

# Course 2022-2023 in Sustainable Finance

## Lecture 6. Global Warming & Climate Change

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<sup>1</sup>The opinions expressed in this presentation are those of the authors and are not meant to represent the opinions or official positions of Amundi Asset Management.

# Climate financial risk

## Climate risks transmission channels to financial stability

- The **physical risks** that arise from the increased frequency and severity of climate and weather related events that damage property and disrupt trade
- The **liability risks** stemming from parties who have suffered loss from the effects of climate change seeking compensation from those they hold responsible
- The **transition risks** that can arise through a sudden and disorderly adjustment to a low carbon economy

Speech by Mark Carney at the International Climate Risk Conference for Supervisors, Amsterdam, April 6, 2018

Physical and transition risks  $\Leftrightarrow$  **E**

Liability risks  $\Leftrightarrow$  **S** (and **G**?)

# Climate financial risk

## Risks are transversal to financial risks

- **Carbon risk** (reputational and regulation risks)  $\Rightarrow$  economic, market and credit risks
- **Climate risk** (extreme weather events, natural disasters)  $\Rightarrow$  economic, operational, credit and market risks

Carbon/climate risks are part of risk management

# Climate financial risk

## Climate risk(s)

Climate risks include transition risk and physical risks:

- Transition risk is defined as the financial risk associated with the transition to a low-carbon economy. It includes policy changes, reputational impacts, and shifts in market preferences, norms and technology
- Physical risk is defined as the financial losses due to extreme weather events and climate disasters like flooding, sea level rise, wildfires, droughts and storms

# Global warming

## Global warming ( $\approx$ climate change)

Global warming is the long-term heating of Earth's climate system observed since the pre-industrial period (between 1850 and 1900) due to human activities, primarily fossil fuel burning

NASA Global Climate Change — <https://climate.nasa.gov>

# Global warming

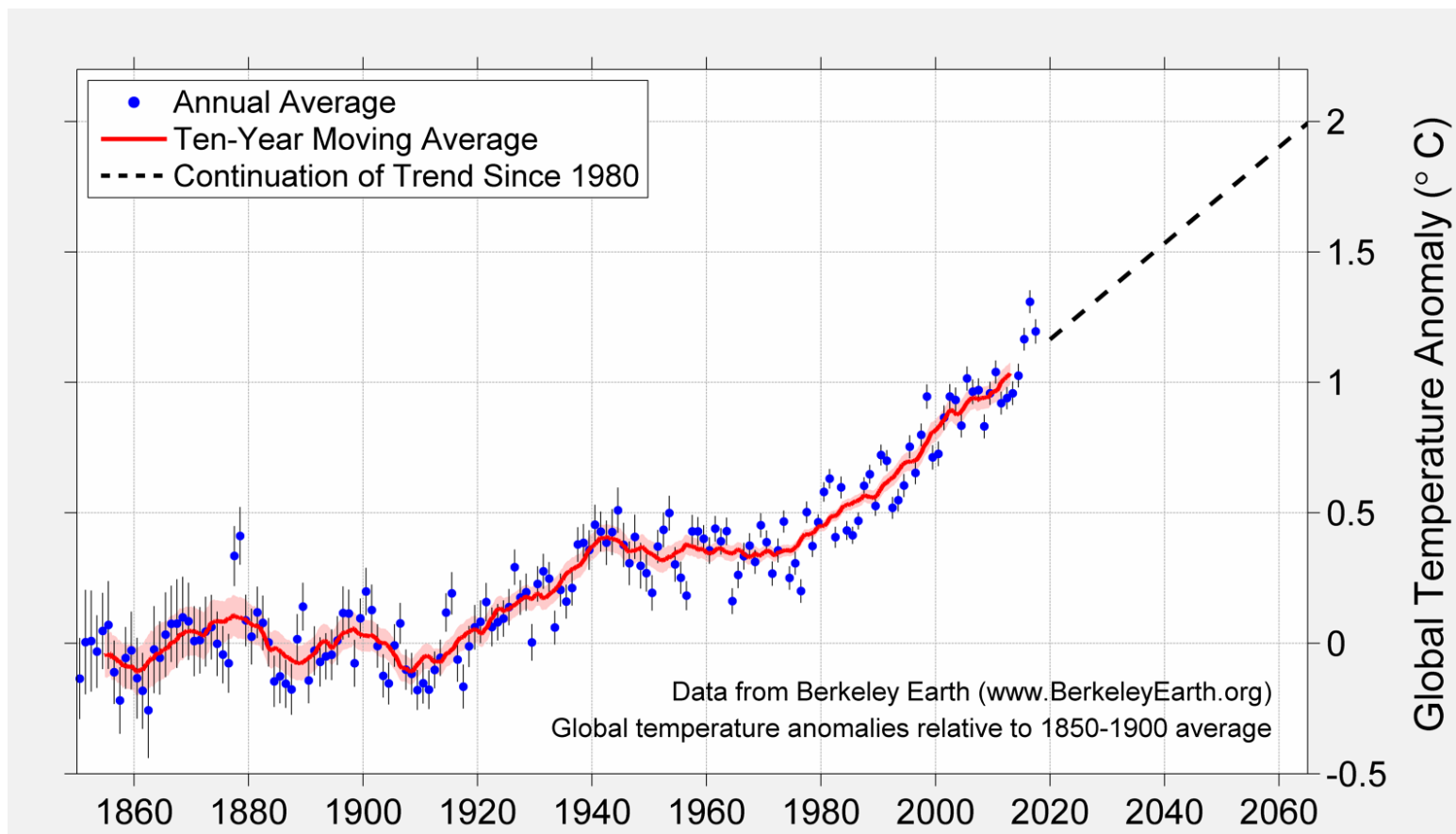


Figure 1: Global temperature anomaly

Source: Berkeley Earth (2018), <http://berkeleyearth.org>

# Global warming

## Carbon risk

Carbon risks correspond to the potential financial losses due to greenhouse gas (or GHG) emissions, mainly CO<sub>2</sub> emissions (in a strengthening regulatory context)

# Global warming

## GHG

Greenhouse gases absorb and emit radiation energy, causing the greenhouse effect<sup>a</sup>:

- 1 Water vapour (H<sub>2</sub>O)
- 2 Carbon dioxide (CO<sub>2</sub>)
- 3 Methane (CH<sub>4</sub>)
- 4 Nitrous oxide (N<sub>2</sub>O)
- 5 Ozone (O<sub>3</sub>)

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<sup>a</sup>Without greenhouse effect, the average temperature of Earth's surface would be about  $-18^{\circ}\text{C}$ . With greenhouse effect, the current temperature of Earth's surface is about  $+15^{\circ}\text{C}$ .



# Global warming

Table 1: Pros and cons of greenhouse gases

GHG	Pros	Cons	Global warming
Water vapour	Life		
Carbon dioxide	Photosynthesis	Pollution	✓
Methane	Energy	Explosive <sup>2</sup>	✓
Nitrous oxide	Dentist 😊		✓
Ozone	UV rays		

<sup>2</sup>And dangerous for human life

# Global warming

## Carbon equivalent

Carbon dioxide equivalent (or CO<sub>2</sub>e) is a term for describing different GHG in a common unit

- A quantity of GHG can be expressed as CO<sub>2</sub>e by multiplying the amount of the GHG by its global warming potential (GWP)
- 1 kg of carbone dioxide corresponds to 1 kg of CO<sub>2</sub>
- 1 kg of methane corresponds to 28 kg of CO<sub>2</sub>
- 1 kg of nitrous oxide corresponds to 273 kg of CO<sub>2</sub>

# CO<sub>2</sub> emissions

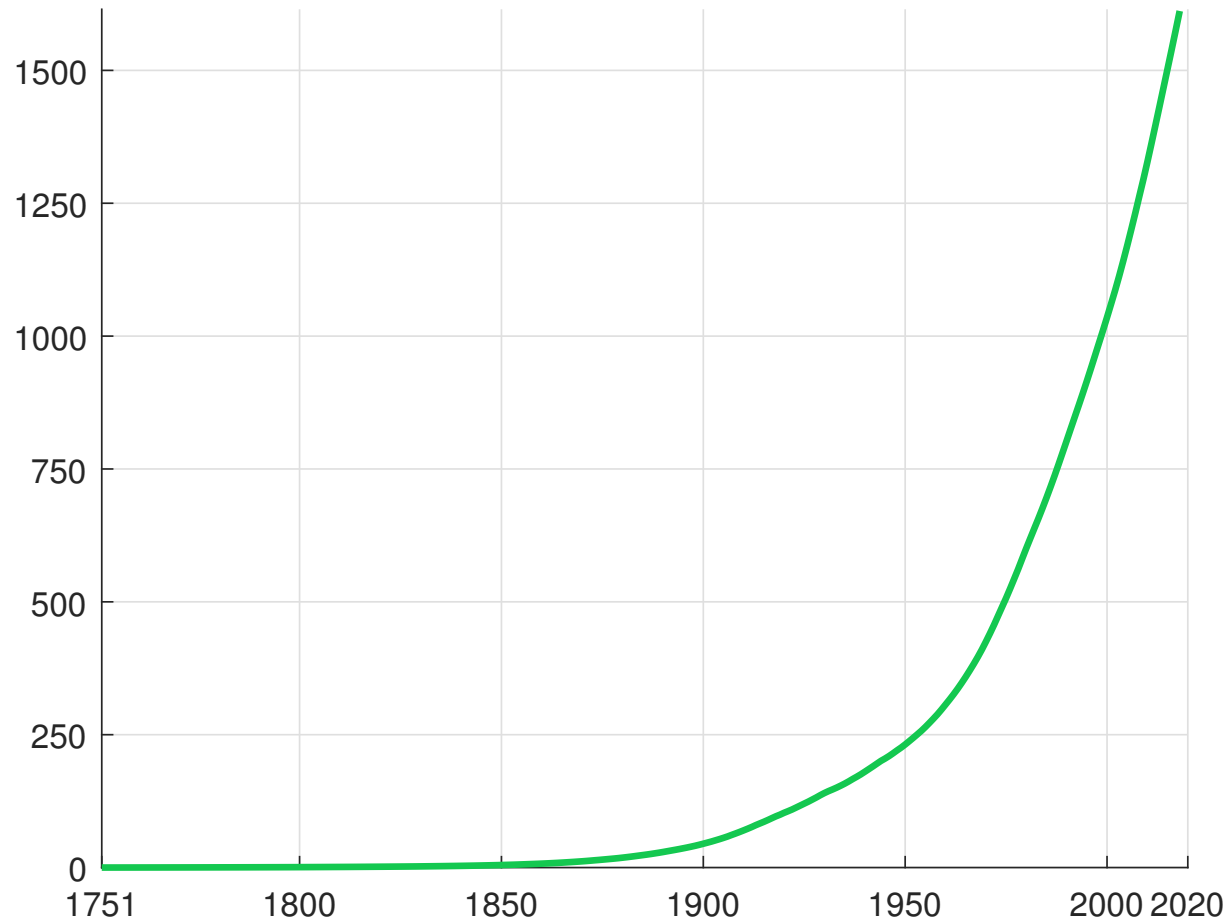


Figure 2: Cumulative CO<sub>2</sub>e emissions (in GtCO<sub>2</sub>e)

Source: Data on CO<sub>2</sub> and GHG Emissions by Our World in Data (<https://github.com/owid/co2-data>)

# CO<sub>2</sub> emissions

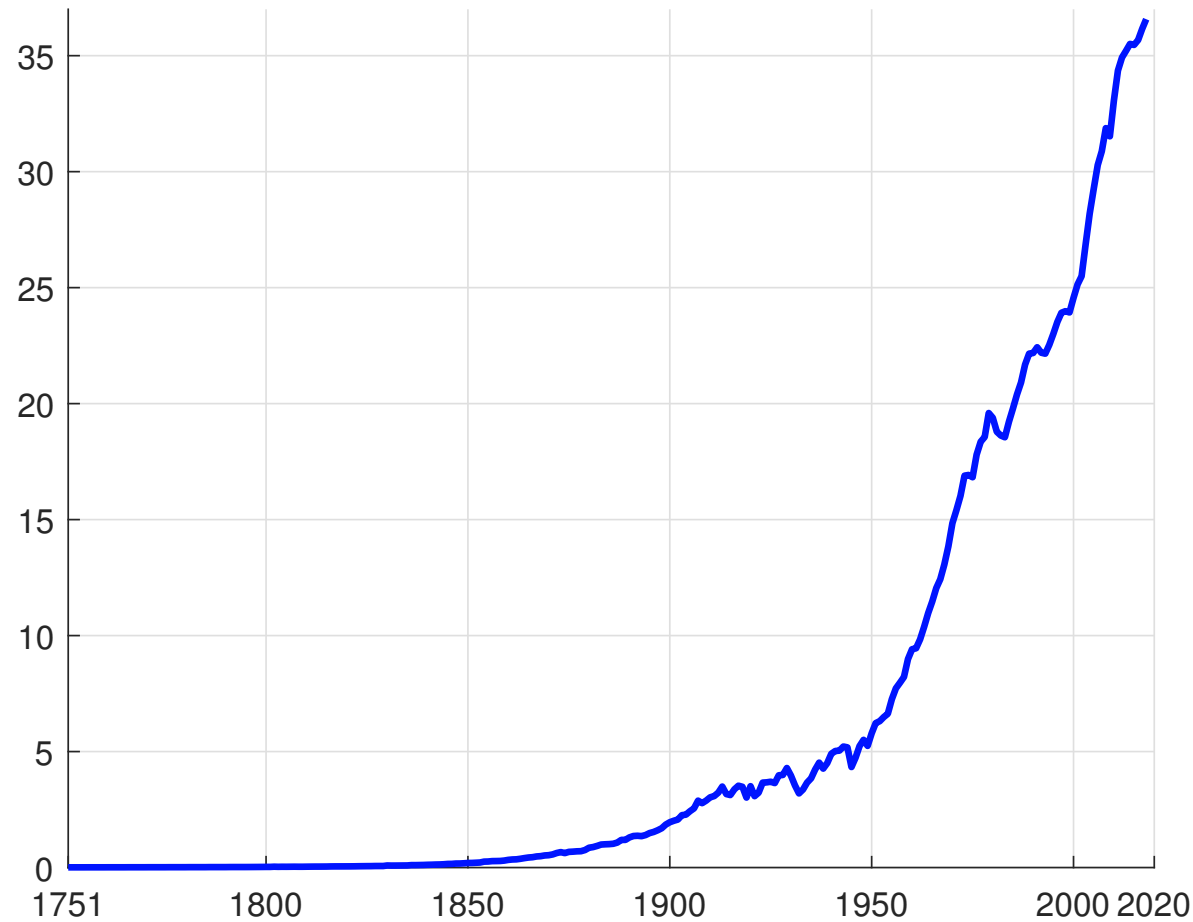


Figure 3: Annual CO<sub>2</sub>e emissions (in GtCO<sub>2</sub>e)

Source: Data on CO<sub>2</sub> and GHG Emissions by Our World in Data (<https://github.com/owid/co2-data>)

# CO<sub>2</sub> emissions

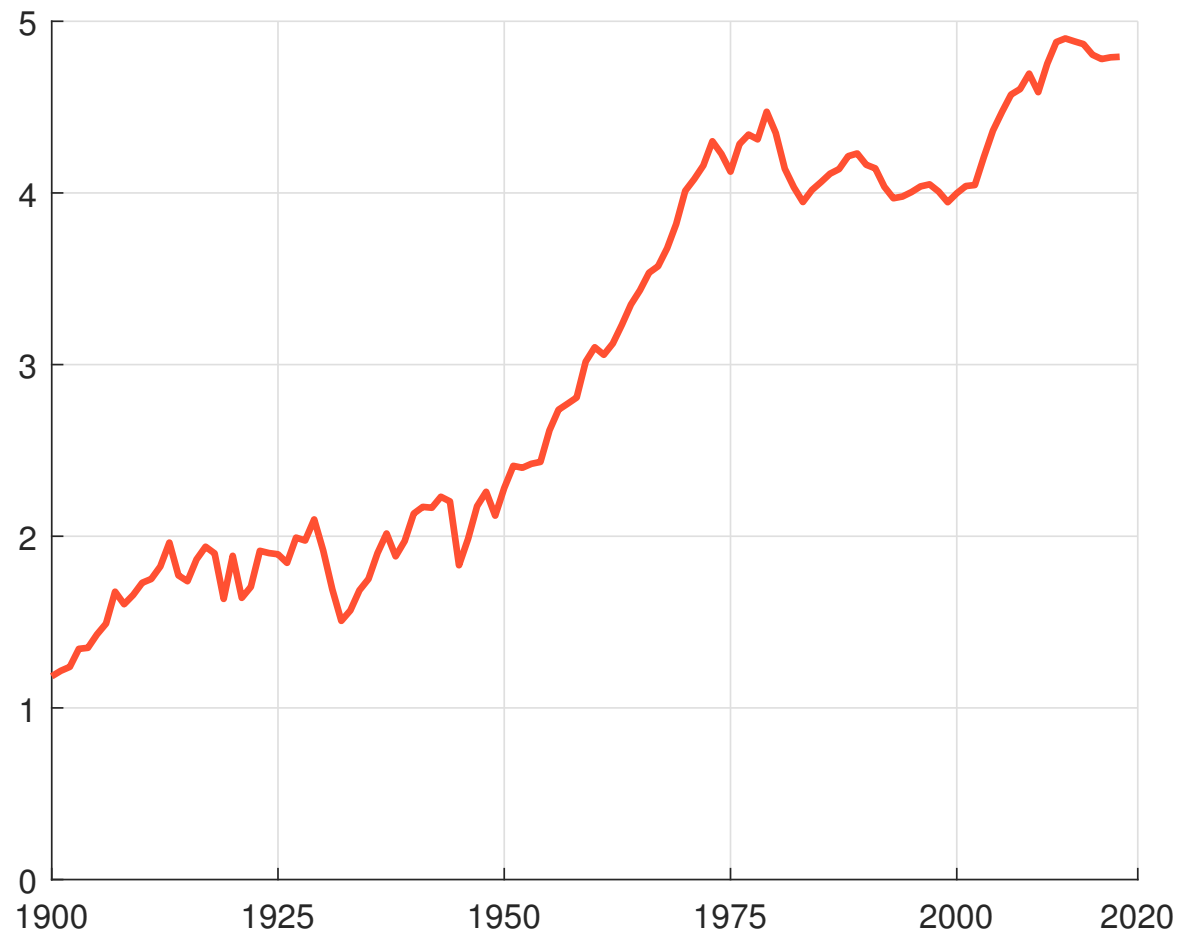


Figure 4: CO<sub>2</sub>e emissions per capita (in tonnes per capita)

Source: Data on CO<sub>2</sub> and GHG Emissions by Our World in Data (<https://github.com/owid/co2-data>)

# CO<sub>2</sub> emissions

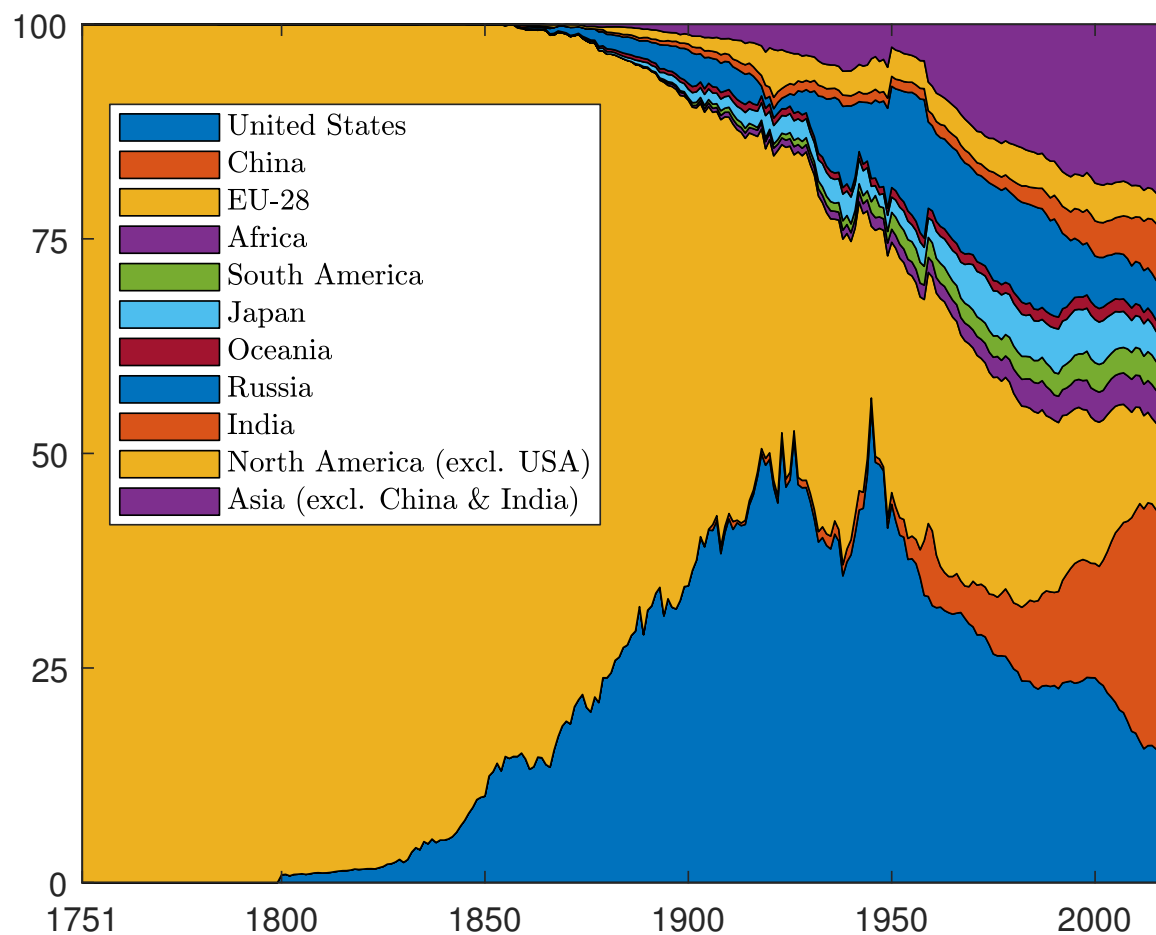


Figure 5: Share of CO<sub>2</sub>e emissions (in %)

Source: Data on CO<sub>2</sub> and GHG Emissions by Our World in Data (<https://github.com/owid/co2-data>)

# CO<sub>2</sub> emissions

## Top options for reducing your carbon footprint

Average reduction per person per year in tonnes of CO<sub>2</sub> equivalent



Live car-free  
**2.04**



Refurbishment  
/renovation  
**0.895**



Battery electric car  
**1.95**



Vegan diet  
**0.8**



One less long-haul  
flight per year  
**1.68**



Heat pump  
**0.795**



Renewable energy  
**1.6**



Improved cooking  
equipment  
**0.65**



Public transport  
**0.98**



Renewable-based  
heating  
**0.64**

Source: Centre for Research into Energy Demand Solutions



# Scientific evidence of global warming: a rocky road

- 1824: Joseph Fourier published the scientific article “*Remarques générales sur les températures du globe terrestre et des espaces planétaires*” ⇒ the greenhouse effect
- 1863: John Tyndall published the books “*Heat Considered as a Mode of Motion*” in 1863 and “*Contributions to Molecular Physics in the Domain of Radiant Heat*” in 1872
- 1896: Svante Arrhenius published the scientific article “*On the Influence of Carbonic Acid in the Air upon the Temperature of the Ground*” ⇒ if the quantity of carbonic acid increases in geometric progression, the augmentation of the temperature will increase nearly in arithmetic progression
- 1958: Charles David Keeling started collecting carbon dioxide samples at the Mauna Loa Observatory (Hawai) ⇒ Keeling curve
- 2021: Klaus Hasselmann and Syukuro Manabe won the Nobel Prize in Physics for the physical modelling of Earth’s climate, quantifying variability and reliably predicting global warming



# Scientific evidence of global warming: a rocky road

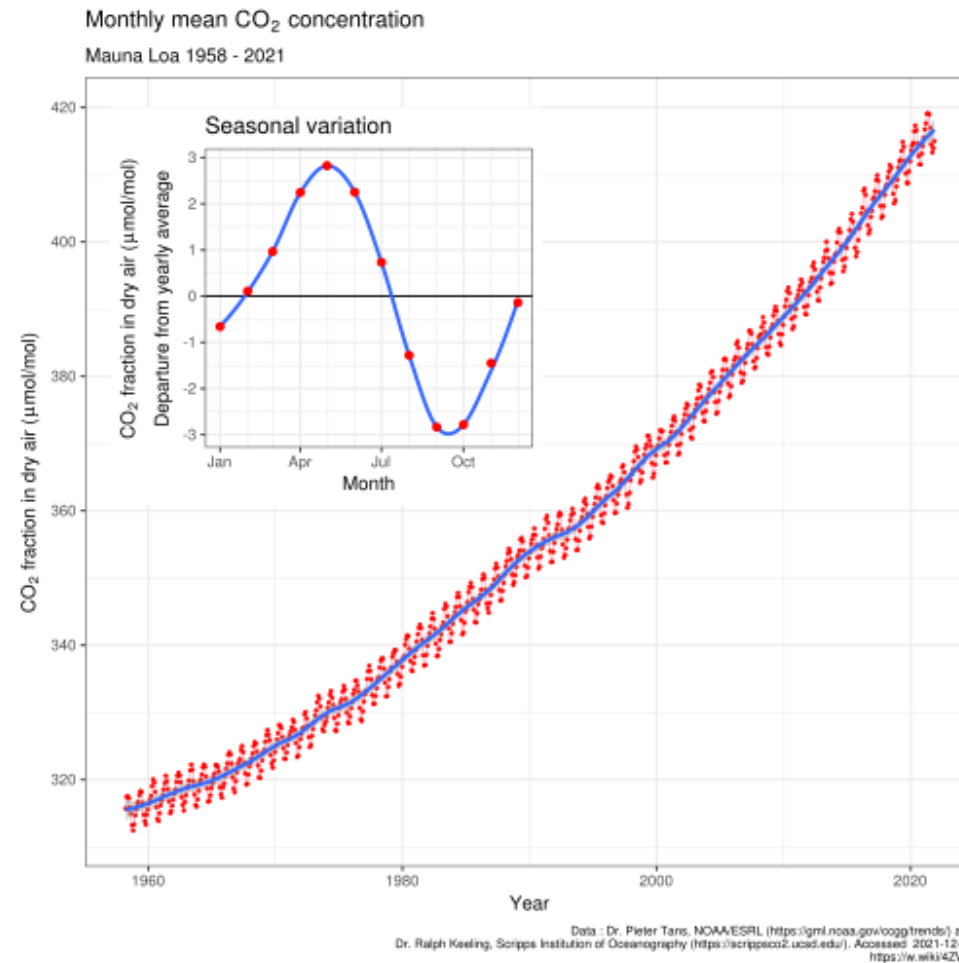


Figure 6: Keeling curve

Source: [https://en.wikipedia.org/wiki/Keeling\\_Curve](https://en.wikipedia.org/wiki/Keeling_Curve).

# Scientific evidence of global warming

# From the Holocene to the Anthropocene

# The physics of climate change

# IPCC

- The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body for assessing the science related to climate change
- The IPCC was created to provide policymakers with regular scientific assessments on climate change, its implications and potential future risks, as well as to put forward adaptation and mitigation options
- Website: <https://www.ipcc.ch>

## Remark

IPCC is known as “*Groupe d’experts intergouvernemental sur l’évolution du climat*” (GIEC) in French

⇒ Other international bodies: International Energy Agency (IEA), etc.

# IPCC

## Past

- Global sea level rose by 19 cm over the period 1901-2010
- Global glacier volume loss is equivalent to 400 bn tons per year since 30 years

## Future

- Global sea level could increase by 82 cm by 2100
- Global glacier volume could decrease by 85% by 2100

IPCC, Climate Change Synthesis Report (2014)

# IPCC

## IPCC working groups

- The IPCC Working Group I (WGI) examines the physical science underpinning past, present, and future climate change
- The IPCC Working Group II (WGII) assesses the impacts, adaptation and vulnerabilities related to climate change
- The IPCC Working Group III (WGIII) focuses on climate change mitigation, assessing methods for reducing greenhouse gas emissions, and removing greenhouse gases from the atmosphere

# IPCC

## Some famous reports

- IPCC Fifth Assessment Report (AR5): Climate Change 2014 — [www.ipcc.ch/report/ar5](http://www.ipcc.ch/report/ar5)
- Global Warming of 1.5°C — [www.ipcc.ch/sr15](http://www.ipcc.ch/sr15)
- IPCC Sixth Assessment Report (AR6): Climate Change 2022 — [www.ipcc.ch/report/sixth-assessment-report-cycle](http://www.ipcc.ch/report/sixth-assessment-report-cycle)



# IPCC scenarios

- Website: <https://www.ipcc.ch/data>
- AR5
- SR15
- AR6

# Carbon neutrality

**Carbon neutrality** (or net zero) means that any CO<sub>2</sub> released into the atmosphere from human activity is balanced by an equivalent amount being removed

Apple Commits to Become Carbon Neutral to by 2030  
(<https://www.bbc.com/news/technology-53485560>)

# Carbon dioxide removal

## Carbon dioxide removal (CDR)

### 1 Nature-based solutions

- Afforestation (creating new forests)
- Reforestation (multiplying trees in old forests)
- Restoration of peat bogs
- Restoration of coastal and marine habitats

### 2 Enhanced natural processes

- Land management and no-till agriculture, which avoids carbon release through soil disturbance
- Better wildfire management
- Ocean fertilisation to increase its capacity to absorb CO<sub>2</sub> (enhanced weathering)

### 3 Technology solutions

- Bioenergy with carbon capture and storage (BECCS)
- Direct air capture (DAC)
- Carbon mineralization

# Carbon dioxide removal

## The example of peatlands

- Peatlands are the largest natural terrestrial carbon store
- The term “*peatland*” refers to peat soil and wetland habitats
- They cover only 3% of the Earth’s surface
- They store 600 GtCO<sub>2</sub>e
  - ≈ 45% of all soil carbon
  - ≈ 67% of all atmosphere carbon
- A depth of one meter corresponds to 1 000 years of carbon storage
- Natural peatlands store 0.37 GtCO<sub>2</sub>e per year

Two issues:

- 1 Stopping the destruction
- 2 Restoring and rebuilding

# Carbon offsetting

Carbon offsetting  $\neq$  carbon emissions reduction

## Definition

*“Carbon offsetting consists for an entity in compensating its own carbon emissions by providing for emissions reductions outside its business boundaries [...] It allows an entity to claim carbon reductions from projects financed either directly or indirectly through carbon credits” (Créhalet, 2021).*

# Carbon offsetting

Carbon offsetting mechanisms:

Suppliers of carbon offsets



Carbon credits



Purchasers of carbon offsets

⇒ Many issues: carbon credit issuance, double counting, leakage, certification, etc.

Examples with **REDD+** projects:

- Reducing **E**missions from **D**eforestation and **F**orest **D**egradation
- What will happen if the forest has burned down?
- Issues of land management (afforestation in one area can lead to a deforestation in another area)

# Climate risk and missing factors

## The example of permafrost

- The permafrost contains **1 700 billion tons of carbon**, almost double the amount of carbon that is currently in the atmosphere.
- Arctic permafrost holds roughly **15 million gallons of mercury** – at least twice the amount contained in the oceans, atmosphere and all other land combined.
- A global temperature rise of **1.5°C** above current levels would be enough to start the thawing of permafrost in Siberia.
- The global warming will become **out-of-control** after this tipping point.
- The thawing of the permafrost also threatens to unlock **disease-causing viruses** long trapped in the ice.

⇒ The **survival of Humanity becomes uncertain** if the tipping point is reached

# Regulation of climate risk

- UN, international bodies & coalitions
- Countries
- Cities
- Industry self-regulation
- Non-governmental organizations (NGO)
- Financial regulators

**Hard regulation** ≠ **soft regulation**



# Regulation of climate risk

## UN

### United Nations Climate Change Conference

- Conference of the Parties (COP)
- Dealing with climate change
- COP 1: Berlin (1995)
- COP 3: Kyoto (1997) ⇒ Kyoto Protocol (CMP)
- COP 21: Paris (2015) ⇒ Paris Agreement (CMA)
- COP 26: Glasgow (November 2021)

# Regulation of climate risk

## UN

The **Kyoto Protocol** is an international treaty that commits state parties to reduce GHG emissions, based on the scientific consensus that:

- 1 **Global warming is occurring**
- 2 It is likely that **human-made CO<sub>2</sub> emissions have caused it**

# Regulation of climate risk

## UN

The **Paris Agreement** is an international treaty with the following goals:

- 1 Keep a global temperature rise this century well below 2°C above the pre-industrial levels
- 2 Pursue efforts to limit the temperature increase to 1.5°C
- 3 Increase the ability of countries to deal with the impacts of climate change
- 4 Make finance flows consistent with low GHG emissions and climate-resilient pathways

⇒ Nationally determined contributions (NDC)

# Regulation of climate risk

UN

Table 2: CO<sub>2</sub> emissions by country

Rank	Country	CO <sub>2</sub> emissions Total (in GT)	Share	CO <sub>2</sub> emissions Per capita (in MT)
1	China	10.06	28%	7.2
2	USA	5.41	15%	15.5
3	India	2.65	7%	1.8
4	Russia	1.71	5%	12.0
5	Japan	1.16	3%	8.9
6	Germany	0.75	2%	8.8
7	Iran	0.72	2%	8.3
8	South Korea	0.72	2%	12.1
9	Saudi Arabia	0.72	2%	17.4
10	Indonesia	0.72	2%	2.2
11	Canada	0.56	2%	15.1
15	Turkey	0.42	1%	4.7
17	United Kingdom	0.37	1%	5.8
19	France	0.33	1%	4.6
20	Italy	0.33	1%	5.3

Source: Earth System Science Data, <https://earth-system-science-data.net>

World Bank Open Data, <https://data.worldbank.org/topic/climate-change>

# Regulation of climate risk

## UN

### Paris Agreement: where we are?

- 194 states have signed the Agreement
- They represent about 80% of GHG emissions
- USA, Iran and Turkey have not signed the Agreement

# Regulation of climate risk

UN



Figure 7: Paris Agreement assessments of aviation and shipping

Source: Climate Action Tracker (CAT), <https://climateactiontracker.org>

# Regulation of climate risk

## Coalitions

- **The Coalition of Finance Ministers for Climate Action**

[www.financeministersforclimate.org](http://www.financeministersforclimate.org)

- Commitment to implement fully the Paris Agreement
- Santiago Action Plan
- Helsinki principles (1. align, 2. share, 3. promote, 4. mainstream, 5. mobilize, 6. engage)

# Regulation of climate risk

## Coalitions

- **One Planet Summit**

[www.oneplanetsummit.fr](http://www.oneplanetsummit.fr)

- **One Planet Sovereign Wealth Funds (OPSWF)**

- Funding members: Abu Dhabi Investment Authority (ADIA), Kuwait Investment Authority (KIA), NZ Superannuation Fund (NZSF), Public Investment Fund (PIF), Qatar Investment Authority (QIA), NBIM
- New members: Bpifrance, CDP Equity, COFIDES, FONSI, ISIF, KIC, Mubadala IC, NIIF, NIC NBK

- **One Planet Asset Managers**

- Funding members: Amundi AM, BlackRock, BNP PAM, GSAM, HSBC Global AM, Natixis IM, Northern Trust AM, SSGA
- New members: AXA IM, Invesco, Legal & General IM, Morgan Stanley IM, PIMCO UBS AM

- **One Planet Private Equity Funds**

- Members: Ardian, Carlyle Group, Global Infrastructure Partners, Macquarie Infrastructure and Real Assets (MIRA), SoftBank IA



# Regulation of climate risk

## Countries

### The example of France

- August 2015: French Energy Transition for Green Growth Law (or Energy Transition Law)
- Roadmap to mitigate climate change and diversify the energy mix

Other examples: Germany (2021 Renewable Energy Act), UK (2013 Energy Act), The Netherlands (2019 Climate Change Mitigation Act), etc.

# Regulation of climate risk

## Countries

### Article 173 of the French Energy Transition Law

- The annual report of listed companies must include:
  - Financial risks related to the effects of climate change
  - The measures adopted by the company to reduce them
  - The consequences of climate change on the company's activities
- New requirements for investors:
  - Disclosure of climate (and ESG) criteria into investment decision making process
  - Disclosure of the contribution to the energy transition and the global warming limitation international objective
  - Reporting on climate change-related risks (including both physical risks and transition risks), and GHG emissions of assets
- Banks and credit providers shall conduct climate stress testing

# Regulation of climate risk

## Carbon pricing

- Polluter pays principle
  - A carbon price is a cost applied to carbon pollution to encourage polluters to reduce the amount of GHG they emit into the atmosphere
  - Negative externality
- Two instruments of carbon pricing
  - 1 **Carbon tax**
  - 2 **Cap-and-trade** (CAT) or **emissions trading scheme** (ETS)
- Some examples
  - 1 EU emissions trading system (2005) — [https://ec.europa.eu/clima/policies/ets\\_en](https://ec.europa.eu/clima/policies/ets_en)
  - 2 New Zealand ETS (2008)
  - 3 Chinese national carbon trading scheme (2017)

# Regulation of climate risk

## Carbon pricing

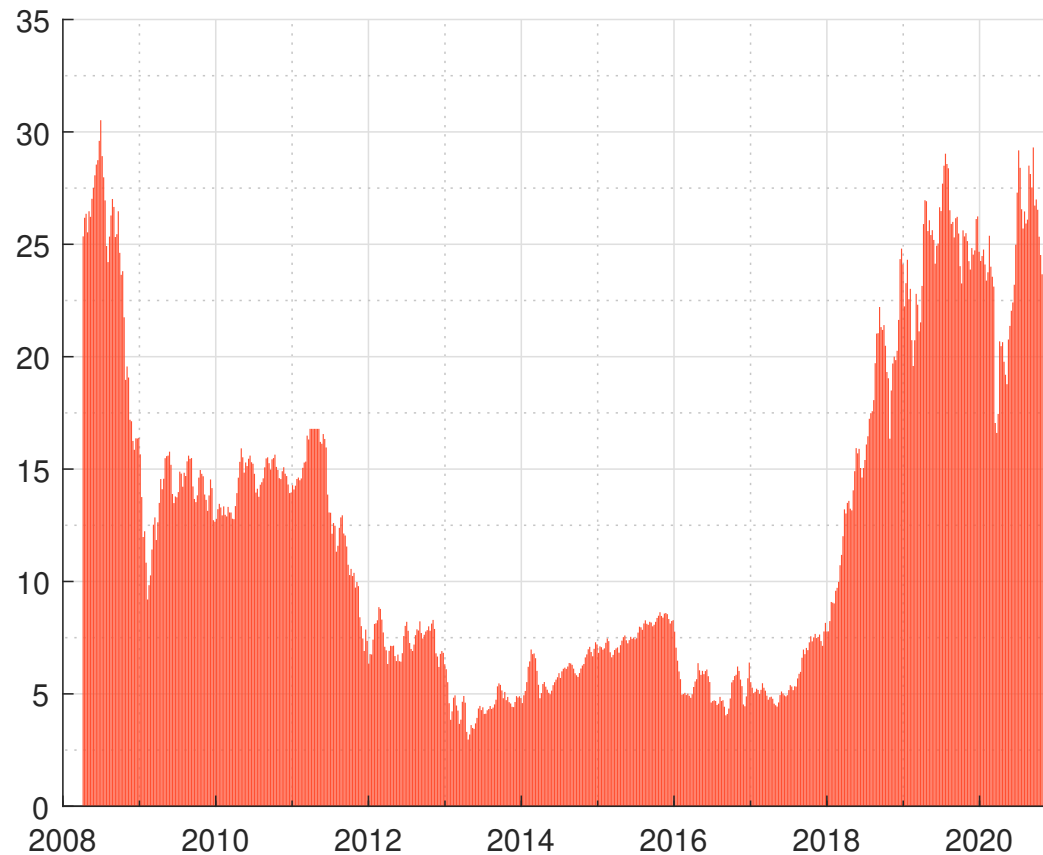


Figure 8: EU ETS carbon price\* (in €/tCO<sub>2</sub>)

(\* )The carbon price reaches 34.43 euros a tonne on Monday 11, 2021

# Regulation of climate risk

## Carbon pricing

**Table 3: Carbon tax (in \$/tCO<sub>2</sub>)**

Country	2018	2019	2020	Country	2018	2019	2020
Sweden	139.11	126.78	133.26	Latvia	5.58	5.06	10.49
Liechtenstein	100.90	96.46	105.69	South Africa			7.38
Switzerland	100.90	96.46	104.65	France	55.30	50.11	6.98
Finland	76.87	69.66	72.24	Argentina		6.24	5.94
Norway	64.29	59.22	57.14	Chile	5.00	5.00	5.00
Ireland	24.80	22.47	30.30	Colombia	5.67	5.17	4.45
Iceland	35.71	31.34	30.01	Singapore		3.69	3.66
Denmark	28.82	26.39	27.70	Mexico	3.01	2.99	2.79
Portugal	8.49	14.31	27.52	Japan	2.74	2.60	2.76
United Kingdom	25.46	23.59	23.23	Estonia	2.48	2.25	2.33
Slovenia	21.45	19.44	20.16	Ukraine	0.02	0.37	0.35
Spain	24.80	16.85	17.48	Poland	0.09	0.08	0.08

Source: World Bank Carbon Pricing Dashboard, <https://carbonpricingdashboard.worldbank.org>

# Regulation of climate risk

## Stranded assets

- Stranded Assets are assets that have suffered from unanticipated or premature write-downs, devaluations or conversion to liabilities
- For example, a 2°C alignment implies to keep a large proportion of existing fossil fuel reserves in the ground (30% of oil reserves, 50% of gas reserves and 80% of coal)
- Risk factors: Regulations, carbon prices, change in demand, social pressure, etc.
- Example of the covid-19 crisis ⇒ air travel

# Regulation of climate risk

## Financial regulation

- Financial Stability Board (FSB)
- European Central Bank (ECB)
- The French Prudential Supervision and Resolution Authority (ACPR)
- The Prudential Regulation Authority (PRA)
- Network for Greening the Financial System (NGFS)
- Etc.

# Regulation of climate risk

## Financial regulation

Bolton, P., Despres, M., Pereira Da Silva, L.A., Samama, F. and Svartzman, R. (2020), *The Green Swan — Central Banking and Financial Stability in the Age of Climate Change*, BIS Publication, <https://www.bis.org/publ/othp31.htm>





# Regulation of climate risk

## Financial regulation

### Task Force on Climate-related Financial Disclosures (TCFD)

- Established by the FSB in 2015 to develop a set of voluntary, consistent disclosure recommendations for use by companies in providing information to investors, lenders and insurance underwriters about their climate-related financial risks
- Website: [www.fsb-tcfd.org](http://www.fsb-tcfd.org)
- Chairman: Michael R. Bloomberg (founder of Bloomberg L.P.)
- 31 members
- June 2017: Publication of the “*Recommendations of the Task Force on Climate-related Financial Disclosures*”
- October 2020: Publication of the 2020 “*Status Report: Task Force on Climate-related Financial Disclosures*”

# Regulation of climate risk

## Financial regulation

Recommendation	ID	Recommended Disclosure
Governance	1	Board oversight
	2	Management's role
Strategy	3	Risks and opportunities
	4	Impact on organization
	5	Resilience of strategy
Risk management	6	Risk ID and assessment processes
	7	Risk management processes
	8	Integration into overall risk management
Metrics and targets	9	Climate-related metrics
	10	Scope 1, 2, 3 GHG emissions
	11	Climate-related targets

**Table 4:** The 11 recommended disclosures (TCFD, 2017)

# Regulation of climate risk

## Financial regulation

Some key findings of the 2020 Status Report (TCFD, 2020):

- Disclosure of climate-related financial information has increased since 2017, but continuing progress is needed
- Average level of disclosure across the Task Force's 11 recommended disclosures was 40% for energy companies and 30% for materials and buildings companies
- Asset manager and asset owner reporting to their clients and beneficiaries, respectively, is likely insufficient

# Climate stress testing

- ACPR (2020): Climate Risk Analysis and Supervision<sup>3</sup>
- Bank of England (2021): Climate Biennial Exploratory Scenario (June 2021)

Top-down approach  $\neq$  bottom-up approach

Stress of risk-weighted asset: Bouchet and Le Guenedal (2020).

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<sup>3</sup><https://acpr.banque-france.fr/en/scenarios-and-main-assumptions-acpr-pilot-climate-exercise>

# Climate capital requirements

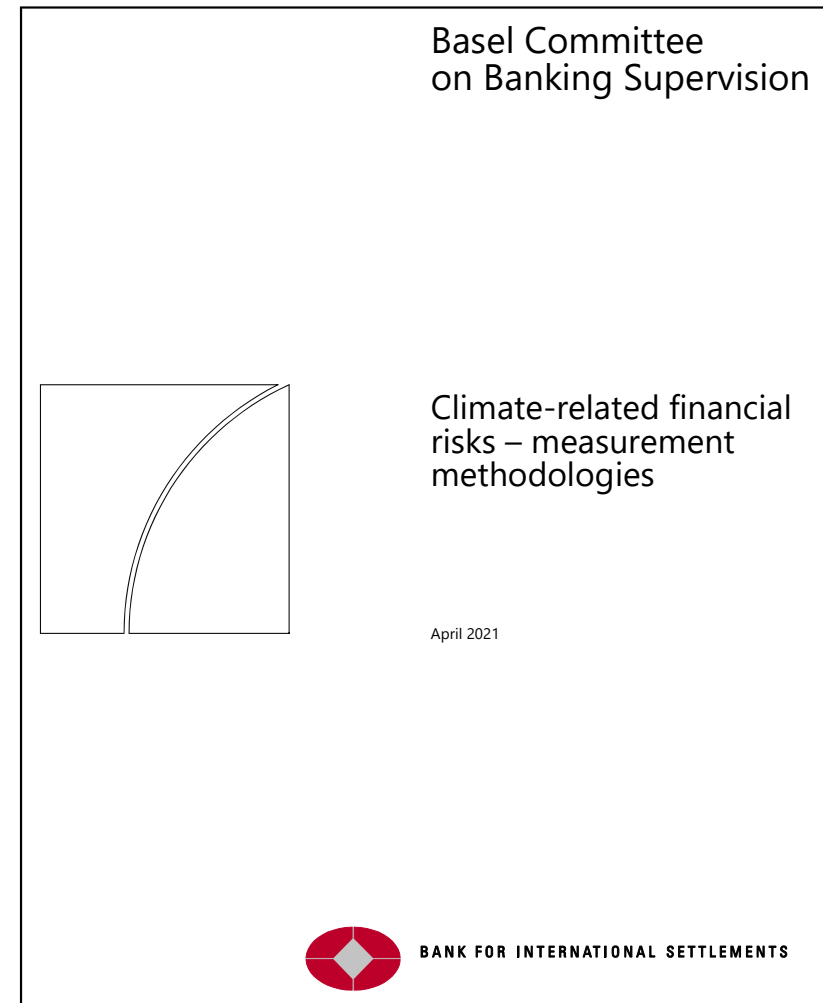
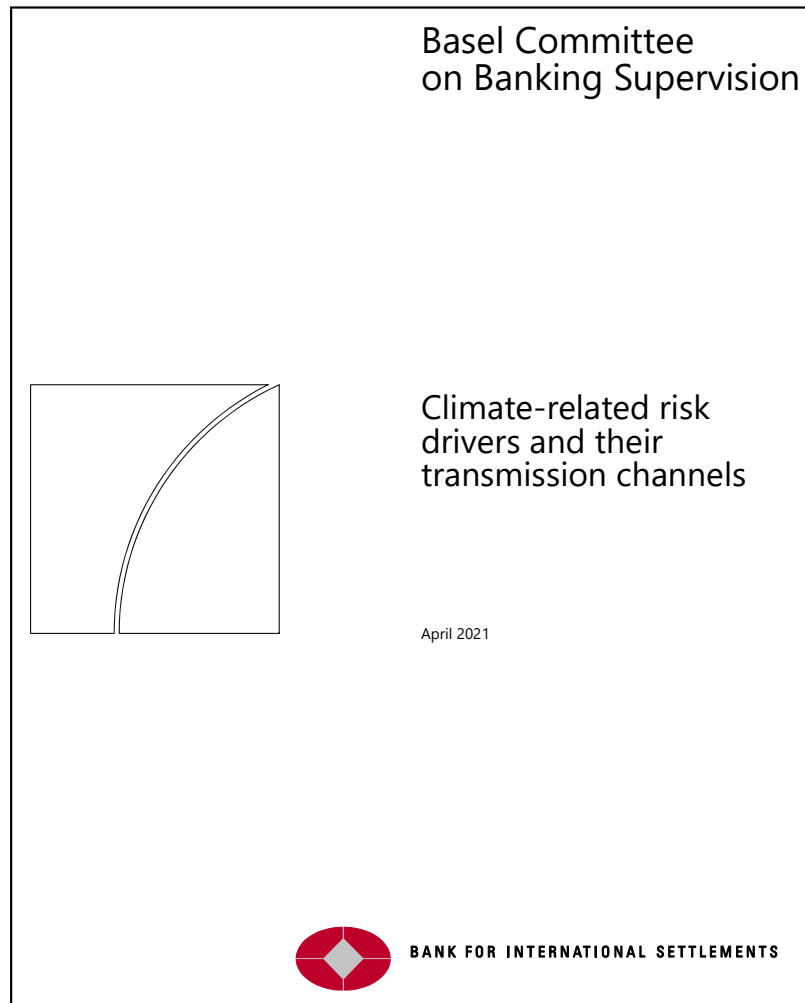
## Green supporting factor

- Risk weights may depend on the green/brown nature of the credit
- Green loans
- Green supporting factor  $\neq$  Brown penalising factor

Similar idea: Green Quantitative Easing (GQE)

# Climate capital requirements

Figure 9: In April 2021, Basel Committee publishes two reports on climate risk



# Climate capital requirements

In June 2022, Basel Committee publishes guidelines:

Principles for the effective management  
and supervision of climate-related financial risks