Climate Risk Macroeconomic Forecasting

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Today’s Speakers

Economics & Business Analytics

Luca Magni
Associate Director

Petr Zemcik, PhD
Senior Director

Chris Lafakis
Director

Janet Lee
Director
Economics & Business Analytics ESGC Initiatives

Today’s Focus

Climate Change Economic Scenarios

Economic Losses of Climate Events

Connecting Climate Change drivers to Retail Portfolios

ESG Score Predictor: Scoring Un-Rated Firms
Agenda

1. Regulatory Environment
3. UK & US Climate Change Scenarios
1 Regulatory Environment
Regulatory Environment

» Network for Greening the Financial System (NGFS) and Task Force on Climate-related Financial Disclosures (TCFD) are leading voices for a call to action in the financial system.

- **NGFS** is a group of over 35 central banks and regulatory agencies worldwide established at the Paris “One Planet Summit” in December 2017. Includes: BoE, ECB/EBA, Banque De France, The Peoples Bank of China, EIOPA
- **TCFD** is a taskforce set up by the Financial Stability Board, comprised of over 785 influential organizations from around the world.
- Scenario-based risk analysis is an integral part to both the NGFS and TCFD’s action plans.

**UK- BoE/PRA**

- SS3/19: Enhancing banks’ and insurers’ approaches to managing the financial risks from climate change April 2019
- The 2021 biennial exploratory scenario (BES) on the financial risks from climate change, BoE Discussion Paper 2019.
- Three scenarios corresponding to NGFS scenarios.
- Climate Change Committee/Climate Change Act

**US-FED**

- Fed Chair Powell & Vice Chair Quarles indicated that the FED wants to engage with NGFS
- Financial Stability Report, November 202
- Statement by Governor Lael Brainard
- September 2020 – an advisory panel to the Commodity Futures Trading Commission released a report ‘Managing Climate Risk in the U.S. Financial System.’
## Economic vs Climate Risk Scenarios

**Differentiation between standard forecasts and climate risk scenarios**

<table>
<thead>
<tr>
<th>Economic Scenario</th>
<th>Climate Risk Scenario</th>
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<tbody>
<tr>
<td>• 5- to 30-yr forecast horizon</td>
<td>• 30- to 80-yr forecast horizon</td>
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<tr>
<td>• Used to measure capital and assess risk</td>
<td>• Used to assess risk</td>
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<tr>
<td>• Shock inputs are provided by Moody’s Analytics, clients or regulators</td>
<td>• Impact channels must be translated into shock inputs</td>
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<tr>
<td>• Stable economic relationships</td>
<td>• Increased uncertainty over how impact channels translate into economic inputs</td>
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<td>• Shock inputs do not depend on carbon dioxide trajectory</td>
<td>• Increased uncertainty over how the economy transitions from fossil fuels to renewables</td>
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<td>• Shock inputs depend on carbon dioxide trajectory</td>
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<td>• Requires new forecast variables and model equations</td>
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Constructing Climate Risk Scenarios

**Climate Risk Variables**

- Physical Variables
  - Global & regional temperature pathways
  - Health & productivity effects
  - Sea level rise
  - Energy demand and tourism

- Transition Variables
  - Carbon price pathways
  - Emissions pathways
  - Commodity & energy prices; energy mix

**Macrofinancial Variables**

- Macroeconomic Variables
  - GDP & unemployment
  - Inflation & central bank rates
  - Corporate profits & household income
  - Residential & commercial property prices

- Financial Market Variables
  - Government & corporate bond yields
  - Equity indexes
  - Exchange rates & bank rates

Start with regulators’ parameters
Expand scenario to extrapolate additional variables
Using global macro model with climate risk components
Moody’s Analytics Global Macroeconomic Model

100+ Country Modules Linked via Trade and Finance

Specification choice
- Theoretical reasoning versus statistical properties

In-sample equation fit
- R-squared, RMSE, information criteria
- Fitted values and residuals

Forecasting performance
- Back-testing: conditional and unconditional evaluation
- Benchmarking during important past episodes

Sensitivity to shocks
- Forecasts across scenarios
- Response to individual shocks
IPCC Scenarios

Greenhouse gas concentration levels define four distinct scenarios

Representative Concentration Pathways (RCPs) created by the Intergovernmental Panel on Climate Change (IPCC) to represent plausible long-run greenhouse gas emission pathways.

- **RCP 2.6** (The Paris Accord Scenario)
  - +1°C temperature increase
  - More transition risks
  - Corrective transition responses
  - Emission-curbing policies
  - Decarbonization
  - Global coordination

- **RCP 4.5** (Moderate Warming)
  - 1.9°C temperature increase
  - No policy change, "business as intended"
  - Climate hazard intensifies
  - Corrective transition responses

- **RCP 6** (Late-Century Warming)
  - 2.4°C temperature increase
  - RCP 8.5 (No Mitigation)
  - 4.1°C temperature increase
  - Temperature rises in tandem with the emission level
  - High carbon intensity
  - No mitigating policies
Modelling Framework: Physical & Transition Risk
Incorporating Transition and Physical Risk Risk Scenarios

- CO₂ Pathway
- Temperature Pathway
- Physical Risk Shock Inputs
- Financial Impact
- Carbon Tax, Other Climate Policy
- Climate Risk Scenarios
Modelling Framework

Impact Channel

1. Sea level rise
2. Agricultural productivity
3. Heat stress effect on labor productivity
4. Human health effects
5. Tourism
6. Energy demand

Mnemonics
- $C_{\text{GEO}}$
- $PROD_{\text{POT_GEO}}$
- $PROD_{\text{POT_GEO}}$
- $PROD_{\text{POT_GEO}}$
- $NETEX$_{\text{L_GEO}}$
- $PIFICEBOIU$_{\text{US}}$

Energy Consumption

1. Coal
2. Natural gas
3. Petroleum and other liquid

Mnemonics
- $COALCONQ_{\text{IGEO}}$
- $NGASCONQ_{\text{IGEO}}$
- $PETCONQ_{\text{IGEO}}$

CO2 Taxes

1. Dividend dummy
2. Carbon tax dummy
3. Carbon tax rate
4. Carbon tax revenue
   4-i. Carbon tax revenue: Coal
   4-i. Carbon tax revenue: Natural gas
   4-i. Carbon tax revenue: Petroleum

Mnemonics
- $\text{DUM}_\text{CARBONDIV}_{\text{IGEO}}$
- $\text{DUM}_\text{CARBONTAX}_{\text{IGEO}}$
- $\text{CARBONTAX}_{\text{IGEO}}$
- $\text{CARBONREV}_{\text{IGEO}}$
- $\text{COALREV}_{\text{IGEO}}$
- $\text{NGASREV}_{\text{IGEO}}$
- $\text{PETREV}_{\text{IGEO}}$

CO2 Emissions

1. Coal
2. Natural gas
3. Oil

Mnemonics
- $COALCO2EQ_{\text{IGEO}}$
- $NGASCO2EQ_{\text{IGEO}}$
- $PETCO2EQ_{\text{IGEO}}$

Energy Prices

1. Coal
2. Natural gas
3. Oil

Mnemonics
- $COALDOM_{\text{IGEO}}$
- $NGASDOM_{\text{IGEO}}$
- $OILDOM_{\text{IGEO}}$

Government Finances

1. Total revenue
2. Total expense
3. Expenditure intermediate term
4. Expenditure residual

Mnemonics
- $\text{GGREV}_{\text{IGEO}}$
- $\text{GGEXP}_{\text{IGEO}}$
- $\text{GGEXP}_{\text{L_GEO}}$
- $\text{GGEXP}_{\text{RESID_{IGEO}}}$
Moody's Analytics physical risk assessment is based on:

- Combined output delta
- Temperature pathways from NGFS Scenarios
- Chronic physical risk (vs acute)
- Forecasting horizon from 2050 to 2100
- Transition risk added later
- Moody's Global Macroeconomic Model.
NGFS Scenarios

World Temperature Pathway (°C rel. to 1850-1900)

- Immediate 2C with CDR (Orderly, Rep)
- Delayed 2C with limited CDR (Disorderly, Rep)
- Current policies (Hot house world, Rep)

Sources: Network for Greening the Financial System
NGFS Consistent Scenarios

**Energy Consumption**
REMIND IAM
Translate into fuel emissions by source

**Physical Risk**
MA Approach
MA population and GDP assumptions

**Energy Prices & Price Indices**
CO2 tax set to match emissions
Prices reflect the taxes

**Output**
GDP paths consistent with assumptions regarding physical and transition risk
Industrial detail projections
### TCFD Recommendation

Eight higher-risk sectors to have more detailed climate-related financial disclosures.

### PRA General Insurance Stress Test 2019

Nine sectors to provide factors to assess the potential impact on the market of investments from transition and physical risks in each of the climate scenarios.

### Moody’s Global Macro model currently forecasts:

- Employment and Gross Value Added by industry for most European countries and some Asian countries
- 20 industries according to NACE classification (seven in the goods-producing sector and 13 in the service-providing sector)

### TCFD Higher-Risk Industries

- Energy
- Transportation
- Materials & buildings
- Agriculture, food & forest products
- Banks
- Insurance companies
- Asset owners
- Asset managers

### PRA Higher-Risk Industries

- Fuel extraction
- Power generation
- Transport
- Energy-intensive ind. (materials/metals)
- Agriculture & food security
- Water utilities
- Real estate assets (incl. CRE, rental & leasing, construction, infrastructure)
- Sovereign & municipal bonds
- Others

### Moody’s Higher-Risk Industries

- Mining & quarrying
- Electricity: gas, steam & air cond. supply
- Transportation & storage
- Manufacturing
- Agriculture, forestry & fishing
- Water supply; sewerage, waste management & remediation
- Construction
- Real estate
- Financial & insurance
- Public administration & defense
- Wholesale & retail trade
- Accommodations & food service
- Information & communication
- Professional: scientific & technical
- Administrative & support service
- Education
- Human health & social work
- Arts: entertainment & recreation
- Other services
- Activities of household as employers
3 UK & US Climate Change Scenarios
U.K. Carbon Dioxide Tax Rate

GBP per metric ton, NSA

NGFS Current (Hot house world)
NGFS Delay (Disorderly)
NGFS Immediate (Orderly)

Sources: Network for Greening the Financial System; Moody’s Analytics
U.S. Carbon Dioxide Tax Rate

USD per metric ton, NSA

Sources: Network for Greening the Financial System; Moody’s Analytics
U.K. Effective Domestic Price: Coal

1/100 GBP per #, NSA (Log scale)

Sources: U.K. Department for Business, Energy & Industrial Strategy; Moody’s Analytics
U.S. Effective Domestic Price: Natural Gas

USD per MMBtu, SA (LOG scale)

Sources: Network for Greening the Financial System; Moody’s Analytics
U.K. Energy Consumption: Coal

Tril. BTU, SAAR (Log scale)

Sources: U.S. Energy Information Administration; Moody’s Analytics
U.S. Energy Consumption: Natural Gas

Ths. Short Tons, SAAR

Sources: Network for Greening the Financial System; Moody’s Analytics
U.K.: Real GDP Scenario Comparison

% deviation from NGFS Current

Sources: Network for Greening the Financial System; Moody's Analytics
U.S. Real GDP Scenario Comparison

% deviation from NGFS Current

Sources: Network for Greening the Financial System; Moody’s Analytics
U.K. GVA-Services Prod. Industry Scenario Comparison

% deviation from NGFS Current

Sources: Network for Greening the Financial System; Moody's Analytics
U.S. GPO-Mining Industry Scenario Comparison

% deviation from NGFS Current

Sources: Network for Greening the Financial System; Moody’s Analytics
U.K. Employment-Services Prod. Industry Scenario Comparison

% deviation from NGFS Current

Sources: Network for Greening the Financial System; Moody’s Analytics
U.S. Employment-Mining Industry Scenario Comparison

% deviation from NGFS Current

Sources: Network for Greening the Financial System; Moody’s Analytics
Key Takeaways

1. Regulatory pressure to quantify climate risk has increased.
2. Generating NGFS consistent scenarios will require target prioritization.
3. Transition risk will be critical for countries such as the U.K. and the U.S, and its impacts will vary substantially across industries.

Q&A

Email us at help@economy.com