Application of Climate Related Scenarios

The Webinar will begin shortly
• All participants have been automatically muted upon entry. Video and screen sharing features have been disabled, except for the panelists.

• Use the Q&A feature in Zoom during the webinar to ask a question. All questions will be handled at the end of the presentation.

• If you wish to make a verbal contribution during the Q&A period, please use the “Raise Hand” feature. Once recognized by the moderator, you will be unmuted. Contributions need to be limited to 3 minutes or less.

• The webinar is being recorded and will be made available on the IAA Website and our YouTube channel.
Application of Climate Related Scenarios

Micheline Dionne – Moderator
Rade Musulin, Evelyn Yong, Eric Dal Moro - Presenters

29 September 2021
Micheline Dionne – Introduction
IAA climate related risk initiative (launched May 2020)

Purpose

• Wider awareness of the potential impacts of climate-related risks on financial risk management, reporting and disclosure;
• Increased recognition for the potential contribution of actuaries as risk experts on the part of supranational organizations, government agencies, industry and the public; and
• Development of the actuarial profession’s skill sets and capabilities to assist third parties in managing climate-related risks.

Prior Papers

• Importance of Climate-related risks for Actuaries
• Introduction to Climate Related Scenarios

Accessible via: www.actuaries.org → Publications → Papers
IAA climate related risk initiative – future work

Projected Future Papers

- Paper on application of climate-related risk scenarios to asset portfolios
- Advice on climate-related financial risk management, reporting, and disclosure
- Paper on transition and adaptation and on the consequences for the private and public insurance and pension sectors
- Review of existing IAA publications regarding climate-related risks
- Paper on the link between climate-related risk scenarios and social security
Speakers

**Rade Musulin (Australia)**
Member of the IAA Climate Risk Task Force, Lead Author
Vice-Chair of the IAA Resources and Environment Virtual Forum
Member of the Casualty Actuarial Society

**Evelyn Yong (Australia)**
Co-author
Member of the Actuaries Institute

**Eric Dal Moro (Switzerland)**
Co-author
Member of the Association Suisse des Actuaires
• Rade Musulin (Lead), ACAS, MAAA, CCRMP (Australia);
• Eric Dal Moro, CERA, Member of the Association Suisse des Actuaires (Switzerland)
• Sam Gutterman, FSA, MAAA (United States)
• Evelyn Yong, FIAA (Australia)
• Tracey Zalk, Qualified Actuary (United Kingdom)
Rade Musulin – Sections 1, 3, and 4

Sources of Information and Considerations for Reporting Financial Effects
Considering Interactions and Systematic Issues
Updating Scenarios and Integration with ERM Frameworks
General components of scenarios

- **Representative Concentration Pathways (RCPs)**, which are related to various warming scenarios
- **Time horizons** (points where conditions will be evaluated)
- **Localized impacts**, taking output from Global Climate Models (GCMs) and translating them into local weather
- **Shared Socioeconomic Pathways (SSPs)**, which can include:
  - Economic and technical changes
  - A view of the prospective political situation
  - The nature of economic changes (e.g., gradual or abrupt)
  - The level of societal resilience
- **The time horizons may differ**; physical risk is generally slower and gradual, transition risk (including Legal & Reputational) can be abrupt and subject to reversals
- **Geographic scope**: physical risk reflects global efforts, transition may be local
The CMSI is an example of how GCMs can be adapted for use in local areas such as countries (the CMSI was developed in Australia).

It considers a low emissions (RCP 2.6) and high emissions (RCP 8.5) and various times (e.g., 2030, 2050, and 2090).

It discusses two types of climate effects:
- Acute (extreme weather events such as cyclones)
- Chronic (gradual effects such as heat or sea levels)

It offers projections of specific weather effects.

The goal is to provide a common framework for scenarios which can facilitate comparisons between firms.

For more information see https://www.cmsi.org.au/
## CMSI examples

<table>
<thead>
<tr>
<th>Extreme or hazard</th>
<th>Average in 1966-2005</th>
<th>Observed change and attribution</th>
<th>2030</th>
<th>2050</th>
<th>2090</th>
<th>Confidence rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tropical cyclone (TC) frequency in Australian region</td>
<td>10-11 per year</td>
<td>-10%, weak</td>
<td>East -4% [-8% to 1%]; West -6% [-10% to -2%]</td>
<td>East -4% [-9% to 1%]; West -6% [-10% to -2%]</td>
<td>East -4% [-10% to -2%]</td>
<td>Medium</td>
</tr>
<tr>
<td>Cal-45 TC (a less common 30°S less common)</td>
<td>2-3 per year</td>
<td>Little change (if non-large variability); none</td>
<td>Little change or small increase</td>
<td>Little change or small increase</td>
<td>Little change or increase</td>
<td>Low-Medium (for examples of numbers published in previous studies see Section 3.2)</td>
</tr>
<tr>
<td>TC location (latitude) with changes noted for southern extent</td>
<td>10-20°S</td>
<td>Little change or small poleward expansion, none</td>
<td>Little change or small poleward expansion</td>
<td>Little change or small poleward expansion</td>
<td>Little change or poleward expansion</td>
<td>Low (for examples of numbers published in previous studies see Section 3.3)</td>
</tr>
<tr>
<td>East coast low (ECL) frequency</td>
<td>20 per year, with 2-3 intense ECLs per year impacting on land</td>
<td>-10% (but with large variability); weak</td>
<td>-10% [-10% to -5%]</td>
<td>-10% [-10% to -5%]</td>
<td>-10% [-10% to -5%]</td>
<td>Medium (Low for summer and High for winter)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Climate variable</th>
<th>Observed change and attribution</th>
<th>2030</th>
<th>2050</th>
<th>2090</th>
<th>Confidence rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual average temperature</td>
<td>Around +1.4°C since 1910 (strong)</td>
<td>+0.8 to 1.4°C</td>
<td>+0.5 to 1.5°C</td>
<td>+0.5 to 1.5°C</td>
<td>Very High</td>
</tr>
<tr>
<td>Average sea level</td>
<td>Increased by 3.1 mm/year during 1993-2009 (strong)</td>
<td>+0.07 to 0.2 m</td>
<td>+0.1 to 0.3 m</td>
<td>+0.2 to 0.6 m</td>
<td>Very High</td>
</tr>
<tr>
<td>Average annual rainfall</td>
<td>Decreased 11% in the southeast during April to October for 1999 to 2018 relative to 1900 to 1998, and decreased 20% in the southwest during May to July since 1970 relative to 1950 to 1990 (strong), with an increase of 10mm/decade from 1900-2019 in the north (weak)</td>
<td>East: -13 to -5%; North: +6 to +14%; South: -9 to -2%; Rangelands: -10 to +6%</td>
<td>Drier in the south and east, uncertain in the north (see Tables 3.1-3.4)</td>
<td>Drier in the south and east, uncertain in the north (see Tables 3.1-3.4)</td>
<td>High in southern Australia. Low elsewhere</td>
</tr>
<tr>
<td>Time in drought</td>
<td>Insignificant (weak)</td>
<td>Increase in many regions (see Table 3.6 and 3.7)</td>
<td>No data</td>
<td>Significant increase in many regions (see Table 3.6, 3.7)</td>
<td>High in southern Australia. Low elsewhere</td>
</tr>
<tr>
<td>Annual days</td>
<td>&gt;25°C</td>
<td>Increase (strong)</td>
<td>Increase (see Table 3.8)</td>
<td>Increases (see Table 3.8)</td>
<td>High</td>
</tr>
</tbody>
</table>

### Balance sheet
- **Banks**: Loans to firms and households, Outstanding claims, Reinsurance recoveries on outstanding claims
- **General Insurers**: Total value of investments, Values of investments in physical infrastructure and/or other real estate
- **Asset Owners**: Adjustments to the value of income from investment in physical infrastructure and/or other real estate

### Income statement
- **Loans impairment charges**: Gross incurred claims, Reinsurance recoveries on incurred claims, Gross premium income, Reinsurance expenses

### Other metrics
- **Impact on probability of default**: Portfolio Annual Average Losses for weather-related events
- **Impact on loss given default**: Portfolio Annual Exceedance Probabilities for in 1n 100-year events
- **Portfolio gross and net of reinsurance**: Probable Maximum Losses for in 1n 200-year weather related events
- **Overall % of value of investments subject to material physical risk**: High in southern Australia. Low elsewhere
Transition risk (and opportunity) scenario considerations

- **Identify potential actions** by governments, regulators, shareholders, and other stakeholders which would affect the macroeconomic environment in which a firm operates.
- **Designate timeframes** over which the actions may materialize.
- **Describe specific national policies**, such as net zero targets (including timing), electrification of the vehicle fleet, enactment of carbon taxes, etc.
- **Identify demographic and macroeconomic shifts**, such as population movements reflecting drought, changes in manufacturing, or different tourism patterns.
- **Translate these overall goals into specific actions** for the insurance sector and/or firm, such as changing underwriting practices, developing new products, or adjusting investments.
- **Identify risks and opportunities** for the firm, such as increased morbidity from heat stress, higher mental health claims, changes in supply chains for repair parts, etc.
- **Legal & Reputational Risks** are also important, such as determining if past occurrence liability policies covered risks exposed to fossil fuel litigation.
Global initiatives

- Public and private institutions around the world are developing scenario analysis tools:
  - EIOPA published an opinion on the supervision of the use of climate change risk scenarios in the Own Risk and Solvency Assessment (ORSA)
  - EIOPA also published a Discussion Paper on Methodological Principles of Insurance Stress Testing in June 2020 in the process of enhancing its bottom-up stress-test framework
  - The French Prudential Supervision and Resolution Authority published a provisional hypothesis of the climate change pilot exercise in May 2020, which contained several scenarios that have been tested by nine banking groups and 15 insurance groups
  - The Bank of England conducted its Climate Biennial Exploratory Scenario (CBES) for banks and insurers in June 2021
  - APRA in Australia has published a draft Prudential Practice Guide and Climate Vulnerability Assessment framework
- Various financial reporting bodies, such as the IASB and IFRS, are exploring climate risk reporting standards including scenario analysis
Wikipedia defines systems thinking as “… the interdisciplinary study of systems. A system is a cohesive conglomeration of interrelated and interdependent parts which can be natural or human-made. Every system is bounded by space and time, influenced by its environment, defined by its structure and purpose, and expressed through its functioning.”

Practitioners developing scenarios need to consider the interconnectedness inherent in complex systems like a modern economy, such as political fragility, the economic and legal landscape, the state and quantity of natural resources, mitigation and adaptation efforts underway, and the environment.

For example:
- How might the system react to the actions of a firm or government?
- Are countries dependent on the actions of others?
- Are systems fragile and subject to catastrophic failure from “black swans”?

System thinking requires actuaries to operate in multidisciplinary teams which contain diverse expertise in fields such as climate, macroeconomics, or social science.
Effective climate risk management requires **integration** with a firm’s larger ERM framework.

Scenarios **should not be viewed as static**, to be constructed and left for years.

**Multiple scenarios** reflecting alternative futures should be developed.

It can be helpful to consider a **baseline where no action is taken**.

**Question clusters and signposts** can be an effective tool to track whether scenarios need to be modified over time; for example, if a scenario involves achieving net zero by 2050:

- At what point will the vehicle fleet be required to be electric, or hydrogen-powered?
- Will related infrastructure keep pace and how is this measured?
- Will carbon taxes be implemented? If so, when? How will they be implemented, and will there be social justice offsets?

**Bottom-up methods** can also be effective, such as considering the effect of a scenario on every aspect of a firm’s operations and processes.

A **blend of stochastic and scenario approaches** is needed.
Actuarial Considerations
Actuarial considerations

Section 2 contents

• Actuarial considerations in climate-related risk analysis
• Information Note from the Actuaries Institute Australia provides guidance on climate-related risks to Appointed Actuaries in preparing Financial Condition Reports (FCRs)
  – Key issues on capital, reinsurance, and investment management
  – Specific issues for general, life, and health insurers
• Other global sources of actuarial practice guidance
Actuarial considerations – risk assessment

Four ways an actuary can assess a firm in the context of its ERM framework

Does the institution and its management team:

1. Have appropriate governance and leader engagement to address climate-related risks?

2. Understand the financial and strategic risk associated with climate change?

3. Have an effective plan or strategy to assess and address climate-related risks?

4. Have a process to evaluate customer considerations and reputation risk?
Climate-related risks and insurance processes
Climate-related risks and insurance processes

- Key callouts for capital adequacy, reinsurance, and investment management

**Capital**
- Allow for uncertainties in stress margins in insurance risk and target capital
- Use longer time horizon than a general stress test (3 years in Australia)
- Reflect potential climate-related risks on claims costs
- Consider the effect of climate change on investment value and returns
- Allow for shifts in geographic distribution of natural hazard and health risks

**Reinsurance**
- Consider availability and price of reinsurance over medium to long term
- Consider credit-rating targets as rating agencies incorporate climate-related risks in their credit-rating determination

**Investment**
- Consider impact from politics and response paths; quality of climate risk information on securities; extreme events and climate tipping points, and suitability of macroeconomic assumptions
- View transition risks over longer term e.g. risk of stranded assets, meeting customer expectations
- Include “shadow” carbon price to reflect transition costs
- Establish criteria for fund manager selection
- Reflect climate change on liability duration and volatility
General insurers – physical risks

Exposure to physical risks through:

- **Claims** on insured events
- **Investment values** on asset portfolios
- Assessment of **credit** risk
- **Workers’ compensation** claims
- **Professional Indemnity** insurance contracts

- Higher sea levels
- Reputation risk if claim denied or unanticipated ex-gratia

- More rainfall, flooding
- Cyclone hazards in coastal areas
- Need cyclone resilient building codes

- Coral bleaching
- Reduced resilience of coastal properties to storm surge

- Higher temperatures
- Changing severity and frequency

- Rainfall pattern changes
- Conditions for crops and fish move

- Higher rainfall intensity
- Urban drainage become ineffective in major events

Physical risk impacts differ by region
General insurers – actuarial considerations

- **Appropriateness of pricing** / underwriting policy (similar to Solvency II requirement)
  - Annually renewable contracts so insurers can reprice, product designs can be reviewed frequently; however, consider affordability issues, regulatory and reputational risks when premiums increase or coverage becomes limited

- **Reserving** methods can be affected by changes in claim payment patterns

- **Catastrophe model** should be adjusted, consider:
  - Capturing climate-related risks in underlying assumptions, segregated by geographical areas
  - Allowing for other factors e.g., demand surge and business interruption
  - Analysing different time horizons for different applications

<table>
<thead>
<tr>
<th>Time horizon</th>
<th>Applications</th>
<th>How to adjust natural hazard catastrophe model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short term</td>
<td>Annual pricing and valuation</td>
<td>Use current climate-related risks with small annual increments</td>
</tr>
<tr>
<td>Medium term</td>
<td>Portfolio steering</td>
<td>Sensitivity testing with trend or step change in parameters</td>
</tr>
<tr>
<td>Long term</td>
<td>Capital position Rebalancing business</td>
<td>Sensitivity testing under different climate scenarios</td>
</tr>
</tbody>
</table>
Physical risks impact claims arising from mortality, morbidity, and longevity risks

**Mortality**
- Additional deaths from weather changes
- Change to mortality curve from shifts in climate patterns

**Morbidity**
- Heat-related stressors and poor air quality impact on respiratory and cardio-vascular health
- Additional mental health impacts

**Longevity**
- Benefit from income streams ending earlier than expected in the short-term
- Adversely impacted by less need for longevity protection in the long-term

Customers’ ability to pay premiums: lapse, retention, and new business sales
Examples of how life insurers are exposed to transition risks:

- Disruptions to job stability in some sectors and could result in claims arising from mental health due to unemployment.
- New and changing industries mean uncertainty to occupation ratings for pricing.
- Impacts investment portfolios creating positive and negative outcomes (e.g., stranded assets).

Due to long-term nature of life insurance contracts, sensitivity of mortality and morbidity rates to unemployment and mental health can be more material than physical risks in the short term.
Health insurers – physical risks and health outcomes

Physical risks

- Heat stress and higher hospital rates
- Mental health is key issue for farmers and families
- Flow on impacts on food affordability and accessibility for low income communities

Rising temperatures & drought

- Physical injuries and psychological distress
- Food and water security
- Mental illness onset from loss of homes and livelihoods

Extreme weather events

- Change optimal conditions for spread of diseases
- Poorer air quality increases the risk of cardiovascular and respiratory diseases

Other changes in climate
Apart from physical risks, also consider:

- Transition of health insurance system so products continue to meet consumers’ changing health needs
- Disruptions to job stability can increase physical and mental health claims (impacts life insurance too)
- Change in spread of pollution-related diseases due to energy transition
- Government policy actions e.g., heatwave- and flood-mitigation plans can reduce level of vulnerability to climate-related risks
- Impact on public health and emergency response services, and ultimately on healthcare system
Actuarial organizations around the world are developing important guidance and information.

Other actuarial associations

- Climate Change for Actuaries: An Introduction
- A Practical Guide to Climate Change for Life Actuaries
- Other similar titles for defined benefit pension actuaries, general insurance actuaries
- Climate Change and Resource Sustainability: An Overview for Actuaries
- Time to Act: Facing the Risks of a Changing Climate
- Climate, Weather, and environmental Sources for Actuaries
- Series of educational notes
Other actuarial considerations

- Recognise high level of correlation between climate change risks
- Develop disclosure of approaches to climate change risk
- Raise awareness and risk identification e.g., logging on risk register
- Analyze qualitative aspects of scenario with alternative potential future paths of climate change and social response
- Mitigate systemic risks and risk of groupthink by collaborating with other non-actuarial professionals, getting multiple views from consulting firms and reinsurers, encourage robust independent challenge and reviews

While outcomes are highly uncertain, there is a high degree of certainty that financial impacts from a combination of physical and transition risks will occur, although their severity, specific location, and timing are uncertain.
Risk identification grid

- To assess the potential climate change risks to which the insurer is subject
- Helps to distinguish between shock (or “acute”) and trend (or “chronic”) impacts
- Example of a risk identification grid

<table>
<thead>
<tr>
<th>Risk Class</th>
<th>Physical</th>
<th>Transition</th>
<th>Liability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Longevity</td>
<td>Yes</td>
<td>Less material</td>
<td>No</td>
</tr>
<tr>
<td>Mortality/Morbidity</td>
<td>Yes</td>
<td>Less material</td>
<td>No</td>
</tr>
<tr>
<td>Lapse</td>
<td>Less material</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Counterparty</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Operational</td>
<td>Less material</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Strategic</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Reputational</td>
<td>n/a</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Case Studies
- Crop insurance in India
- A transition example
- Supply chains and fragility
Case study #1 - crop insurance in India

- Government scheme for agriculture insurance (tender)
- Scheme is index based (yield)
- 2 seasons: Kharif and Rabi
- Main risk: drought
- Product types:
  - Crops
  - Products, index covers are developing quickly
    - Easier to indemnify
    - Less moral hazard
- Challenges:
  - Data
  - Length of available time-series
• Agriculture insurance in India is based on **yield**: this is a **parametric scheme**
• Historical yield data available for approximately **one million location-crop combinations**
• The Indian government-sponsored crop insurance scheme (‘Pradhan Mantri Fasal Bima Yojana’ or ‘PMFBY’) guidelines are applied to **yield data to estimate loss costs** on an annual basis
• According to PMFBY guidelines, a **payout is made when yields are below a certain threshold**
• The threshold yield is calculated by taking the average of the best 5 of the last 7 annual yields, **multiplied by an indemnity level**, which is location-crop specific and can have values such as 70%, 80%, or 90%
• Before applying PMFBY guidelines to calculate annual loss costs, a **detrending procedure** is applied; this means that the original yield data can be transformed to reflect current ‘as-if’ **yields**, considering the possible presence of a yield trend
• Soybean yields have improved on average by 6% (USDA, reflects technology such as Roundup)
• Review the impact of temperature increase on yields (climate change impact)
• Restate the past yield data on an “as-if” basis including the impact of climate-change
  – Based on a climate change scenario (mean temperature increase);
  – And on the impact of temperature increase on yields
• Recalculate the PMFBY average payout including the climate change impact
• Estimate impact of climate change in 2025
  – Horizon is important for the scenario estimation
Scenario definition

- 3 scenarios for 2025 temperature increase:
  - Average scenario = +1.075° vs preindustrial (1850-1900)
  - Upper bound scenario = +1.2° vs preindustrial
  - Lower bound scenario = +0.95° vs preindustrial

- These are based on observations and modelling results of recent temperature levels and trends

- Mean temperature is used here as a major indicator of climate change

- Agriculture losses are rather driven by temperature and precipitation extremes
Various scientific publications link climate change with crop yield changes. These “links” are statistical or process-based models, which are developed/calibrated using observations. Yield trends in this case are mostly driven by temperature changes. Precipitation can have a larger impact on crops, but precipitation trends are weaker. Climate change trends were “converted” to crop yield trends based on scientific literature.

<table>
<thead>
<tr>
<th>season</th>
<th>crop</th>
<th>low</th>
<th>medium</th>
<th>high</th>
<th>comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kharif</td>
<td>Paddy</td>
<td>-0.183</td>
<td>-0.202</td>
<td>-0.221</td>
<td></td>
</tr>
<tr>
<td>Kharif</td>
<td>Soy</td>
<td>-0.180</td>
<td>-0.270</td>
<td>-0.310</td>
<td>Mall et al, 2004</td>
</tr>
<tr>
<td>Kharif</td>
<td>Other</td>
<td>-0.128</td>
<td>-0.142</td>
<td>-0.157</td>
<td>average of maize, sorghum, pigeonpea and groundnut</td>
</tr>
<tr>
<td>Rabi</td>
<td>Wheat</td>
<td>-0.187</td>
<td>-0.212</td>
<td>-0.237</td>
<td></td>
</tr>
<tr>
<td>Rabi</td>
<td>Other</td>
<td>-0.089</td>
<td>-0.102</td>
<td>-0.115</td>
<td>average of barley, chickpea and mustard</td>
</tr>
</tbody>
</table>

*Annual percentage yield change as a result of climate change for India*
Notes

- mean 5’ is calculated as the mean of the 5 best years over the last 7 years
- ‘indem’: according to the PMFBY guidelines, an 80% indemnity level is chosen for this example
- ‘threshold’ is the indemnity level multiplied by the ‘mean 5’
- ‘payout’ equals \(1 - \frac{\text{yield}}{\text{threshold}}\)
- for the climate change assumption, a 0.289% reduction of yield per year is assumed; with this assumption, reduced yield due to climate change can be estimated on an ‘as-if’ basis

### Result – example of one crop-location

<table>
<thead>
<tr>
<th>Year</th>
<th>Yield</th>
<th>Threshold</th>
<th>Payout</th>
<th>Mean 5’</th>
<th>CoV</th>
<th>Mean 7</th>
<th>Mean 5</th>
<th>Indem</th>
<th>Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>300</td>
<td>528</td>
<td>43%</td>
<td>-4.621</td>
<td>-4.332</td>
<td>-4.043</td>
<td>-3.755</td>
<td>0.8</td>
<td>528</td>
</tr>
<tr>
<td>2010</td>
<td>500</td>
<td>528</td>
<td>5%</td>
<td>-4.621</td>
<td>-4.332</td>
<td>-4.043</td>
<td>-3.755</td>
<td>0.8</td>
<td>528</td>
</tr>
<tr>
<td>2011</td>
<td>400</td>
<td>528</td>
<td>24%</td>
<td>-4.621</td>
<td>-4.332</td>
<td>-4.043</td>
<td>-3.755</td>
<td>0.8</td>
<td>528</td>
</tr>
<tr>
<td>2012</td>
<td>600</td>
<td>528</td>
<td>0%</td>
<td>-4.621</td>
<td>-4.332</td>
<td>-4.043</td>
<td>-3.755</td>
<td>0.8</td>
<td>528</td>
</tr>
<tr>
<td>2013</td>
<td>700</td>
<td>528</td>
<td>0%</td>
<td>-4.621</td>
<td>-4.332</td>
<td>-4.043</td>
<td>-3.755</td>
<td>0.8</td>
<td>528</td>
</tr>
<tr>
<td>2014</td>
<td>800</td>
<td>528</td>
<td>0%</td>
<td>-4.621</td>
<td>-4.332</td>
<td>-4.043</td>
<td>-3.755</td>
<td>0.8</td>
<td>528</td>
</tr>
<tr>
<td>2015</td>
<td>200</td>
<td>528</td>
<td>62%</td>
<td>-4.621</td>
<td>-4.332</td>
<td>-4.043</td>
<td>-3.755</td>
<td>0.8</td>
<td>528</td>
</tr>
<tr>
<td>2016</td>
<td>550</td>
<td>528</td>
<td>0%</td>
<td>-4.621</td>
<td>-4.332</td>
<td>-4.043</td>
<td>-3.755</td>
<td>0.8</td>
<td>528</td>
</tr>
<tr>
<td>2017</td>
<td>450</td>
<td>528</td>
<td>15%</td>
<td>-4.621</td>
<td>-4.332</td>
<td>-4.043</td>
<td>-3.755</td>
<td>0.8</td>
<td>528</td>
</tr>
<tr>
<td>2018</td>
<td>650</td>
<td>528</td>
<td>0%</td>
<td>-4.621</td>
<td>-4.332</td>
<td>-4.043</td>
<td>-3.755</td>
<td>0.8</td>
<td>528</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Current India payout estimation</th>
<th>India payout estimation under climate change assumption</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Year</strong></td>
<td><strong>Yield</strong></td>
</tr>
<tr>
<td>2009</td>
<td>300</td>
</tr>
<tr>
<td>2010</td>
<td>500</td>
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<tr>
<td>2011</td>
<td>400</td>
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<td>2012</td>
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<td>550</td>
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<tr>
<td>2017</td>
<td>450</td>
</tr>
<tr>
<td>2018</td>
<td>650</td>
</tr>
</tbody>
</table>

Mean 5’ is 660, mean 7 is 564, CoV is 0.358
Mean 5’ is 660, mean 7 is 564, CoV is 0.360

**Conclusion:** under the proposed scenario, the average payout for this crop-location will increase from 15.0% to 15.2%, which represents a negligible 1.3% increase in 2025.
- Qatar has been a major producer of oil and gas
- Qatari government has laid out a diversification blueprint to diversify its economy to make it more self-sufficient and less reliant on gas and other high emission resources
- Climate change threatens the economy in many ways, including rising temperatures and higher sea levels (which may inundate its airport)
- The government has produced economic forecasts, transition scenarios, and roadmaps to increase renewable energy and sustainable practices
- There is significant uncertainty as to whether Qatar’s gas exports will be deemed partially sustainable during a decarbonization transition
- Two scenarios are presented in the case study
- The IAA paper makes no judgment on the appropriateness of Qatar’s actions; instead, the example illustrates the challenges investment managers and insurance underwriters face
If a pension fund or financial institution were exposed to investments or insurance underwriting in Qatar, consideration of issues such as these would be required:

– Does the investor have internal constraints on investments which include fossil-fuel production, and, if yes, will divestment be required and over what time horizon?
– Regardless of the investor’s internal ESG policies, how will any investments exposed to Qatar be affected by a global push towards decarbonization?
– Regardless of the investor’s internal ESG policies, how will any investments exposed to Qatar be affected by potential divestment actions by other investors?
– Would investments in economic diversification in Qatar qualify under an investor’s ESG policies?
– Has the financial institution adequately protected its policyholders, shareholders, or members from losses due to divestment or stranded assets?
– Is the firm exposed to legal or reputational risk by its involvement with Qatar?
– What is the timeframe of the investment in the context of the expected emergence of transition risk?
Case study #3: supply chains and fragility

• **A food price crisis**
  – Extreme weather in 2010 led to wheat crop failures in key countries; prices skyrocketed
  – Many countries in the Middle East and North Africa imported much of their wheat supply; citizens spent a large proportion of their income on food
  – Food price increases placed great stress on populations and social systems

• **A supply chain problem**
  – Also in 2010, severe flooding in Thailand affected the global supply chain for automobile parts
  – Production was impacted across the world; many manufacturers were caught off guard
  – Flood models used to estimate risk did not cover Thailand well

• **Fragility**
  – Taleb and Blyth illustrate fragility from the conditions which existed before the 2008 Global Financial Crisis (GFC) where governments sought to moderate economic shocks
  – “Those who seek to prevent volatility on the grounds that any and all bumps in the road must be avoided paradoxically increase the probability that a tail risk will cause a major explosion.”
Questions
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Thank you