial pressure on the industry, seeing it enter a low-growth stage by and large, with continued pressure to reduce capacity. Again the analysis pointed to potential for credit rating migration on small- and medium-sized enterprises.

B) Evaluation

Impacts: This report represents the first attempt to conduct a transition risk stress test by ICBC. Therefore, although systematic, the methodology used in the analysis is not seen as sufficiently developed internally for its results to inform lending decisions or to be incorporated in the day-to-day client ratings at this stage. Therefore, the impact of the study so far has been on the consideration of potential amendments to credit policies in the coming year by the loan department, as well as the stimulation of capacity-building and knowledge-sharing. Nationally, the Green Finance Committee, convened by the People's Bank of China, is now promoting the ICBC stress test in China, with further plans by the ICBC to share the methodology. As part of the latter activities, the group is preparing to publish a stress test book in September 2017.

Gaps: The exercise is based on a proprietary model, and the public report contains limited information on the companies it analyses beyond the fact that they are part of the ICBC portfolio. This is not surprising, given that client data and models are sensitive information for financial firms, however it makes it difficult for others to evaluate or replicate findings. Methodologically, the modelling is not dynamic, as it does not incorporate potential mitigation plans by companies. This complicates the differentiation between companies within the same sector and geography. Dynamic modelling is constrained by the current unavailability of data on company-level forward-looking risk mitigation strategies. Process wise, it is an ad-hoc exercise with no existing plans to repeat sectoral tests periodically.

Barriers: Availability and accuracy of data makes dynamic company level analysis difficult. Absence of sophisticated and tested methodologies hampers mainstreaming, as methodologies are not seen as robust enough to be used in mainstream credit tools.

C) Implications

Options for improvement and next steps for mainstreaming: In order to develop the methodology, ICBC is in the process of conducting two further tests. First, together with China Lianhe Equator Environmental Impact Assessment, ICBC is working on a stress test for the iron and steel industry. In this test, ICBC is looking to assess the impact of three levels of stress as per a range of policies and standards that have been established or are about to come out. Compared to the thermal power and cement stress test, two improvements have been made. Firstly, given differences in technology and potential degree of pollution, the stress test has been conducted separately for steel enterprises with the capacity of 10 million tons and 3 million tons (crude steel). Secondly, both end-of-pipe and in-process pollution control have been taken into consideration, such as pollutants reduction in sintering, iron-making and steel-making process. The second test on the aluminium industry will be conducted in cooperation with UK-based Trucost. Compared with previous tests, this test is looking

to incorporate new factors such as environmental emission tax, carbon trading and water consumption.

In addition to these plans, it would be beneficial to consider implementing dynamic modelling, as it can help differentiate between companies in the sector. In the absence of additional quantitative data on mitigation, adjusting qualitative indicators in the rating scoring sheet can be used to differentiate between the ability of companies to react to new air and water pollution controls. Finally, extending the analysis to Scope 2 and Scope 3 emissions would provide a more comprehensive economy-wide picture of the impact.

Within the bank, there are two potential options to mainstream this type of analysis. The first one would be to conduct these tests on a regular basis with the main output being a consistent sector strategy that directs lending and investment into the sector, thereby using the tests to set sectoral risk appetite. To facilitate senior management discussion, this could be complemented by a heat map, which is colour-coded to show the relative financial impact of environmental sources of risks for each sector in the portfolio. Such a heat map would direct attention to the size of the exposure at risk in energy-intensive sectors. The second option would be to use this analysis to provide an internal environmental rating for every client, which would be updated by credit risk analysts in their yearly client review cycle. Once the analysis is sufficiently developed, the scoring metrics used to provide the environmental rating could be incorporated into the main credit rating model, which would ensure that the credit rating incorporates environmental factors.

In terms of broader next steps, meaningful and valid company level disclosure would enable financial firms to conduct dynamic analysis. Further, more progress needs to be made on the development of sophisticated environment risk analysis methodologies. An industry-level conversation, convened by regulators and/or academic institutions could drive methodological development, as well as contribute to raising confidence in the approaches used. More sophisticated methodologies together with increased confidence in the approaches would encourage mainstreaming.

Potential implications of broader uptake/mainstreaming: Based on the assumption that this analysis incorporates a dynamic element, covers all the companies within the cement and thermal power sector, and is adopted across the Chinese banking sector, it might have the following consequences for the industry as a whole. In the presence of valid and meaningful disclosure about possible company level mitigation strategies, the flow of lending and investment within these sectors would be directed to the companies that are better able to absorb or mitigate the effects of environmental policies. In the absence of such disclosure, the flow of lending in the sector would be directed to the better rated corporates under the assumption that better rated corporates will have more financial resources to deal with the effect of the policies. Further, if the analysis is mainstreamed across a number of climate relevant sectors, the lending flow could be redirected towards the sectors, the cost structures of which are the least affected by the introduction of new environmental policies.

Lessons for policy options: A clear timeline of implementation of environmental policies creates confidence that constructed scenarios are adequate, and directs attention from scenarios towards methodologies. This underscores the benefits of policy signalling at the international level. The lack of sophisticated methodologies and efforts to share knowledge would certainly support the creation of a knowledge-sharing platform, required to build capacity at firm level. This would remove methodological barriers to mainstreaming.

3.1.2. Managing the Decarbonization Challenge

Decarbonization poses long-term investment risks for high carbon sectors, notably fossil fuels. Research by Barclays has estimated that a 2°C pathway could reduce the revenues of the upstream fossil fuel industry globally by a cumulative US$33 trillion by 2040.[24] Concerns that assets could become 'stranded' in the transition have prompted an increasing number of investors to assess their carbon exposure and then take action to reduce it.[25] Institutions with over US$10 trillion in assets have committed to publish a 'carbon footprint' of their portfolios,[26] and a leading group is going further by taking action to cut the emissions across US$600 billion of assets.[27]

Carbon risks have attracted the greatest attention from institutional investors, some of whom have undertaken primary research with proprietary models to assess risks to portfolios (i.e. **Allianz**). Interest from asset owners has influenced other actors across the investment chain to devote an increasing share of analytical efforts to understanding and quantifying transition risks, including providers of investment research (i.e. **Barclays**), and investment consultants (i.e. **Mercer**). Beyond the financial sector, NGOs are developing innovative approaches to understanding alignment of portfolios with low-carbon transition policy objectives (i.e. **2 Degrees Investing Initiative**). The key now is to strengthen the link between macro-level scenarios and micro-level impacts on assets – clarifying how ERA is relevant to every-day decision-making, including strategic asset allocation.

Governments and financial regulators in an increasing number of G20 countries[28] (including France, Germany and the UK) are seeking to better understand how transition risks related to carbon assets may hold implications for safety and stability of financial institutions, sectors, the system and the broader macroeconomy. Recently, the German Federal Ministry of Finance commissioned a study examining the impacts of climate change on financial stability in Germany, released in December 2016.[29]. Action by **DNB** in the Netherlands represents a leading approach to assessing aggregated exposure to carbon assets across sectors and by asset class.

Allianz (Germany): Using scenario analysis to assess the impact of carbon and energy regulation in equity analysis

A) Summary

Sector	Investment
Environmental Risk Factor	Transition (impact of environmental regulation and carbon price)
Level of Analysis	Company
Financial Risk Typology	Market
Financial Risk Tools	ClimateXcellence model
Quantitative Results	Impact on company margin in terms of € cent per kWh

Overview of approach and key findings: This institutional investor has developed, with partners, a methodology for modelling the impact of different carbon- and energy-regulation scenarios on the margins of individual carbon-intensive firms so as to support improved stock picking. Working together with the CISL Investment Leaders Group (ILG), the investor has agreed that the most useful impact metric would be the impact on the company margin. Using a reiterative consultation process with the CISL ILG, consensus was achieved on two relevant regulatory scenarios: the transition scenario, which comprised regulations or regulatory changes that have been discussed in the course of election campaigns, were within a legislative process or were confirmed as coming into

effect by 2020, and the '€45 Carbon Price Scenario', which builds in a €45 price on carbon, based on the median Intergovernmental Panel on Climate Change (IPCC) carbon price assumption for achieving a 2°C world. It then used the ClimateXcellence model in order to analyse the near-term (up to 2020) impact of these two scenarios on company margins. Due to its ability to incorporate potential risk mitigation actions at the company level, the model enables investors to differentiate between companies within the same sector and geography. The initial focus was on the dairy and cement industries in Germany, the US and China; this was followed up by analysis on the oil refining, gas production and electric utility sectors in Spain, the UK and Canada. The results reveal significant (positive and negative) impacts of both scenarios on company margins in the utilities sector. The impact of the introduction of the carbon price scenario would have been significant across sectors. Further, the use of dynamic modelling demonstrated significant differences between firms within the same sectors and geographies.

B) Evaluation

Impacts: The original intention of the tool was to contrast the impact of a number of scenarios on the margins of a high energy-intensive (cement) and low energy-intensive (dairy) sectors. The tool was envisaged to encourage equity analysts to model the impact of carbon prices on company financials within the mainstream modelling tools. However on closer analysis, the company-level data disclosure (particularly in the dairy sector) was insufficient to warrant mainstreaming. In addition, equity analysts did not feel that the results were sufficiently material to immediately incorporate them into the models.

The key impact of the tool was to educate and build capacity among equity analysts to analyse the impact of environmental regulation and the introduction of the carbon price on their companies. As a result of this process as well as the overall higher profile of the environmental issues at the European and global level, mainstream analysts are now more aware of the types of impacts that can be seen. Further, the building of the tool has encouraged closer cooperation between environmental risk and mainstream analysts – leading mainstream analysts to approach environmental risk analysts more frequently, with questions driven by increasing client demand, and higher levels of understanding of potential impacts.

Gaps: The tool is still under development. It is based on a proprietary model, which is very data-intensive (with limited public data available). The scope of the analysis is currently limited to a few markets for country operations and is therefore not representative of full company exposure necessary for valuation purposes. Further, the tool has so far been configured to be limited to a set scenario, and ideally firms should be able to set a number of their own scenarios. Extrapolating from the tool to a situation where this type of analysis was performed more generally, there is currently a gap in understanding which data points (or key performance indicators) are critical for understanding the impact of environmental, social and governance (ESG) factors on a company's financial performance in a particular sector. More analysis is needed to find and validate these data points.

Barriers: Availability, accuracy, consistency and comparability of firm level data, together with firm level mitigation strategies makes the analysis difficult. A negative feedback loop can be seen emerging with respect to the provision of ESG data in the market: as there is not enough high quality data for ESG to become a strong signal within the market, it cannot become a differentiating factor for the valuation of securities – which in turn reduces incentives for data provision. Beyond this, more fundamental barriers to mainstreaming remain – currently, the majority of financial analysts are not convinced of the business case for incorporating these types of indicators in their everyday analytical functions. Efforts to support mainstreaming are hampered by high costs of

evaluating and maintaining data, and effectively considering the breadth of different regulatory environments affecting sectors at national and international levels.

C) Implications

Options for improvement and next steps for mainstreaming: A number of opportunities could be taken forward to improve this approach. Firstly, the tool can be developed to allow financial firms and equity analysts to configure and change input scenarios. This would stimulate diversification in terms of the assumptions made and allow financial firms to incorporate proprietary knowledge into the tool. Secondly, it can cover the full operations of a particular company, ensuring a better fit with valuation models. Thirdly, it could be amended to consider Scope 3 emissions. In terms of approach to the tools, it would have been beneficial to raise awareness and build capacity among mainstream analysts before introducing the tool.

More generally, there are a number of ways to aid mainstreaming. The first one would be for equity analysts to use margin impacts calculated by the model in order to understand potential equity price implications of the analysis, and if these implications are material, base their pricing recommendations on it. While such mainstreaming will help divert financial capital flows to those companies better able to adjust their business models, it depends on a number of factors. One of these factors is the ability of the model to allow users to set their own scenarios and input parameters. Another is the consistency and strength of policy signals, which would direct analysts' attention to the need to model the impact of incoming regulations. The final factor is a more nuanced understanding of the key sector-specific indicators that are influenced by ESG factors in the firms' financial statements. Another way to aid mainstreaming would be to use the tool in order to analyse the effectiveness and the impact of particular mitigation measures on financial performance. This would help companies calibrate the effectiveness of their potential response to the incoming regulations.

A number of steps could be taken to address barriers to implementation. Within firms, although equity analysts may be already required to know and understand ESG ratings of the companies they cover, this could be reinforced by management attention to the issue. Such attention could take the form of following up with the analysts of low-rated companies and encouraging them to engage with the companies on the issue. In the market as a whole, there could be appetite for more reference scenarios to encourage discussion and debate. Another potentially game-changing intervention would be for a very large player in the market to publicly announce that they have mainstreamed the approach and that they are seeing substantial benefits to such mainstreaming in terms of performance metrics. Finally, at the national and international level, policy signalling or regulation is key to getting this on the agenda of mainstream financial analysts.

Potential implications of broader uptake/mainstreaming: The more general application of this approach within the bottom-up financial analysis to enable stock picking would firstly automate the currently very complicated and manual process of discerning which company is better positioned with respect to transition risk. The automation of this approach would enable more large-scale analysis to be conducted and effectively increase "green liquidity" as there would be an improved market understanding of where the border between "green" and "brown" lies. Further, mainstreaming such approaches would divert the flow of equity capital to those companies, which have disclosed the most effective mitigation strategies/policies. This might stimulate voluntary disclosure among the more advanced corporates, while at the same time hindering general disclosure for those with a less compelling story to tell. This effect would be seen within sectors as well as across sectors. Finally, given that one of the strengths of this analysis is the granular country-

level analytics, it will enable equity analysts to conduct a more nuanced, effective and accurate analysis of the effect of national regulations on multinational companies.

Lessons for policy options: Judging by the overall appetite for knowledge-sharing, a platform that would enable such activities would be beneficial as it would raise the profile of the issue at hand, signal policy intentions and allow organizations to build capacity in terms of sharing data, developing scenarios as well as methodologies. This case also points to the importance of raising awareness of the potential for environmental factors to have near-term financial relevance – which could be supported by further sharing of information on the benefits of conducting robust ERA, and complemented by activities within public institutions to raise the profile of environmental issues in risk contexts (i.e. through supervisory engagement). Finally, one further option to tackle the tragedy of the time horizon would be to de-emphasize quarterly company reporting, and identify options to encourage the application of performance metrics linked to longer time frames. This could help generate demand for financial analysis on longer-term trends, which in turn may illustrate the importance of environmental risks to future value generation.

Barclays (UK): Analysis of impacts of transition risks on German electricity sector by international investment bank

A) Summary

Sector	Investment
Environmental Risk Factor	Transition - Impact of potential environmental regulation via recalculation of the carbon price
Level of Analysis	Firm
Financial Risk Typology	Market
Financial Risk Tools	DCF + EV/EBITDA
Quantitative Results	Total and per share firm valuation

Overview of approach and key findings: In their September 2016 equity research note *German Utilities: Scoping the 'Tragedy of the Horizon'*, Barclays attempted to demonstrate the impact of transition risk on the German utility sector by assessing the equity price impact of two potential carbon pricing scenarios on the valuations of different fossil fuel plant portfolios of RWE and E.ON. The scenarios addressed the adoption of the full 2°C policy framework at the EU level and the introduction of Germany's 2030 target to reduce emissions by 55% compared to 1990 levels, which would require a "hard cap" in terms of physical emissions, rather than a soft cap, which counts physical emissions together with carbon credits. The starting point of the scenarios is the 2°C policy framework, which then determines the carbon budget. Based on the budget, the relevant carbon price required to achieve this budget is calculated. The report uses SOTP (some of parts) valuation methodology based on DCF and EV/EBITDA models. The equity research note indicates that due to E.ON's younger fleet of more efficient gas-powered plants, the impact of the 2°C policy scenario would be positive for E.ON (+€500 million or €0.3 per share), whereas the impact of Germany's 2030 hard cap would be less positive (+€200 million or €0.1 per share). For RWE, due to its greater exposure to lignite, the impact of the 2°C policy scenario would be negative (decrease in valuation of €1.8 billion or €2.9 per share), with the German 2030 hard cap scenario being less negative to coal, which would mean a smaller hit to the fossil fuel portfolio valuation of €1 billion (€1.6 per share).

B) Evaluation

Impacts: The initial intention of the note was to demonstrate the impact of transition risk on the utilities sector. The analysis points out that climate-related financial risks have already contributed to driving down the share prices of these two companies by almost 85% since their peaks in January 2008 (in comparison to the overall dip on 29% of the Stoxx Europe 600 Utilities index). Due to the number of assumptions made in the analysis, the authors warn against using the calculation results, but rather direct readers' attention towards the comparative analysis of the two companies. On the basis of a H1 results assessment, Barclays cut E.ON's SOTP valuation by €1 per share and RWE valuation by €0.2 per share. However, this carbon pricing scenario analysis did not contribute to the changes in the valuation, due to a number of factors. The first one is that the time horizon for an equity analyst is 12 months, and the impacts of this assessment are felt to materialize beyond this time frame. The second one is that because of the low carbon price currently, there is a market assumption that the current merit order will be maintained until at least 2020. This assumption will likely remain unless policies/regulations are introduced to ensure a higher carbon price. Overall, the main impact of the note so far has been to educate investors and spark the debate about the relationship between a company's long-term exposure to coal and lignite and its influence on the company's long-term equity valuation.

Gaps: The report concentrates on fossil fuel generating assets in continental Europe. Both companies also have non-fossil assets in Germany that are exposed to power prices and generation assets in neighbouring countries that would benefit from higher prices. This means that the impact of the scenarios may be different in comparison to the published analysis. Further, while the analysis considers the potential impact of the regulation on Scope 3 emissions and asset retirement obligations (in this case, Scope 2 emissions are very small and according to the authors do not pose a material risk), the calculation of scenario impacts only takes into account Scope 1 emissions. The analysis also assumes that 2°C scenario only drives switching between coal/lignite and gas, whereas in reality the switch may also drive larger-scale energy storage and smart grid technologies, as well as a demand adjustment. Incorporating these factors will drive the potential upside lower and potential downside greater. Finally, the analysis does not take into account the risks from abrupt sentiment shifts.

Barriers: While good disclosure exists about carbon footprint of the various subsidiaries of both companies, less information is available on the forward-looking strategies of how companies manage financial risks, arising from environmental sources of risk. In addition to disclosure issues, some structural problems create barriers to mainstreaming. These include relatively short investment timeframes (up to 12 months) that prohibit such analyses from being incorporated into pricing recommendations. Further, lack of policy clarity on transition pathways drives the market assumption that the merit order of various energy sources will remain unchanged for the time being.

C) Implications

Options for improvement and next steps for mainstreaming: This analysis is a valid first step in the comparative assessment of the exposure of two German utility companies with similar risk profiles to environmental policies. The assessment only takes into account direct impact of potential scenarios on the companies in question. One way forward would be to conduct a more coherent analysis of the impact on the economy as a whole, which would incorporate indirect effects via the introduction of more energy-efficient technologies and potential demand adjustments. Another would be to consider mitigation actions that companies can undertake and thus make the analysis dynamic.

Progress on the quality of company disclosure of forward-looking risk management strategies for environmental risks would help equity analysts conduct dynamic modelling. Greater public profiling of investment strategies to reduce exposure to transition risk would contribute to a business case for sales professionals to create demand for these types of analysis. More analysis and knowledge-sharing around potential transition pathways and scenarios would help maintain the debate, which would ultimately support a more informed market sentiment. Finally, regulatory clarity and signalling would allow financial institutions to model the impact of these scenarios more accurately.

Potential implications of broader uptake/mainstreaming: Financial markets are driven by fundamentals and sentiment. In terms of fundamentals, the analysis already points out a clear winner between the two companies based on their ability to deal with climate-related financial risks. Investors could use such recommendations to adjust their capital allocation within the sector and reduce their exposure to transition risk. This would result in the redirection of equity capital towards companies that are able to better deal with as well as potentially benefit from the transition. In terms of sentiment, such analyses help raise awareness and influence investor perception as demonstrated by the relative long-term decline of their share prices over time.

Lessons relevant for policy options: This example underscores the value of understanding and dealing with the issue of the inherent short-term orientation of equity analysis. One way to combat this is to incentivize large asset owners to express preference for incorporation of long-term environmental impacts on financial performance indicators into the equity price. Further, this case supports the argument for a knowledge-sharing platform, as it stimulates debate within the sector, therefore raising the profile of environmental risk analysis, and allows market players to improve their environmental risk analysis methodologies.

Mercer (International): Examining the effect of transitions risks on strategic asset allocation

A) Summary

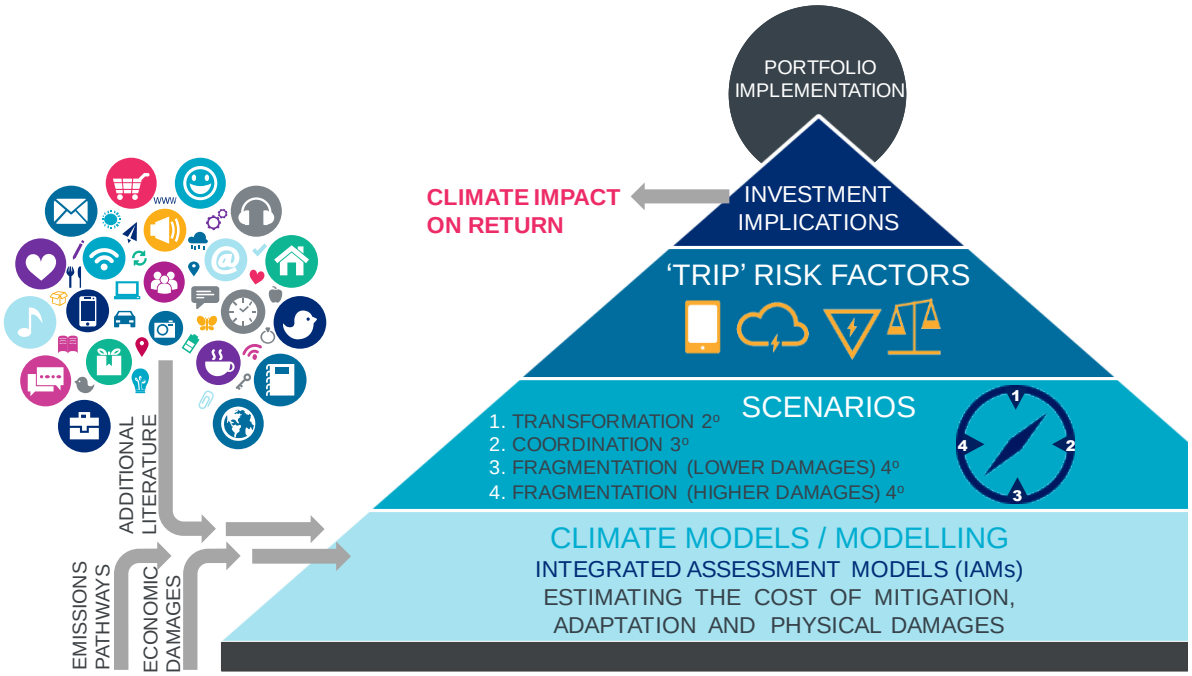
Sector	Investment
Environmental Risk Factor	Transition (climate related)
Level of Analysis	Portfolio, Sector
Financial Risk Typology	Market
Financial Risk Tools	Integrated assessment models incorporated in asset allocation investment model
Quantitative Results	Median additional annual returns to 2050

Overview of approach and key findings: Collaborating with NERA Economic Consulting and Guy Carpenter along with a number of asset owners, asset managers and public partners, Mercer has investigated the impact of four climate risk factors and four climate scenarios on their asset allocation investment model. Based on historical data, the model adopts a forward-looking approach. Climate change is not captured in historical data sets or over typical investor timeframes, so is believed to be missing in the model for setting client strategies to meet objectives. This analysis started with the definition of three scenarios, with higher and lower damages linked to potential physical impacts:

1. Transformation (strong climate mitigation action limiting global warming to 2°C);
2. Coordination (action aligned with limiting warming to 3°C), and
3. Fragmentation (limited action, lack of coordination leading to warming of 4°C or more).

In order to model the impact of the different scenarios on returns, the investment model had to be expanded to include a quantified representation of the future pathways for four potential climate risk factors (TRIP - Technology, Resource availability, Impact and Policy). Risk factors were applied to scenarios over time, as well as sensitivities of different asset classes and industry factors. The TRIP risk factors were selected as key market drivers for incorporation into the standard asset allocation model alongside more traditional drivers such as equity-risk premiums. The approach is visualized below.

Figure 4: Mercer Framework for Modelling Climate Impacts on Portfolios



Source: Mercer, 2016

The impact of scenarios was assessed on a 35-year time frame (until 2050) and clients were provided with the 10-year and 35-year minimum impact on the median additional annual returns together with potential additional variability over the four scenarios. The report estimated that there would be material impacts at both asset and sector levels – notably, for the coal sector, a forecast that annual returns in the coal sector could fall between 18% and 74%. At the asset level, only the developed market global equity has a minimum annual negative impact regardless of the scenario due to its sensitivity to policy factors. At a sector level, renewable energy, health and IT see minimum annual positive impacts across scenarios with some variability depending on the scenario, whereas industrials, consumer staples, financials, materials, utilities, oil and coal have minimum annual negative impacts across all scenarios.

B) Evaluation

Impacts: In addition to the main report, Mercer has conducted detailed portfolio assessments, which include asset class and sector analysis figures and tailored governance recommendations, for the asset owner partners of the study (while asset managers participated, they did not get a tailored report, which is only designed for diversified asset owner portfolios. Asset managers are applying the equity sector work and greater understanding of climate change in their organizations, rather than the outcomes of the model). Three of these have been made public. Since then, the partners have engaged in addressing the governance and portfolio issues raised in these reports. Further, since the issuance of the report, a number of other clients have requested similar evaluations to be conducted on their portfolios.

To facilitate learning and knowledge-sharing around this issue, Mercer convenes a continually growing group of interested partners that engage with each other on a yearly basis on the portfolio impacts and governance issues arising from using this methodology to understand transition risks. Having conducted governance reviews and initial portfolio assessments, all of the group's asset owners have undertaken some portfolio decision changes, including low-carbon allocations (particularly for passive equity exposures) and improved engagement with their managers. Many have moved beyond initial steps and are now focused on transition plans by sector, to drive very specific engagement programs. Others are conducting resilience testing and capital expenditure reviews of their infrastructure assets, and one is now looking at shadow carbon pricing assessments.

All of these are actions that could be taken by individual financial firms. Alongside the initial and growing partner group, since the publication of the report Mercer has been working on incorporating the risk factors and scenarios into their mainstream asset allocation model for all their clients in three main regions. The idea is to conduct a regional roll-out for all clients with a smaller scale service offering, which means that every client would get the opportunity to understand the most obvious transition risks that their portfolio is exposed to. This would raise awareness of the impact of transition risk on all types of financial firms, not just those that proactively seek to conduct these types of analysis. Rolling this out within Mercer's organization is assisting to change 'mainstream' behaviours for senior management and people across research and consulting skill sets.

Gaps: It is difficult to aggregate robust details about impact into a hypothetical view of a theoretical portfolio. Although basic geographic differentiation into developed/developing countries is incorporated into the report, and is complemented by certain country focuses, it could go much further in terms of conducting robust analysis of regional differences. The study is also based on current industry structures, which are certain to evolve over the next 35 years. In this sense, the study does not have a dynamic component. In a similar vein, the study contains an inherent negative bias, as it does not take into account potential firm/industry level adaptations and does not evaluate the potential opportunities that these adaptations can present. Although it is targeted at encouraging strategic discussions on the long term portfolio orientation, the 10 and 35 year time frame of the study makes it less relevant for short-term investment decisions. Similarly, as the focus of the study is sectoral, it does not allow for stock picking within sectors. Finally, the study's emphasis is on the equity and real asset portfolios. There is more granular work to be done on bond portfolios and their susceptibility to potential transition risk.

Barriers: Mercer's report identifies a number of barriers, including policy/regulatory uncertainty, inherent short-termism and reporting cycles (which complicates the consideration and modelling of forward-looking risks), the lack of regulatory emphasis on the relevance of climate related issues to fiduciary duty and of substantive evidence of financial materiality. When conducting this work, Mercer has collaborated with responsible investment as well as mainstream professionals (CIOs) at their partner institutions. It is typically those clients with the greatest governance capacity that have the time, budget and skill levels to tackle this topic. While the involvement of mainstream professionals was clear in some organizations, more could be done to integrate the responsible investment teams into the mainstream, therefore raising the capacity of mainstream analysts. On a personal level, there are a variety of incentives as well as world-view conflicts to be addressed.

C) Implications

Options for improvement and next steps for mainstreaming: In order for this analysis to reach a wider audience, more work is needed to reach conclusions relevant to stock picking and strategic asset allocation over 3-5 year time horizons. In terms of asset class coverage, more effort is required in understanding the impact of scenarios on bond portfolios over the short, medium and long term.

Security level analysis would help understand regional trends as well as provide a dynamic element to the analysis. Mercer is currently in the process of taking forward more advanced work this area, with a new project involving the modelling of assets with low carbon exposure to help demonstrate benefits that could be reaped through portfolio reallocation.

More broadly, industry participants and policymakers/regulators could take several steps to support mainstreaming of such an approach. For investors, these could include building capacity to monitor and act on short-term and long-term climate considerations, and activities to implement the integrated model for addressing environmental risks detailed in the report. Regulators could look to send a strong signal on the importance and expectations for standard integration into current processes (potentially based on fiduciary duty obligations), emphasize medium- and long-term risk management and boost transparency and disclosure. Finally, the industry in collaboration with academic partners could look to develop metrics for measuring success.

Potential implications of broader uptake/mainstreaming: The report advocates the benefits of prioritizing sector analysis within equities, but also getting a total portfolio view by asset class when conducting environmental risk analysis. It puts forward an integrated model for addressing environmental risks for asset owners, consisting of three pillars: beliefs, processes and portfolio. The first two would form part of an environmental risk policy. In terms of portfolio impacts, investors could then look at a number of approaches, for example changing strategic asset allocation, transitioning towards low-carbon options by asset class, and increasing their engagement programme. A portfolio decarbonization strategy, in conjunction with engagement, could potentially reduce the carbon intensity of the investment portfolios. Such a reduction could decrease the policy risk in the portfolio, which would support the flow of capital to resilient low carbon economy, which in turn would go some way towards mitigating physical impact risks. On the opportunity side, it could result in increasing the investment exposure to firms and/or assets that benefit from climate action strategies.

Lessons relevant for policy options: Mercer's experience with convening a number of its clients to share knowledge on environmental risk analysis underlines the industry demand for knowledge-sharing platforms. The report also emphasizes the need for more explicit policy and regulatory signals about the importance of the topic and its link to fiduciary duty obligations.

Emerging Approaches: 2 Degrees Investing Initiative Energy Transition Portfolio Assessment Tool

2° Investing Initiative has led the development of a portfolio assessment tool measuring the alignment of listed equity and corporate bonds portfolios with climate goals, and associated potential capital misallocation under various decarbonization pathways. The tool tracks fixed and planned physical assets associated financial portfolios across 10 climate-related technologies and four sectors, allowing investors to identify the extent to which the portfolio's physical asset or investment profile is aligned with a 2°C emissions pathway alongside assessment of exposure to certain physical risks. Unique features of the analysis involve the use of bottom-up, physical asset-level databases for key sectors and their matching to financial securities (a global universe of listed equities and corporate bonds), as well as the direct reference to economic decarbonization pathways. The model is the only forward-looking portfolio analysis tool to date that assesses capital misallocation in financial portfolios relative to climate objectives and transition pathways – and also calculates exposure to physical risks. It does not explicitly quantify the implications of the results for the prices of financial assets – instead seeking to assess economic capital misallocation in financial portfolios rather than financial risk directly. Results can act as an input for 'traditional' (e.g. discounted cash flow model) financial asset pricing models. A key priority is in this respect is closing the gap between "economic" risk (e.g. risks associated with fixed and planned real assets) and financial risk (e.g. risks associated with financial assets linked to real assets).

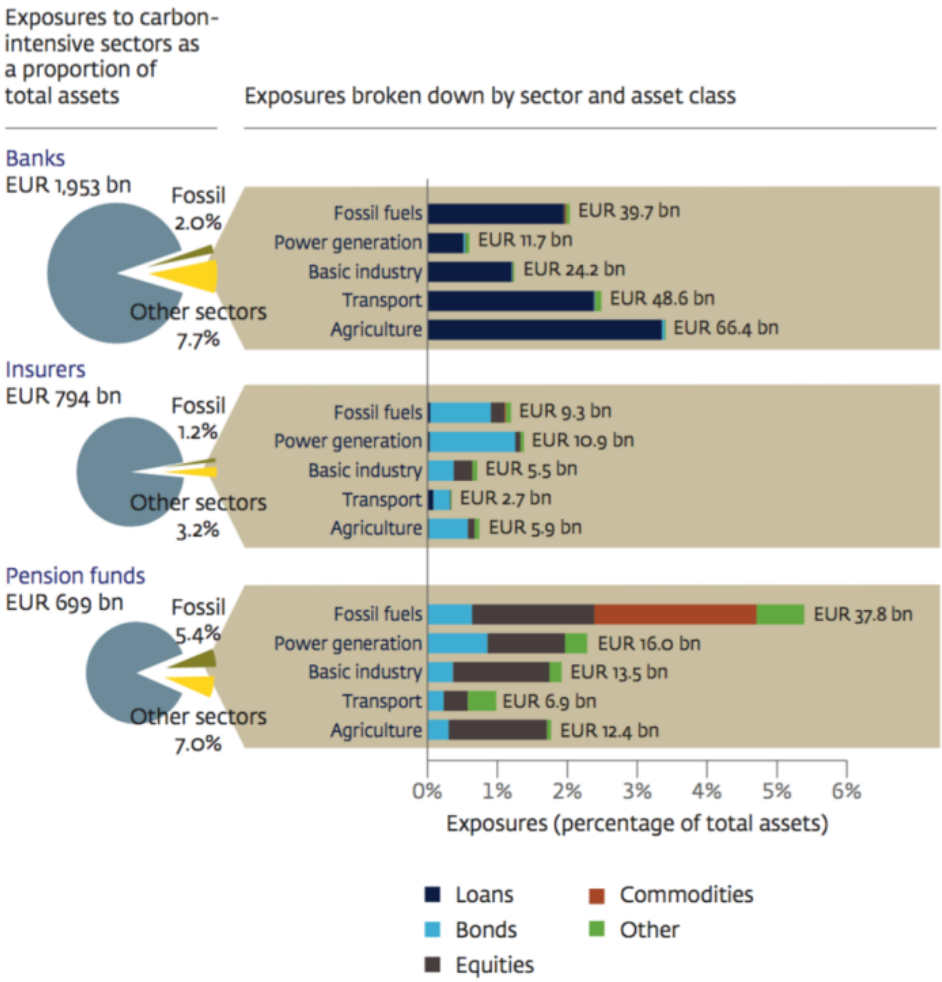
De Nederlansche Bank (Netherlands): Review of financial sector exposures to the energy transition and its macroeconomic implications

A) Summary

Sector	System
Environmental Risk Factor	Transition (climate)
Level of Analysis	Institution, System
Financial Risk Typology	Credit/Market
Financial Risk Tools	Exposure analysis
Quantitative Results	% total portfolios of major financial institutions held in carbon assets (fossil fuels and carbon-intensive economic sectors)

Overview of approach and key findings: DNB convened an internal study group in order to understand the impact of the transition towards a carbon-neutral energy system on the financial sector. The group conducted a number of qualitative interviews and reached out to the largest insurance, investment and banking firms with a request to provide their exposures to several energy-intensive sectors, such as fossil fuels. DNB requested that in addition to standard exposure metrics, financial firms included term profiles of their exposures as well as estimation of exposures of the mortgage collateral pools to energy inefficient assets. The study found that the exposure of different financial industries to both fossil fuel and carbon-intensive industries is not insubstantial (9.7% of total assets for the banks surveyed, 4.5% for the insurers and 12.4% for the pension funds). These results are detailed in Figure 5.

Figure 5: DNB Exposure Analysis



Source: DNB, 2016.

B) Evaluation

Impacts: DNB reports that the results of their exercise have had important signalling effects, including garnering substantial attention from the national press. The Dutch parliament tabled a separate debate on the risks of energy transition and in particular on the likelihood of the carbon bubble. Parallel to this exercise, in mid-2016 a national platform for sustainable finance was created, with DNB in a convening role. This platform features a number of work streams that are initiated and run by financial firms. Examples of streams include climate risks, barriers to green finance, financing of the circular economy and promotion of sustainable finance education. Further, in bilateral conversations with the DNB, a number of financial firms indicated that as a result of the exercise they have started their own work on the issues as well as asked the DNB for input in such work.

Within DNB, the report had three effects. Firstly, it has sparked a number of internal regulatory discussions on the impact of potential transition pathways. Secondly, carbon risk is now part of the macro stability risk register, which means that supervisors can ask financial firms a number of carbon risk-related questions in their supervision discussions. And thirdly, as a follow up, DNB has set up a project to expand its knowledge on the impacts of climate risks on the financial sector, and potential implications for supervision. Finally, globally, other national regulators have reached out and sought to use the DNB methodology in understanding the exposure of their own financial sector to the transition towards a carbon-neutral energy system.

Gaps: DNB's initial assessment represents the start of a more detailed deep dive into understanding environmental risk management procedures within financial firms. Currently, the exercise does not cover the full market, but rather the largest financial firms by market share. It is also limited to a number of energy-intensive sectors. Further, it does not incorporate second round effects from the exposure of one financial firm to another. Overall, it is an exposure collation exercise, which is a first step in any risk management process, therefore more substantial work has to be undertaken in order for viable conclusions to be drawn from it.

Barriers: Ready availability of data is an issue. The variation between industry classification systems used by different financial institutions across different asset classes makes collating exposures across risk types and asset classes challenging at a system level. To overcome this, the DNB had to put forward a standard set of classification codes for financial institutions to use.

C) Implications

Options for improvement and next steps for mainstreaming: Alongside engaging in the 'Regulatory work stream' of the platform for sustainable finance, DNB is exploring the possibilities of a quantitative scenario analysis of the impact of the introduction of a carbon price on the exposures of Dutch financial firms. Additionally, they are looking to explore the preparedness of the Dutch financial sector to potential physical risks, such as flooding. Other plausible next steps could consist in extending the analysis to include a stress test of the portfolio to energy policy changes or abrupt sentiment shifts. Further analysis could be made to estimate the exposure of other sectors not currently considered.

More generally, regulatory actors could use a number of options to encourage mainstreaming of environmental risk analysis. In order to aid exposure collation across different asset classes and risk types, the cross-industry code classification matrix developed during the process could be published. More generally, further work on developing more sophisticated approaches to estimating transition risk exposure, for example quantitative scenario analysis, is required at the firm and national level. At a higher level, such efforts would be strengthened through enhanced climate-related financial disclosures from financial institutions. Clarifying the role for public institutions (including supervisors, regulators and central banks) in supporting implementation stands as an important priority.

Potential implications of broader uptake: Regulatory attempts to estimate exposures are a valid policy signalling mechanism, which raise the profile of environmental risk analysis and encourages financial firms to build capacity in the area. Further, financial institutions in the Netherlands have welcomed and taken great interest in the creation of a broad knowledge-sharing platform, which includes public and private institutions. The working groups of the platform are sponsored by board members of financial institutions, which underscores that largest financial firms are working together to develop viable approaches in the area of sustainable finance.

Broader uptake of an estimation approach by central banks, supervisors, and regulators in G20 countries could represent an important first step towards identifying the potential for transition risk to affect national financial systems. The experience of the Netherlands suggests that such efforts can have catalytic positive effects on the interest of financial institutions to deepen their own understanding of such risks, which – as the previous case studies have illustrated – is a necessary foundation upon which to base further action.

Lessons for policy options: Quantification of financial firms' exposures to energy-intensive sectors by regulators raises awareness of the issue at the national and international levels and stimulates debate within financial firms, between financial firms and regulators as well as within regulatory bodies. The experience of the Netherlands, and of other G20 countries (i.e. China, Indonesia, and Italy[30]) suggests that national financial sector platforms can encourage and efforts to mobilize private capital for green

finance, including through knowledge-sharing among practitioners on topics such as risk management. Developing connectivity between such efforts through a risk analysis lens could potentially be achieved through a mechanism to support international collaboration.

3.2. Physical Risks: Natural Hazards, Climate Events, Water and Natural Capital

Physical risks, including shock events such as natural disasters, are increasingly stark threats to populations and economies posed by environmental factors, with the potential for major impacts to the real economy and financial assets. While transition risks such as carbon are a relatively new concern for financial institutions, the financial system has a long history of assessing and managing physical risks – primarily through the insurance sector. An important recent shift is the recognition of how climate change is accelerating and exacerbating risk trends – in terms of shock events, functioning of ecosystems, and associated stocks and flows of natural assets upon which populations and businesses rely.

More frequent and increasingly severe disasters, compounded significantly by heightened exposures, are set to cause increasing economic losses in coming decades:

- Since 2008, an average of 26.4 million people have been displaced from their homes by natural disasters every year – equivalent to one person every second.[31]
- Total economic losses from natural disasters in the last decade were more than US$1.3 trillion, with total direct losses in the range of US$2.5 trillion so far this century.[32]
- Over 10,000 people lost their lives as a result of natural disasters in 2016, with financial losses of at least US$158 billion.[33]

Critically, these trends are set to be significantly accelerated by climate change: in the past decade, 80% of natural disasters were climate-related,[34] and climate change is predicted to increase the frequency and intensity of extreme weather events such as floods and storms.[35]

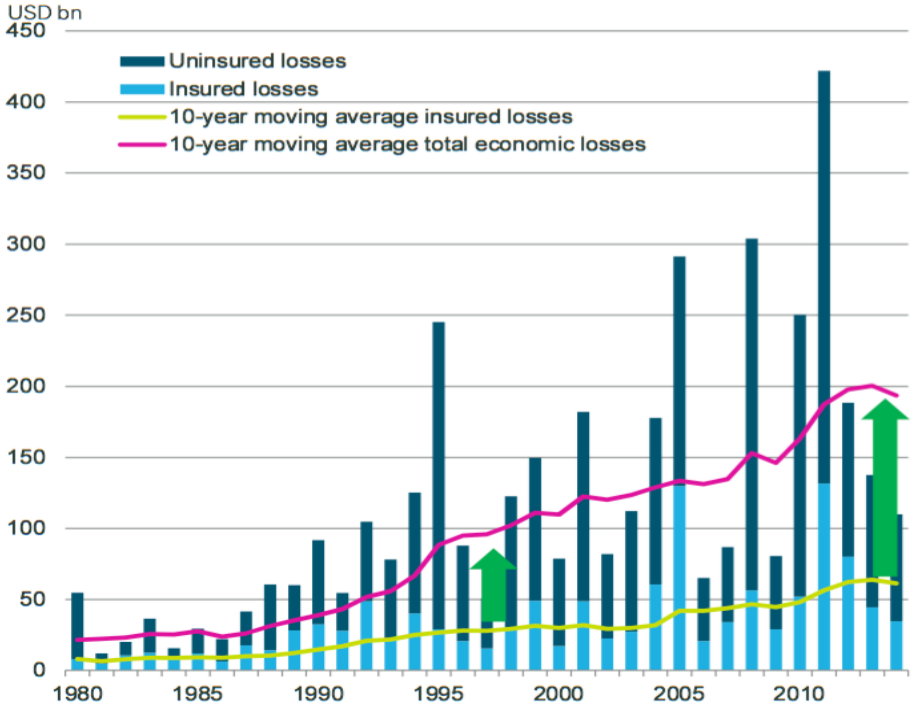
Differences in the distribution of populations and economic activity, development strategies and growth patterns mean that risks posed by physical sources of risk may be unevenly concentrated between firms and sectors, with divergent implications for classes of financial institutions. However, the capacity to assess and manage physical risks has largely been concentrated in selected asset classes (including insurance), and primarily focused on shock events. "Creeping" trends in physical risks, such as increasing water scarcity, are emerging as new concerns across a range of asset classes, including corporate loans and investment portfolios. Beyond the private financial system, natural hazards and other physical environmental phenomena can pose risks to public institutions and governments themselves through financial channels – including through sovereign credit ratings.

Here, we focus on risks and responses by financial institutions in three key areas – Natural Hazards (insurance); Climate Change (sovereign ratings); Water and Natural Capital (banking) – where ERA practice is at varying levels of maturity.

3.2.1. Natural Hazards: Focus on Insurance

The insurance sector has long been the leader within the financial sector on understanding the hazards, vulnerabilities, and exposures stemming from natural phenomena and environmental change. Through its primary role in pricing, carrying, and transferring risk, the insurance sector is the front line of defence against economic losses caused by natural phenomena. A striking illustration of the magnitude of such risks is the "protection gap" between insured and uninsured economic losses resulting from disasters, which has increased significantly in recent decades (Figure 6).

Figure 6: The Growing Protection Gap



Source: Swiss Re, 2016

The global insurance and reinsurance sectors are also central to the resilience of the broader financial system – as losses from environmental risks (such as natural disasters) affect the soundness of individual financial institutions, such as banks.[36] Beyond its primary risk pricing role, the insurance sector carries influence as arbiter of sustainability risks, impacting capital allocation choices by other investment institutions.

Significant investments in developing advanced risk modelling techniques following Hurricane Andrew in 1992,[37] the restructuring of contract parameters, and regulation of solvency capital requirements to reflect 1-in-200 year return periods[38,39] have all contributed to the resilience of the insurance sector against natural disasters of increasing frequency and magnitude. Several leading insurance firms (including **Swiss Re**) have implemented environmental risk assessment frameworks to consider the impacts of environmental hazards across lines of business, as well as strengthening catastrophe models to better consider the wide ranging impacts of climate change on weather, natural hazards and other phenomena.

Swiss Re (International): CatNet Tool

A) Summary

Sector	Insurance
Environmental Risk Factor	Physical (Natural Catastrophes)
Level of Analysis	Asset, Firm
Financial Risk Typology	Market
Financial Risk Tools	CatNet – Online natural hazard risk assessment model
Quantitative Results	Geographic analysis of natural hazard risks to individual locations and at portfolio level

Overview of approach and key findings

Global reinsurer Swiss Re has some of the most advanced environmental risk assessment practices within the insurance sector, and has taken steps to apply them across underwriting and investment practices. Swiss Re's Sustainability Risk Framework is a group-wide risk management methodology, consisting of eight policies on sensitive sectors or issues, a process for sensitive business risks in due diligence, and company and country exclusions.[40]

Swiss Re provides a range of natural hazard risk assessment services to clients, including the CatNet online tool. This online interface can be used by clients to assess the risk of natural hazards to individual locations or entire portfolios by combining hazard, loss, exposure and insurance information with selected background maps and satellite imagery. This asset-level approach examines physical risk profiles of geographic coordinates, and can be used in a range of applications – from underwriting to data cleansing and post-event discussions.

Banca d'Italia: Implications of Climate Change for Disaster Risk and Bank Lending[41]

An ongoing study proposes an investigation of the disaster risk borne by the banking sector, studying the case of Italian banks' exposure to flood risk.[42] In Italy flood risk is the main hydrogeological source of concern for firms in terms of number of firms exposed. It is therefore often chosen as a proxy for disaster risk at large. Using a measure of disaster risk at provincial level as the share of firms at high risk of floods per province, *High-Flooding Impact* (HFI) provinces are defined as those with a share of exposed firms higher than the median exposure rate. Risky firms in one province are firms located in areas with at least one estimated flood occurrence over a 50-year horizon (P3 in the flood-risk scale).

As of end-2014, total lending to firms by Italian banks amounted to €856 billion, of which 40% targeted HFI provinces. Concerning credit granted to HFI provinces, 41% of it was directed to firms located in Emilia Romagna, 23% in Tuscany, 14% in Veneto and 9% in Liguria. Exploiting the sectorial breakdown of bank loans, it is also noted that both manufacturing and service sectors are at risk, with about half of the total of HFI loans concentrated in Construction, Trade and Real Estate Services.

Moreover, using the proportion of exposed firms as a measure of disaster risk, the paper tests whether the amount of bank credit granted to firms is correlated with the level of flood risk. Specifically, the stock of outstanding loans in 2014 is regressed against the disaster risk proxy, controlling for regional and industry characteristics, the province's valued added, the dimension of the creditor, and for bank size.

The results show that disaster risk is negatively correlated with the amount of bank loans granted to SMEs: a 10% reduction in disaster risk is associated with a 3.1% increase of the outstanding loans to SMEs. By contrast, there is no a statistical link with the loans granted to big firms. Size is also important in determining banks' aversion to disaster risk: bigger banks appear to be more prone to lend to firms located in riskier areas.

Source: Italian Ministry of Environment and UN Environment Inquiry, 2017[43]

3.2.2. Climate Change: Focus on Sovereign Credit Ratings

There is increasing evidence that physical risk factors such as extreme weather may affect the credit ratings of sovereigns – through direct losses to infrastructure, as well as impacts on economic activity. Several credit ratings decisions taken by major agencies have identified the role of environmental factors in contributing to conditions leading to a ratings action.

Ratings agencies (including **Moody's**) have developed frameworks to integrate climate change factors into existing rating methodologies, and examined how different countries may be more or less susceptible to ratings downgrades affected or exacerbated by the impacts of climate change.

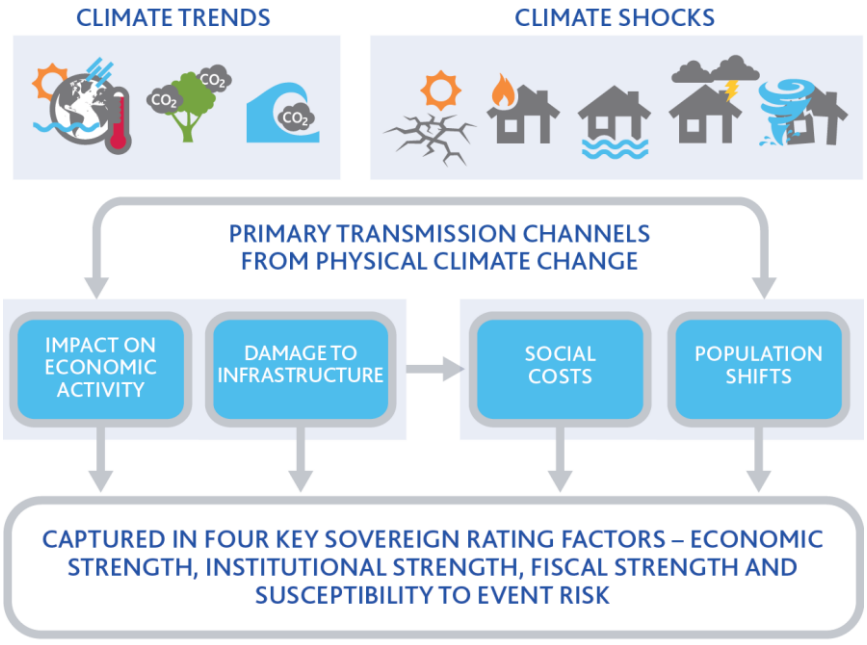
Moody's (International): Assessing Physical Effects of Climate Change on Sovereign Issuers

A) Summary

Sector	Investment
Environmental Risk Factor	Physical (Climate Change)
Level of Analysis	Asset (Sovereign Debt)
Financial Risk Typology	Credit
Financial Risk Tools	Sovereign Rating Model
Quantitative Results	Assessment of susceptibility of sovereigns to climate change

Overview of approach and key findings: In November 2016, Moody's released a report detailing its methodology for assessing the physical risks of climate change to sovereign ratings.[44] Moody's sovereign bond rating methodology does not separately or exclusively account for credit risks caused by climate change, but rather considers how climate change may affect the key rating factors affecting sovereigns' willingness and ability to pay debt: Economic Strength, Institutional Strength, Fiscal Strength, and Susceptibility to event risk (Figure 7).

Figure 7: Moody's Approach to Assessing Climate Risks in Sovereign Credit Analysis



Source: Moody's Investor Service, 2016

Moody's identifies four primary transmission channels through which the effects of climate change trends and shocks may have primary impacts on sovereigns' credit profiles.

I. **Potential impact on economic activity**: material weakening of economic activity due to climate change will weigh on fiscal revenues and may lead to an increase in transfer payments and welfare expenditure.

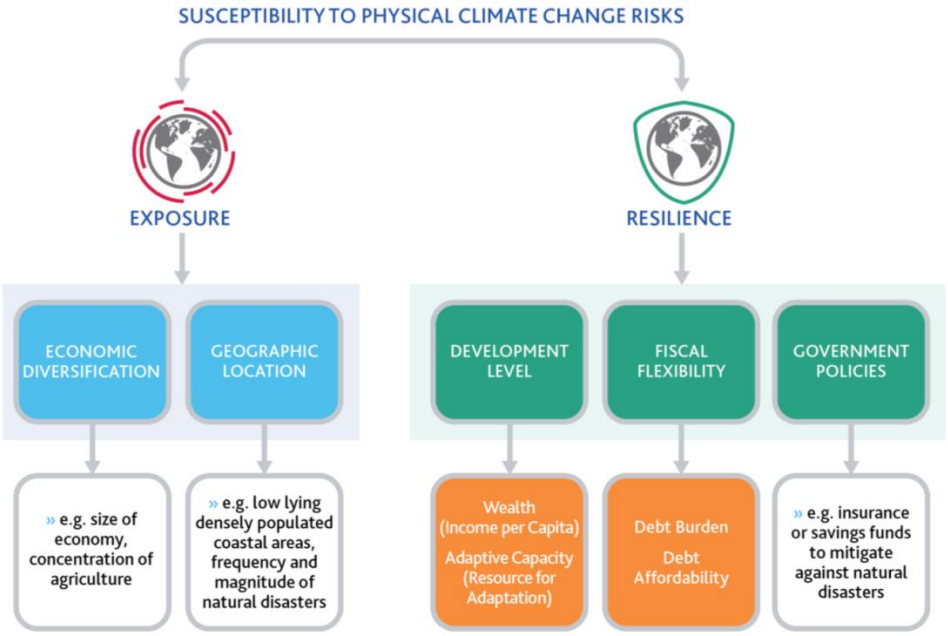
II. **Damage to infrastructure**, including the provision of critical services such as electricity and water supply, as well as damage to critical economic infrastructure (roads, ports, etc.): replacement costs may impact public finances heavily, while persistent shocks may pose increasing expenses relating to adaptation and resilience.

III. **Rising social costs**: brought about, for example, by a health crisis or food security concerns, posing high response costs, or high costs to government of social unrest.

IV. **Population shifts**: forced displacements resulting from climate change, including short-term internal displacement and longer-term international migration, affecting labour markets and livelihoods in both affected home countries and destination countries.

Moody's calculates susceptibility as a function of both exposure and resilience to climate risks (Figure 8), considering economic diversification and geographic location, development level, fiscal flexibility, and policy frameworks (including financial mechanisms to support resilience).

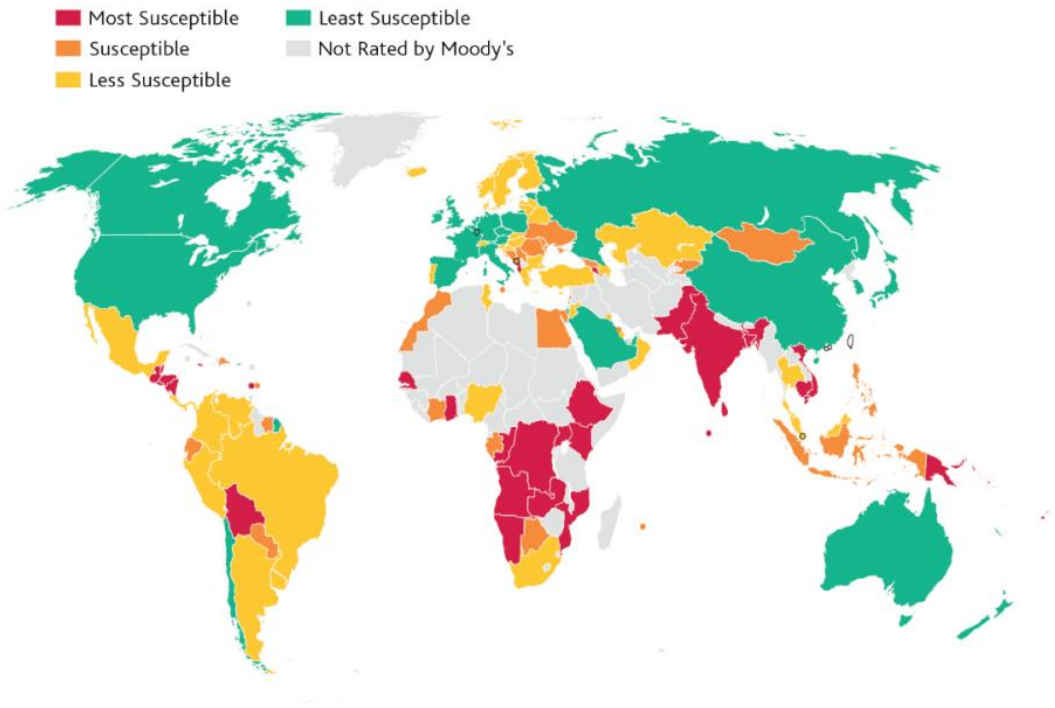
Figure 8: Susceptibility to Physical Climate Risks



Source: Moody's Investor Service, 2016

Moody's then compiled data to deliver an illustrative assessment the susceptibility of sovereign ratings to climate change effects on the basis of macroeconomic variables and independent data sources, including the Notre Dame Global Adaptation Index (ND-GAIN) vulnerability country indices. Exposure factors were given a weighting of 70%, while resilience factors were weighted at 30%. A visualization of degrees of susceptibility to ratings downgrades is provided in Figure 9.

Figure 9: Susceptibility to Physical Climate Change of Moody's-rated Sovereigns Based on Illustrative Data



Source: Moody's Investor Service, 2016

B) Evaluation

Impacts: Moody's concludes that climate change is already exerting "some influence" on the credit ratings of sovereign nations highly susceptible to its effects, such as India. However, due the long-term nature of climate change and associated physical risks, Moody's concludes that climate change does not have near-term implications for sovereign ratings. As such, this exercise has not had impacts on ratings directly, but rather illustrates how ratings may be further affected as climate change accelerates.

Gaps: The potential for secondary risk factors – such as feedback loops between climate trends, or transition risks stemming from economic reliance on fossil fuels – have not been considered in this analysis as a component of sovereigns' susceptibility to climate change. A rapid and disruptive transition away from fossil fuels could pose significant material risks for economic, institutional, and fiscal strength. Moody's has set out its intention to examine the credit implications of transition risks, including the credit impact of increased costs and business model adjustments associated with decarbonization.[45]

C) Implications

Options for improvement and next steps for mainstreaming: Efforts have been under way to support the integration of ESG factors by an international coalition of credit ratings agencies, in response to calls from a critical mass of asset owners convened by the Principles for Responsible Investment (PRI). A potential next step could be to leverage these efforts to support knowledge-sharing on approaches, drawing in smaller national ratings entities. Through this, consideration could be given to mitigating the potential unintended negative implications of mainstreaming (see below). Further steps could focus on approaches to reflecting secondary risks (including to transition

factors, or adaptation) that have the potential to affect key ratings factors – such as alignment of industrial policies with climate targets.

Potential implications of broader uptake: Credit rating downgrades stemming from environmental factors – while in one respect a correction of risk mispricing by the marketplace – could pose serious negative implications for vulnerable countries, including a higher cost of capital for government borrowing. In countries highly reliant on the issuance of sovereign debt, an increase in cost of capital could significantly constrain investments in resilience, such as green infrastructure. Impacts on sovereign credit ratings may also have second-order effects on economic competitiveness and attractiveness for foreign direct investment. Therefore, one area that would need further consideration is how to appropriately reflect efforts to build resilience into ratings methodologies.

Lessons for policy options: This example illustrates the importance of ratings agencies in informing the efforts of other financial institutions in assessing environmental risks, and evaluating their impacts on financial decision-making. The findings of this research point to a strategic need for G20 countries to deepen their own understanding of how environmental factors may pose macroeconomic risks, which in turn could corroborate other factors influencing a rating downgrade. Similarly, identifying efforts to build adaptive capacity with respect to those credit risk indicators (such as institutional strength) could be beneficial for countries at a higher risk of negative impact from climate shocks. Within the financial system, there is a need for further knowledge-sharing around the consideration of environmental risk in sovereign ratings – and collaboration to identify best practices and options to guard against unintended consequences.

Sovereign credit ratings act as a nexus point between the financial and real economy, and may be used as a leverage point from which to approach broader policy challenges related to investments in resilience to environmental risk. Applying a green lens to sovereign debt – including through the issuance of Sovereign Green Bonds – represents a promising new opportunity to leverage significant international demand for long-term green assets with green finance needs in developing countries.

3.2.3. Water and Natural Capital

Efforts to assess and manage physical risks in the financial system have concentrated on natural hazards, and to a lesser extent the implications of climate trends and shocks. Recently, financial institutions have increasingly recognized the importance of a broader range of natural capital factors – including water scarcity, land degradation, deforestation, and supply chain risks – for the health of corporate sectors, and the resultant implications for financial assets and liabilities.

- Water risks – including incremental threats to water scarcity, pollution, and shock events such as droughts – are complex in their interlinkages between physical environmental phenomena and demand patterns, including population growth, changing consumption patterns, conflicting user groups, and geopolitical dimensions (such as cross-border water sources). A key challenge associated with natural capital risks (including water) is their potential impacts across a range of credit, market, and business risk factors, including secondary knock-on effects between real economy sectors.
- Risks originating from other natural capital factors – including terrestrial assets, such as land use and forestry – have been recognized as potentially material for financial institutions. Here, reputational risks are originating for firms engaged in financing unsustainable agricultural supply chains linked to deforestation, such as palm oil production.

Financial institutions are taking different approaches to better understand water and natural capital risks, ranging from initial exposure assessments (i.e. **YES Bank**) to more detailed scenario analysis and stress testing (i.e. **NCFA/GIZ**). Methodologies are more advanced with respect to water risk, due to its more direct quantification and more widely available data sources.

NCFA/GIZ (International): Assessing the impacts of drought on corporate lending portfolios

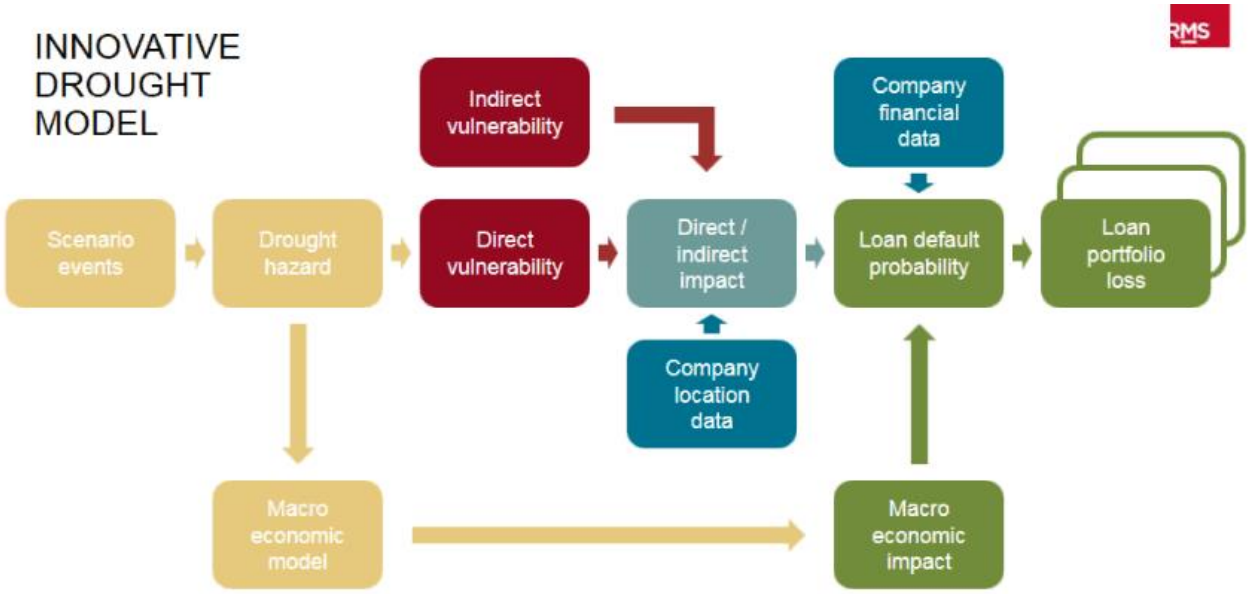
A) Summary

Sector	Banking
Environmental Risk Factor	Physical (direct and secondary impacts of water scarcity)
Level of Analysis	Asset, Firm, Portfolio
Financial Risk Typology	Credit
Financial Risk Tools	Drought risk model, based on natural catastrophe model for direct damages and input-output model for indirect damages
Quantitative Results	Overall expected losses for banking portfolios

In partnership with GIZ, the Natural Capital Finance Alliance (NCFA) is currently developing with catastrophe risk modelling firm RMS and several financial institutions[46] a drought stress testing tool that assesses the impact of drought on corporate lending portfolios. The tool includes five different drought scenarios based on historical observances and covers four different countries: Brazil, China, Mexico and the US. The tool enables analysts to enter relevant financial and location data for the companies in their portfolios and obtain the overall expected loss as well as other risk metrics for the portfolio, including direct risks from the drought on the company operations as well as macroeconomic risk – with a view of estimating credit rating transition matrices and expected credit losses.

The tool combined two modelling approaches to assess the direct and indirect impacts of drought on corporate sectors. The basic framework is outlined in Figure 10. Based on a catastrophe risk model, the tool generates drought risk information at high levels of geographic granularity in the various countries. Direct impacts on companies are calculated on the basis of industry class, geographic location, relative water use, water dependency and mitigation strategies applied to address water risks. An input-output model for indirect damages is applied to calculate broader impacts of water availability on power generation. This information is then combined to generate potential impact on companies in terms of loss of functionality and cost of goods sold, yielding end impacts on revenue and operating costs. Drawing on company financial data, these values are then used to generate a loan default probability, aggregated into an expected loss across the corporate lending portfolio.

Figure 10: NCFA/GIZ/RMS Drought Risk Tool Framework



Source: NCFA/GIZ/RMS, 2017

The 2017 drought stress testing tool represents the continuation of NCFA's previous work on water risks for financial institutions, including:

- In partnership with Bloomberg, a **Water Risk Valuation Tool** was developed to enable financial analysts to incorporate water risks into company valuations in the copper and gold mining industries.[47] The tool uses an adjustable water stranding scenario that links water risk to revenue, while an optional shadow price reflecting the social cost of water can be accounted for in operating expenses. In this way, analysts can model the change in future profitability of a company with different water scenarios.
- Developed in partnership with GIZ, the **Corporate Bonds Water Credit Risk Tool**[48] integrates water stress factors into credit assessments of bond issuers in the beverages, mining and power utilities sectors. The tool enables users[49] to integrate financial risk exposure to water scarcity into standard financial models used to assess the credit strengths of corporates across water-intensive sectors. By combining data on the quantity of corporate water use per production location with data on site-specific water supply and demand conditions, the tool allows financial analysts to quantify corporate exposure to water stress and its potential impact on a company's credit ratios. It contains analysis of 24 companies in the beverages, mining and power sectors, and allows users to add their own companies and analysis.

The NCFA is now working with member financial institutions to pilot the tool in different countries around the world. A report summarizing the findings of this work has been published in the second quarter of 2017.

YES Bank/Trucost (India): Examining natural capital exposure of an Indian commercial bank

A) Summary

Sector	Banking
Environmental Risk Factor	Physical and Transition (direct and secondary impacts of natural capital degradation)
Level of Analysis	Asset, Firm, Portfolio
Financial Risk Typology	Credit
Financial Risk Tools	Environmentally extended input output model (EEIO), India Natural Capital Model
Quantitative Results	Estimation of natural capital costs apportioned to the loans and advances of YES Bank (INR1,226 billion); Natural Capital Exposure ratio.

Overview of approach and key findings: Trucost used its environmentally extended input-output (EEIO) model to put a monetary value on environmental and social impacts in India so that they can be integrated into decision-making in a more effective way. Natural capital costs at the sector level were then mapped to YES Bank's sectoral distribution of loans and advances, covering 47 per cent of the bank's loans and advances as of March 2015. The EEIO model integrates data concerning the use and emissions of over 700 environmental resources across more than 500 business activities, prices each environmental resource, and assesses, in financial terms, the economic and environmental performance of each sector. Trucost used the EEIO model to quantify the natural capital costs of 50 economic sectors in India identified as being relevant to the financial sector through shareholdings and lending data of the Reserve Bank of India (RBI). These include sectors such as: coal-fired power generation, iron ore mining, textiles manufacturing, food processing and agricultural sectors such as cotton, wheat and rice farming. For each sector, the natural capital costs associated with six key environmental impacts were calculated: GHG emissions, land-use conversion, water consumption, waste, water pollution and air pollution. The exposure of banks to these natural capital costs was calculated by mapping the amounts of money loaned to those sectors and regions. This can be used to assess the potential magnitude of the natural capital risk in a bank's loan book. For ten of the sectors, the study also calculated the different natural capital impacts across six regions of India as the same activity can have different impacts depending on the geographical location.

After quantifying the overall natural capital costs generated by a sector, a framework was developed to identify the drivers that can lead natural capital cost internalisation for a company. Natural capital costs represent the cost to society from a company's use or impact on unpriced natural capital. Companies often do not pay this social cost, but it can be internalized through mechanisms such as 'polluter pays' regulation, resource depletion, removal of subsidies, reputational damage and changing consumer preferences. The final step involved assessing the potential for a company's natural capital risk to be translated into a risk for an investor or financier.

Applying this approach, Trucost estimated that that the unpriced natural capital costs apportioned to the loans and advances of YES Bank are INR1,226 billion, compared to investments analysed of INR357 billion. The bank's Natural Capital Exposure (NCE) ratio is 3.4 – meaning that for each INR million of credit disbursed, YES Bank is financing over three times the natural capital costs generated by these sectors. This is higher than then the industry benchmark across commercial banking of 2.9.

B) Evaluation

Impacts: In undertaking the first assessment of its kind within India, YES Bank's study generated leading insights regarding its loan portfolio – including agriculture (see "barriers" below). More importantly, the process of the study itself led to a range of impacts within YES Bank – including being confronted with a lack of capacity to assess environmental factors within the risk unit. YES Bank is now seeking to expand this unit within the credit risk team, as well as build linkages with its Responsible Banking team. YES Bank is seeking to apply other methods to assess environment risks in a forward-looking way, including insurance industry techniques for assessing 1-in-100 year physical risk events. In addition, it intends to develop a framework for stress testing its loan portfolio against climate factors – including for water risks.[50] A future step for YES Bank will be moving from risk assessment and mitigation to the financing of sustainable alternatives and issuance of securities, including potentially through a "blue bond" for water projects.

Gaps: To date, most approaches to incorporating environmental and social risk (such as sustainability indices) focus on assessing company policies and management with regards to environmental and social risks. The natural capital valuation approach supplements the ESG analysis with economic valuation of environmental inputs. This, in theory, could allow for consideration of environmental externalities in financial analysis of companies, and the potential impacts on financials and credit risk. There are, however, issues associated with such an analysis – primarily stemming from translating natural capital values into something useful for financial decision-making. Estimated values for environmental inputs, while in certain respects more reflective of total internalized costs, may be so far from current pricing that an implied valuation cannot be usefully factored into existing risk pricing mechanisms (i.e. shifting pricing by orders of magnitude). Similarly, issues result from translating estimated values for environmental risks in monetary terms for aggregation at portfolio level – in essence, making the jump from financial analysis of environmental factors to a consideration of environmental factors in mainstream portfolio analysis.

Barriers: YES Bank's experience illustrates how barriers may emerge between risk assessment and mitigation, including from policy frameworks (in this case policies to direct bank credit to specific sectors). Agriculture accounts for 15% of YES Bank's loans and advances compared to 13% of total industry commercial bank lending, in line with the RBI's Priority Sector Lending (PSL) requirements. Yet, the industries with the highest natural capital intensities in India were agricultural industries such as cotton farming (NCE ratio of 12.9) and wheat farming (10.5) due to the significant use of direct water for irrigation. The agriculture accounts for 78% of natural capital costs within YES Bank's loan book compared to 71% for the commercial banking industry as a whole. As a way to address this exposure, YES Bank is considering projects to develop the capacity of farmers for climate resilience, encouraging climate-smart agricultural practices by promoting drip irrigation clients to farmers to reduce water stress. YES Bank reports that more sustainable agricultural practices are at a nascent stage in India, with a risk of loan non-performance remaining. In this context, the bank is also seeking to find new innovative financing channels, including integrating loans with crop insurance policies.

C) Implications

Options for improvement and next steps for mainstreaming: YES Bank's experience highlights the range of internal impacts risk assessment can have, including in terms of capacity-building, and broader strategy and product development efforts outside of risk functions. It also illustrates how ERA practice can evolve within a financial institution – with insights from an initial assessment (i.e. basic risk exposures) clarifying the need for more specialized techniques and methodologies (i.e. stress testing). A forward-looking assessment of risks can then lead to the identification of

opportunities, including the issuance of new products to channel capital to green investment. Knowledge-sharing on the positive benefits of this approach could support mainstreaming.

Potential implications of broader uptake/mainstreaming: As noted above, India's PSL requirements constrain the capacity of financial institutions to reallocate capital – meaning that there is less risk of withdrawal of capital from sectors at a higher risk from natural capital factors (i.e. agriculture). Broadening YES Bank's approach across the Indian financial sector could build awareness of environmental risks among financial institutions, potentially generating positive feedback effects between risk mitigation actions (such as capacity-building with clients) and scaling up the financing of green alternatives within priority sectors.

Lessons for policy options: ERA practice is an evolutionary process which can lead to a range of activities in financial institutions outside of risk functions. Moving from one stage to the next, however, requires significant capacity-building – which could be supported through international collaboration between leading financial institutions, and knowledge-sharing on emerging approaches (such as stress testing). Leveraging existing collaborative networks at national levels, or on specific topics, could support such efforts.

4. Discussion

4.1. Lessons from Practice

Looking at the examples from practice, several general conclusions can be drawn about the state of environmental risk assessment in the financial system:

- Momentum is building around ERA, with rapid progress as financial institutions concentrate innovation on specific risks to specific assets. However, ERA practice is far from mainstream.
- The focus of ERA efforts is expanding to a broader range of risk factors and asset classes. In terms of physical risks, new areas of focus include water and natural capital. In terms of transition risks, these include social and public health issues such as air pollution. To date, there has been a lack of work on technology or sentiment sources of risk.
- ERA innovation is being led by large, international financial institutions working independently or in collaboration, with the support of smaller boutique players. However, innovation is often confined to these institutions and is not mainstreamed across competitors, or within smaller firms.
- Financial institutions are now seeking to deepen understanding on linking "macro-level" physical and transition scenarios with financial risks to individual assets and liabilities.
- Activities to assess environmental risks, and the results of these activities, may have a range of impacts on financial decision-making and market behaviour.

Examples reviewed confirm that ERA practice is an evolutionary process, which may have a range of impacts on decision-making and market behaviour as its sophistication increases. A three-step process can be identified:

I. **Risk Identification**: Strategic reviews to understand how environmental factors may pose physical and transition risks, involving qualitative analysis with no quantitative components.

II. **Risk Assessment**: Basic estimation of exposure to environmental risks through financial channels. Activities at this level involve high-level tools to provide a general picture of the scale and scope of risks, often through the use of representative proxies (i.e. exposure to carbon assets). Undertaking detailed analysis to translate environmental factors into financial risks to assets and portfolios, including through the application of stress testing, scenario analysis, portfolio modelling, probabilistic modelling and other techniques.

III. **Risk Management**: Various activities to reduce risk exposure, mitigate risks, transfer risks, or support risk reduction.

In terms of risk management, financial institutions may respond to the results of risk analysis in different ways. Some institutions may employ basic risk management efforts to address near-term prudential risks. Others are choosing a more strategic response, helping to reduce overall systemic risks by supporting an orderly market transition to a lower carbon, environmentally sustainable economy. The range of actions taken at these two levels is described further below:

1) **Addressing near-term prudential risks at firm-level**

- **Analysis of near-term financial impacts at an individual firm level** through more sophisticated ERA techniques;
- **Embedding ERA practices**: Seeking to mainstream ERA practice across all activities; and

- **Revising risk management governance**, i.e. amending credit policies, introducing sector limits, reducing systemic risks to the financial system as a whole.

2) **Reducing overall systemic risks through supporting an orderly transition**

- **Deepening understanding** of wider systemic risks from environmental factors, and considering institutional responsibilities to address these;
- **Developing a strategic framework** extending beyond managing near-term prudential risks to also include actions to support an orderly market transition; and
- **Taking action to implement the framework** beyond prudential risk functions, such as:
    - **Product Innovation**: development of 'green' products and services;
    - **Reallocating capital**, both away from assets evaluated as high-risk as well as seeking new green investment opportunities; and
    - **Engaging with stakeholders**: engaging with clients, investees, market intermediaries and policymakers, often forming collaborative partnerships address systemic risks that fall outside immediate prudential considerations.

4.2. Key Challenges

An interlocking set of challenges are holding back the mainstreaming of ERA practice in financial institutions. Different challenges may arise depending on the level of maturity around a given risk factor or methodology, geography and competitive landscape. Six key typologies emerge:

Technical Barriers: Overcoming technical barriers – including those associated with the inputs and tools involved in conducting ERA – remains a critical challenge for institutions seeking to assess environmental risks. Technical barriers are specific to the ERA tools that may be applied by a financial institution, as well as the level of sophistication and familiarity in using such tools:

- In areas where practice is nascent (i.e. assessing "new" risks such as water or natural capital), barriers can relate to foundational building blocks of ERA approaches – including definitions and accepted standards for pricing the impact of a given risk factor, choosing appropriate indicators and addressing data gaps (or, in some cases, the absence of any data and need for proxies).
- In areas where practice is rapidly developing (i.e. carbon risk to investment portfolios), a range of barriers have been identified with different assessment methodologies, including striking an appropriate balance between granularity, robustness and comparability.
- In areas where ERA practice is maturing (i.e. catastrophe risk modelling), technical barriers may relate to defining parameters associated with complex and dynamic risks into existing systems (i.e. the impacts of climate change on extreme weather).

Overall, there is a lack of consistency in how financial institutions and regulators are seeking to apply environmental risks – even when applying comparatively similar tools and methodologies. Minor inconsistencies – including in inputs and assumptions, the definition of parameters for key variables, and communication of results – can result in similar approaches yielding significantly different results to a given analytical challenge. In areas where practice is developing, such as scenario analysis, movement towards some degree of consistency in approach (i.e. "two-degree" scenarios) will inevitably be complicated by a range of variables and uncertainties (including the definitions, parameters and dynamics of such scenarios, and the balance of responsibility for provision and maintenance of scenario information).

Capacity: Many financial institutions lack knowledge on how to assess environmental risk, as well as lack understanding of best practice, budget, staff and tools to cover all funds, with limited incentives to build capacity. While risk assessment methodologies are advancing with respect to certain environmental risks in certain asset classes (i.e. investment), there is little incentive for firms to develop capacity in other areas where the costs and benefits of expanding ERA capacity may not be immediately clear, due to the presence of other barriers (i.e. policy signalling). In institutions where some level of ERA capacity is present, institutional barriers may affect the degree to which this capacity can be effectively deployed.

Time Horizons and Orientation: As efforts to better understand environmental risks increase in sophistication, there has been a shift from only considering historic results and past performance to emphasizing the centrality of forward-looking material – which will be critical to enabling clients, investors and other stakeholders to understand how well a financial institution is grappling with competing future risk trajectories. A key challenge for many financial institutions is striking an appropriate balance between the "backward-looking" (i.e. historical data based on observations) and "forward-looking" analysis (i.e. consideration of a range of potential futures). For example, while established approaches such as portfolio carbon footprinting can be an important foundational step for investors, such an approach will not yield forward-looking information or sufficient insight into how well a company board is assessing and managing environmental risks.

A more fundamental issue for risk analysis is the time horizons over which risk assessment tools are applied – and the degree to which longer-term, more uncertain risk factors such as climate change may be considered (the "Tragedy of the Horizon"). The issue here is the degree to which environmental risks may be similar to other long-term risks, or better understood as unique in their breadth of potential implications and range of potential costs. At its core, ERA is about making decisions about long-term, non-linear risks in the context of high uncertainty – including uncertainty over the range of potential timelines for which short and long-term climate risks may manifest.

Financial Norms and Regulation: In certain jurisdictions, existing legislation or regulation may constrain the capacity of institutions to consider environmental factors within risk analysis processes. While progress is being made with respect to fiduciary duties in many jurisdictions, a lack of clarity on how environmental risks may be relevant to the core duties and obligations of financial institutions (i.e. pension funds) may affect the willingness of management to pursue the mainstreaming of environmental risks. Similarly, a lack of clarity within existing regulations on the consideration of environmental factors may stand as a barrier.

Market Incentives and Behaviour: The current alignment of performance-linked incentives within the financial sector may act as a major barrier to taking a long-term view. The analytical time horizons for most "long-term" investors are as short as 3-5 years – with an average 100% turnover period of 1.7 years.[51] Critically, 80% of the NPV of securities is based on a longer-term timeframe (beyond 3-5 years) – but the most significant impacts of a higher-risk high-carbon scenario vs. low-carbon scenario for a given asset will not be visible over the short term. A critical driving force in this respect is the needs and demands of asset owners with respect to ERA practice, and their mandates to investment consultants and asset owners. Asset manager practices in turn drive demand for the provision of appropriate ERA information from credit rating agencies and sell-side financial analysts.

More broadly, the current alignment of performance-linked incentives within the financial sector may act as a major barrier to taking a long-term view. The current constellation of performance structures for difference agents in the investment chain can strengthen feedback loops short-term performance maximization and capital allocation choices. In this way, short-termism can constrain efforts to reallocate capital towards green investment options, many of which are inherently longer-

term in return timeframes and holding periods (Table 5). A range of other behavioural barriers exist to the mainstreaming of environmental factors into every-day practices of financial practitioners. These include conflicting priorities between personal choices and institutional values, limited resources to conduct analysis considered additional or peripheral, and individual biases towards the relative importance of environmental factors.

Table 5: Links between Incentives, Short-Termism and Capital Allocation

Incentive	Link to short-termism	Influence on capital allocation
Benchmark-relative performance	Conventional timeframes for performance benchmarks may be from one quarter to three years	Short-term performance structures may unduly penalize investment strategies which deviate from established timeframes
Transaction-linked performance	Portfolio turnover increases, holding periods decrease	Shorter holding periods may decrease incentives for long-term management
Earnings performance	Performance timeframes incentivize share price growth over investment	Managers are incentivized to increase short-term earnings, reducing investment in longer-term growth
Dividend payouts and share buy-backs	Pressure for increased short-term dividend growth reduces retained cash	Reduced equity capital decreases capacity for investment in internal R&D and innovation

Source: UN Environment Inquiry, 2016

Policy signals: Finally, a lack of clear and consistent policy signals relating to environmental issues, including frameworks for the low-carbon transition, remains a source of deep uncertainty for financial institutions. Policy signals can be a major barrier even where technology, market or other factors considered as part of environmental risk analysis point to a strong business case behind a given credit, investment, or underwriting decision. Similarly, inconsistent or incoherent policy signals obfuscate the process of translating future scenarios into micro-level risk factors, affecting broader portfolio risk assessment efforts. Financial institutions need to see clear, stable policy frameworks that support strong environmental risk assessment and management by companies in high risk sectors if they are see a business case for seriously investing in risk assessment capacities themselves. High-level global policy signals on environmental priorities (such as the Paris Climate Agreement) are a positive step in this respect – the challenge now is to translate global goals into robust country-level implementation plans.

4.3. Key Priorities

From the examples reviewed, and discussions held in GFSG meetings, a number of priorities for enhancing ERA practice emerge.

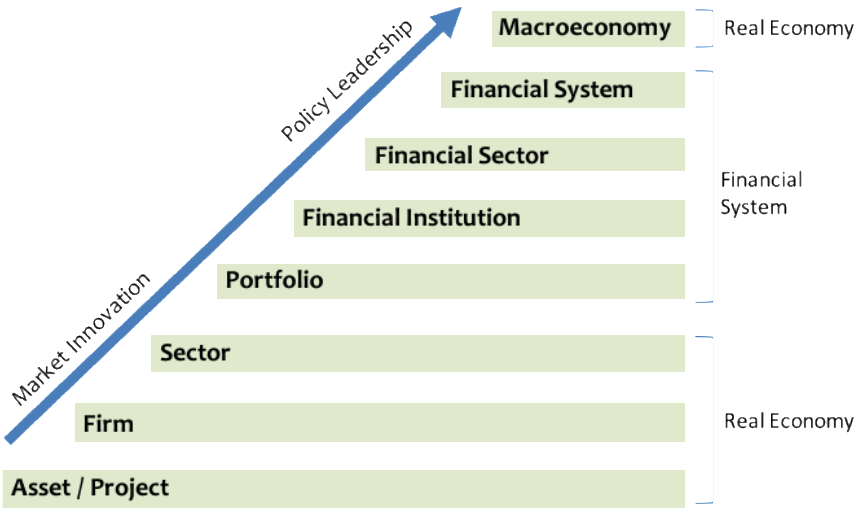
Integration into core processes: Looking at the evolution of ERA practice within firms, a twofold process of integration takes place. First, action is taken to better understand environmental factors and their financial dynamics; second, this information is applied and then successively integrated into core risk assessment, management and governance systems. Representatives of financial institutions report much higher appetite within firms to integrate new types of risk into existing tools, rather than track environmental risk assessment as a separate process. Linked to this is the understanding that risk assessment is an iterative process that takes place at multiple points

throughout decision and management cycles within financial institutions. Environmental factors may therefore be relevant to broader governance mechanisms and strategy processes, including controls on risk appetite, regulatory constraints (i.e. on risk capital), or indicators used to monitor and evaluate financial performance.

Broadening risk scope: The examples reviewed here illustrate that while attention has been concentrated on a specific set of climate and transition-related risks, efforts to assess other environmental factors (such as water) have been limited. Clearly, efforts will be required to deepen understanding of yet a further set of environmental factors – such as land use and forestry – that in many jurisdictions are under- or as yet un-priced into financial decision-making. Linked to this are efforts to move beyond primary impacts on financial institutions to assess secondary impacts and feedback effects.[52] Deepening understanding of these dynamics is a priority for supervisory and regulatory bodies, recognizing that the effective analysis and management of risk is at the core of efforts to promote the safety and soundness of financial institutions.

Linking assessment across scales: As methodologies advance, there is increasing recognition of the importance of linking risk assessment across scales: from project level, through sectors, institutions and finally financial market and system levels (Figure 11).

Figure 11: Risk Assessment from Asset to System Levels



Source: UN Environment Inquiry, 2016

- **Asset**: the specific environmental risk factors facing an existing or new real asset, and implications for the financial holdings or securities linked to the asset.
- **Firm**: the implications or environmental risk factors for a specific firm, communicated through corporate disclosures or as requested by a growing number of investors.
- **Sector**: aggregating firm-level risks to enable a comparative view across companies in the same sector.
- **Portfolio**: providing the basis for a cross-sectoral analysis at the portfolio level.
- **Institution**: understanding how a range of portfolio implications can be integrated and aggregated across asset classes and business units.
- **Financial Sector**: for financial regulators, the overall implications for the safety and soundness of financial institutions in a specific subsector (banking, insurance or investment).

- **System**: the potential for environmental risks to affect the financial system as a whole.
- **Macro-economy**: Finally, system level impacts can feed through to macro-economic variables such as growth, employment and prices, fiscal and trade balances, as well as inequality and environmental quality.

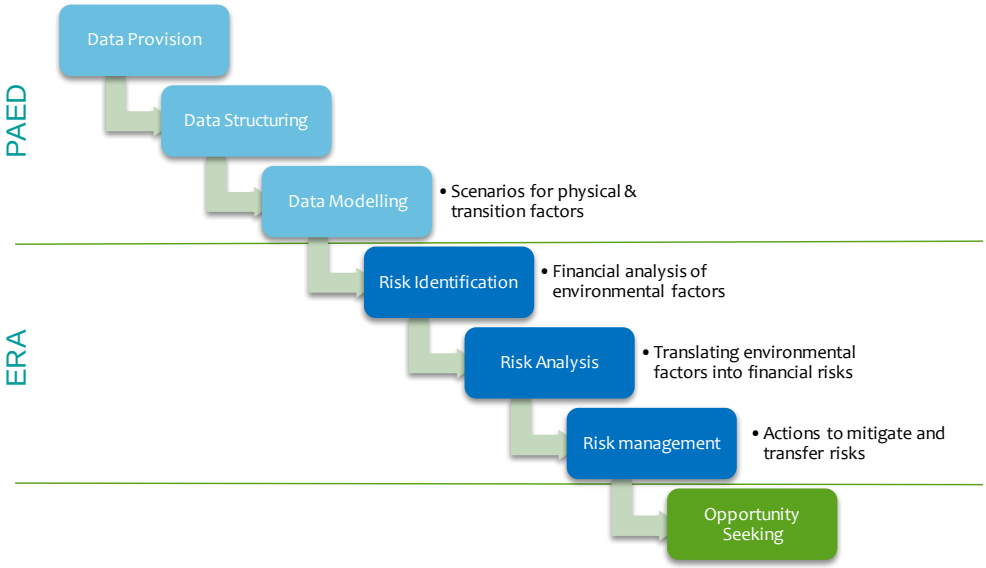
Promoting coherence in scenario analysis: Creating a discussion around a number of potential reference scenarios raises the profile of environmental factors and ultimately lowers the methodological hurdles for the less sophisticated users. There is a balance to be struck between accelerating learning through the provision of publicly available reference scenarios and not facilitating herding or acceptance of ready-made scenarios without putting due thought into the assumptions. One way to address this challenge would be to publicize very simple solutions, which would, on the one hand, create discussion, while, on the other hand, necessitate refinement by more sophisticated institutions. In any case, given that even the large financial firms currently struggle with defining relevant scenarios, as well as with shouldering the costs of having to update a number of scenarios in line with the constantly changing policy environment, in the current nascent state of the market the benefits of the approach outweigh its potential risks.

Simplification of information: It is widely acknowledged that there is a pressing need to identify robust sources of environmental information for use in ERA by financial institutions. Data alone, however, has proven to be not enough – rather, the key is to translate this information into something more useful for the financial industry. Opportunities to leverage existing information by financial institutions – such as the use of energy efficiency information to tag mortgages for higher-performing housing as green loans – could represent an easy step to simplifying the ERA process. Critical here will be linking efforts across the GFSG's ERA and PAED Research Subjects.

Moving from a prudential to systemic view of environmental risks: While important progress is being made using ERA to consider near-term, firm level prudential implications, the mobilization of private capital for green investments can be supported by institutions taking a wider view of systemic risks, and developing a high level, institution-wide, strategic framework to respond.

Strategically, seven key steps can be identified that connect data, risk assessment and the mobilization of green investment (Figure 12).

Figure 12: Seven Steps to the Green Capital Mobilization



Source: GFSG, 2017

5. Policy Options

To address some of the above-mentioned challenges, beyond ensuring more consistent policy signals, the GFSG has identified a number of options for encouraging voluntary adoption of ERA that the G20, country authorities and financial institutions could consider:

1. **Ensure consistency of policy signals**: member states could reduce business uncertainty by improving transparency on policy measures to be taken to align the economy and the financial system with environmental sustainability.
2. **Raise awareness of the importance of ERA for financial institutions that have significant environmental exposures.** G20 members could consider encouraging the integration of ERA into mainstream practice within financial institutions by sending signals on its importance, and, where appropriate, by cooperating with country- and sector-level industrial initiatives (e.g., banking, insurance and asset management associations) in developing or adopting ERA methodologies.
3. **Encourage better quality and more effective use of environmental data.** G20 members could consider actions to encourage voluntary disclosure of material environmental information by listed companies and bond issuers.[53]
4. **Encourage public institutions to assess environmental risks and their financial implications in different country settings.** G20 central banks as well as other financial supervisors and regulators could consider deepening research on assessments of physical and transition environmental risks and their implications, as well as initiating conversations on ERA with supervised entities.
5. **Review and, if appropriate, clarify financial institutions responsibilities to consider environmental factors.** In some G20 countries, there have been reviews of board level responsibilities for integrating environmental risks into financial decision-making. G20 members could consider commissioning further reviews of experiences and best practice in this area, where appropriate, and seek to clarify institutional roles and contributions for considering environmental factors, for example, through guidance and codes of practice.

Enhance capacity-building via knowledge-sharing networks on financial sector ERA. The G20 could support private-sector-led fora or networks that focus on knowledge-sharing and resource pooling for the development and usage of tools and methodologies for ERA. These fora/networks would promote cross-party dialogue on ERA between financial practitioners; support the development, evaluation and integration of ERA tools into general risk analysis framework and financial decision-making processes; help raise the awareness of the need for environmental risk analysis, and build necessary capacity within the financial industry.

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