

# From Climate Risk to Financial Risk: Climate scenarios, transition risk and climate stress- tests for financial institutions

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# Climate-related financial risk

- **Scientific evidence** known since two decades (*IPCC 2013, 2018*) about:
  - physical risk of unmitigated climate change
  - scale and pace of transformation required for mitigation
- **Characteristics** of climate risk (*Battiston ea. 2017 Nat Clim. Ch.; Battiston 2019 in Banque de France FSR; Monasterolo 2020 Ann. Rev. Res. Econ.*)
  - **endogeneity**: perceptions of climate risk impact on policy and investment decisions that make difference between succeeding and failing mitigation
  - **deep uncertainty**: resulting from endogeneity + climate model uncertainty
  - **tipping points**: irreversible changes in system earth dynamics
- Climate risk recognised by financial authorities as source of financial risk only recently (*NGFS 2019*). Major step ahead. Yet, much work to do.

# Climate risk: the mitigation challenge

- Remarkable growth of **sustainable finance** (under various labels e.g. ESG, etc.). Yet all economies failed to deliver emissions reductions under Paris Agreement.
- Limiting **global warming** below 2C (Paris Agreement) requires profound **transformation** of energy and production systems and consumption patterns
- **Scale and pace of transformation:**
  - large portions of assets are affected
  - need for proactive role of financial system in reallocation of capital from high to low-carbon activities: can we take this for granted?
  - transition risk stemming from expectations about the future scenarios
- **Financial risk** is key driver of financial actors' investment decisions. Outcome of the transition depends on whether climate-related risk is taken into account by businesses and financial institutions.
- What conceptual framework to assess climate transition risk?

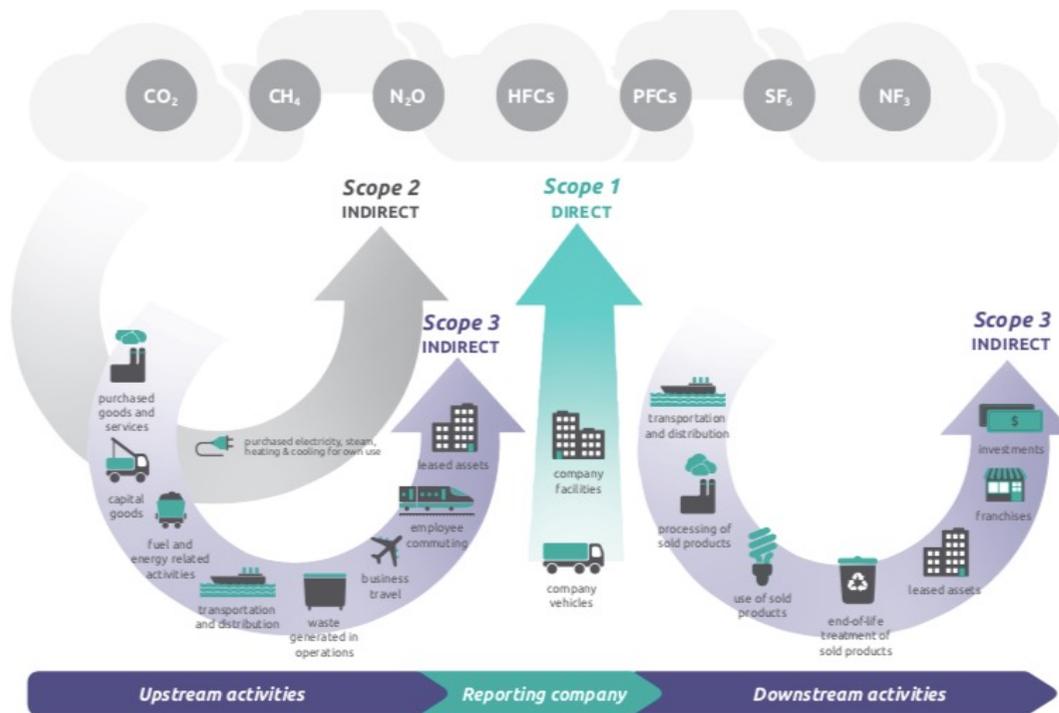
## Assessment of transition risk: conceptual framework

- Need for a conceptual framework.
- Based on our stream of scientific work and experience with practitioners we propose the following operational procedure.
  1. First step. Climate Policy Relevant Sectors: a classification of economic activities to group assets into transition risk categories
  2. Second step: Transition scenarios
  3. Third step: Climate stress-test and risk measures
  4. Fourth step: endogeneity of scenarios: the role of the financial system

**First step.**

**Classification of economic activities wrt to transition risk**

# GHG Emission Accounting. Issues for assessing transition risk



## Issues

- **Transition risk** depends critically on Scope 3 (e.g. end-use for for oil companies, investments for financial firms).
- But Scope 3 is based on internal models: often **not comparable across companies**: not usable to assess financial portfolios.

## Definitions of Scope 1, 2, 3

**Scope 1:** emissions in the production process, e.g. fuel combustion, company vehicles, fugitive emissions

**Scope 2:** emissions associated with energy input for production, i.e. purchased electricity, heat and steam.

**Scope 3:** upstream (purchased goods and services, business travel, employee commuting); downstream (waste disposal, processing and end-use of sold products); up- and downstream ( transportation and distribution); investments (leased assets and franchises)

*Figure source: Technical Guidance for Calculating Scope 3 Emissions (version 1.0). Supplement to the Corporate Value Chain (Scope 3) Accounting & Reporting Standard. By: GHG Protocol and Carbon Trust Team and World Resources Institute Contributors. <https://ghgprotocol.org/about-us>*

## Climate Policy Relevant Sectors

### Motivation

- GHG emission indicators useful to track emission reductions, but not sufficient. E.g. an electricity company with coal-based plants could reduce Scope 1 emissions intensity by expanding its business line in electricity trading.
- Tracking production and investments across technologies is also needed.
- Standard classifications of economic activities (NACE, NAICS, ISIC) include ~ 1000 sectors (at 4 digits). Designed for national accounting, but not for climate risk.

**Problem:** can we group NACE sectors in few categories with distinct features in terms of transition risk?

### Solution:

1. Identify key dimensions in energy value chain, policy processes, business model
2. Remap NACE 4 digit codes into categories CPRS (level 1, 2, granular)
3. CPRS categories can be applied immediately across portfolios and jurisdictions.

## NACE Rev2. Example: where are the activities with revenues from fossil fuels?

Division	Group	Class	
<b>SECTION B - MINING AND QUARRYING</b>			
05	05.1		Mining of coal and lignite
			Mining of hard coal
	05.2	05.10	Mining of hard coal
		05.20	Mining of lignite
06	06.1		Extraction of crude petroleum and natural gas
			Extraction of crude petroleum
	06.2	06.10	Extraction of crude petroleum
		06.20	Extraction of natural gas
07	07.1		Mining of metal ores
			Mining of iron ores
	07.2	07.10	Mining of iron ores
		07.21	Mining of uranium and thorium ores
		07.29	Mining of other non-ferrous metal ores

<b>SECTION H- TRANSPORT</b>			
49.4			Freight transport by road and removal services
		49.41	Freight transport by road
		49.42	Removal services
49.5			Transport via pipeline
		49.50	Transport via pipeline

<b>SECTION C- MANUFACTURING</b>			
19	19.1		Manufacture of coke and refined petroleum products
			Manufacture of coke oven products
		19.10	Manufacture of coke oven products
20	20.1		Manufacture of refined petroleum products
			Manufacture of refined petroleum products
		19.20	Manufacture of refined petroleum products
20	20.1		Manufacture of chemicals and chemical products
			Manufacture of basic chemicals, fertilisers and nitrogen compounds, synthetic rubber in primary forms
	20.11		Manufacture of industrial gases

<b>SECTION D — ELECTRICITY, GAS, STEAM AND AIR CONDITIONING SUPPLY</b>				
35	35.1		Electricity, gas, steam and air conditioning supply	
			Electric power generation, transmission and distribution	
			35.11	Production of electricity
			35.12	Transmission of electricity
			35.13	Distribution of electricity
	35.2			Trade of electricity
				Manufacture of gas; distribution of gaseous fuels through mains
			35.21	Manufacture of gas
			35.22	Distribution of gaseous fuels through mains
			35.23	Trade of gas through mains
	35.3			Steam and air conditioning supply
			35.30	Steam and air conditioning supply

**CPRS 01-Fossil:** activities in or supporting extraction, production, transportation sale of primary energy derived from fossil

1. low direct emission, high indirect emissions
2. specific policy processes
3. no substitutability of input

# Climate Policy Relevant Sectors

“Can we group NACE sectors in few categories with distinct features in terms of transition risk?”  
 We define four dimensions to use for such grouping.

CPRS identification and main dimensions				
Role in value chain	Role in GHG emissions value chain		Specific policy processes	Nature of transition risk w.r.t business model
Primary energy (e.g. fossil fuel) vs. secondary energy (from fuel mix)	Direct/ indirect  CO2 / other GHG		Authorities  Taxes/subsidies	Fossil fuel: low medium high substitutability
Production of goods services (non-energy)	Negative emissions		Lobbying	Other types of emission reductions

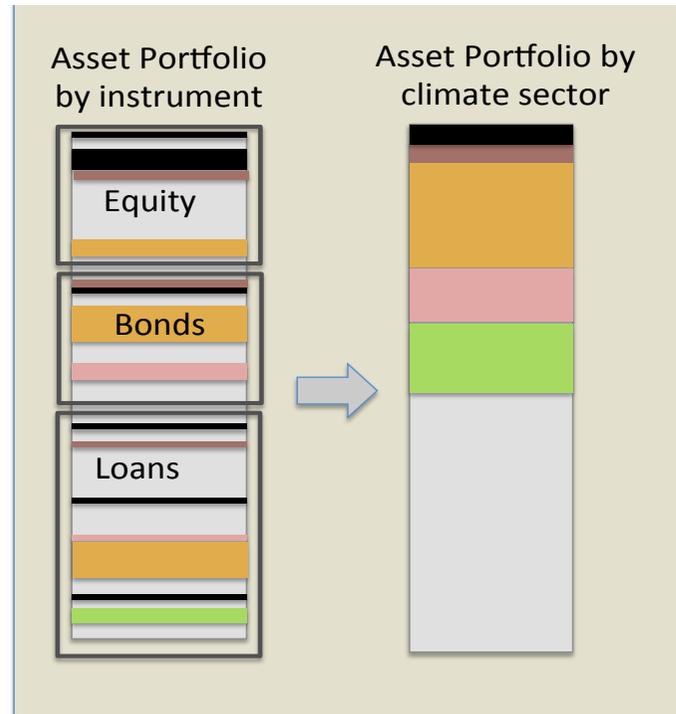
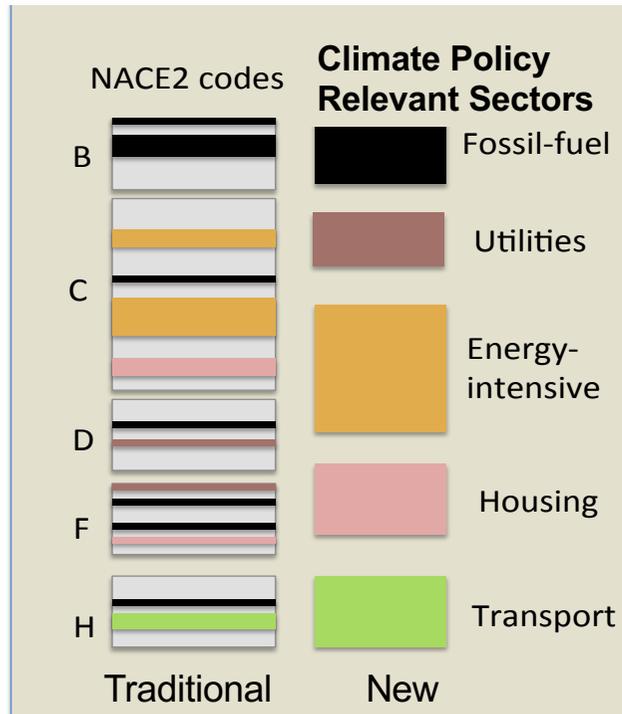
Examination of individual codes lead to following categories → next slide

# Climate Policy Relevant Sectors

CPRS Level 1	Category of economic activities	Role in GHG emissions value chain	Specific policy processes	Nature of transition risk in relation to business model	NACE 4 digits Main groups of codes (selected, see full table)
<b>Fossil fuel</b>	Carry out / support production / delivery of primary energy based on fossil fuel.	Mostly indirect CO2 emissions	Oil politics, taxes/subsidies	No fuel substitutability	B-Mining and quarrying: coal, oil and gas; C-Manufacturing: coal, oil and gas; D-Electricity and gas (e.g. 35.21); G-Wholesale: fuel sales (e.g. 47.30); H-Transportation: pipelines (e.g. 49.50).
<b>Utility electricity</b>	Carry out or support production of secondary energy.	Mostly direct CO2 emissions (fuel mix).	Electricity authorities (e.g. feed-in tariffs)	Medium fuel substitutability (e.g. wind farms).	D-Electricity production, transmission and distribution (e.g. 35.11, 35.12, 35.13)
<b>Energy intensive</b>	Manufacturing activities with intensive use of energy according to EU classification Carbon Leakage	Mostly direct CO2 emissions (fuel mix).	No specific policy processes as a group.	Low substitutability (e.g. steel or rockets)	See Carbon Leakage list. B-Mining and quarrying (e.g. 07.10, 07.29, 08.91 etc.); C-Manufacturing (about 200+ sectors, e.g. 11.01, 13.10, 15.11 etc.). NOTE: Nace codes falling in other CPRS are not included.
<b>Transport</b>	Provision of or support to transport services (e.g. vehicles manufacturing, roads and railways)	Mostly direct CO2 emissions (fuel mix).	Transport authorities and policies.	Low substitutability (e.g. motor vehicles fleet)	C-Manufacturing: motor vehicles, ships and trains (e.g. 29.10, 29.20, 30.11, 30.20 etc.); F-construction: roadways and railways (e.g. 42.11, 42.12); G-Wholesale: vehicles (e.g. 45.32); H-Transportation: land, air, and sea transport (49.10, 49.20, 49.41, 50.10, 51.10, etc.)
<b>Buildings</b>	Provision of or support to buildings services (e.g. residential and commercial)	Mostly direct CO2 emissions (fuel mix).	Housing policies.	Low substitutability (e.g. heating/cooking)	F-Construction: residential and commercial building (e.g. 41.10, 41.20, 43.22, 43.91 etc.); I-Accommodation (e.g. 55.10, 55.20); L-Real-estate (e.g. 68.10, 68.20, 68.30); M-Professional: architectural activities (e.g. 71.11)
<b>Agriculture</b>	Provision of and support of agriculture and forestry	Direct CO2 emissions from fossil fuel; other direct GHG emissions. Negative emissions (afforestation).	Agricultural policies.	Low Substitutability (as for transport). But emission reductions via low carbon farming.	A - Agriculture forestry and fishery (from 01.10 to 02.40)

Mapping table NACE – CPRS available as xls file at <https://www.finexus.uzh.ch/en/projects/CPRS.html>

# Reclassification from NACE to Climate-Policy Relevant Sectors



Step 1: remap assets associated to a NACE sector into corresponding CPRS

Step 2: carry out for each instrument class

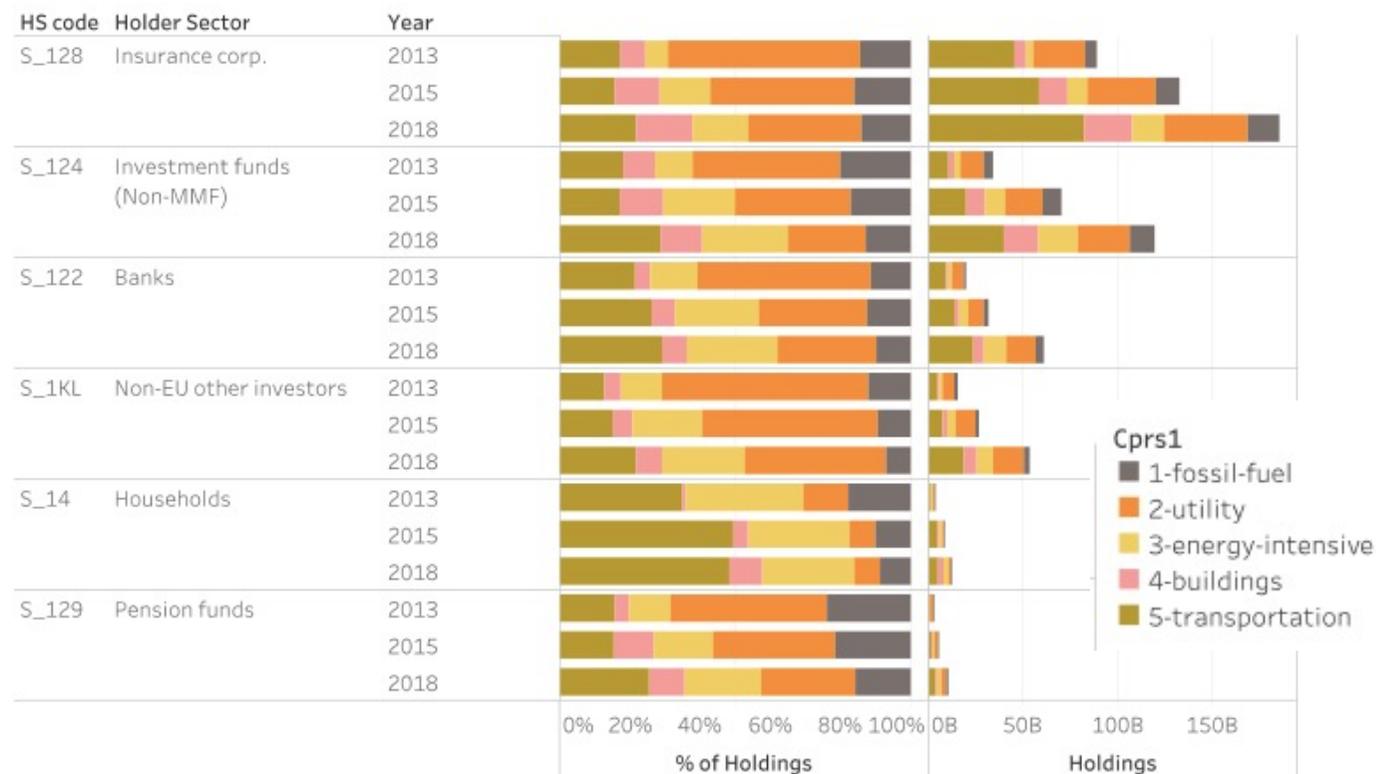
Step 3: choose appropriate further aggregation

# CPRS used by financial supervisors

The CPRS methodology allows to map financial assets into few distinct categories of transition risk.

## Selected policy works using CPRS

- *JRC study of EU Taxonomy financial impact (Alessi et al 2019)*
- *ECB Financial Stability Review 2019, 2020*
- *EIOPA's Financial Stability Review 2019*
- *EBA Risk assessment of the EU banking system, Dec. 2020*
- *ESMA Advice to European Commission under Article 8 of the Taxonomy Regulation (2020)*
- *National Bank of Austria, Financial Stability Report 2020*
- *Banco de Mexico 2021, J.Fin. Stab.*



Breakdown by CPRS Main for bond holdings of EU resident issuers in billion EUR. Source: Alessi et al. (2019).

## Climate Policy Relevant Sectors and related tools

### **CPRS**

(Battiston et al. 2017 Nature Climate Change).

Allow to group assets in the portfolio by few categories of transition risk and several granular categories based on specific technologies

Question addressed: what is the portion of assets exposed to each transition risk category?

Excel tool available at <https://www.finexus.uzh.ch/en/projects/CPRS.html>

### **Taxonomy alignment Coefficients (TAC)**

Excel tool available at <https://publications.jrc.ec.europa.eu/repository/handle/JRC118663>

### **Transition Risk Exposure coefficients (TEC)**

(Alessi and Battiston 2021, forthcoming).

Question addressed: what is the portion of assets  
1) aligned to the EU Taxonomy  
2) adversely affected by high transition risk (building on CPRS

### **Climate risk measures**

(Battiston et al. 2021, Science)

Value at risk, Expected Shortfall etc., condition to climate transition scenario from IPCC, NGFS, and IEA

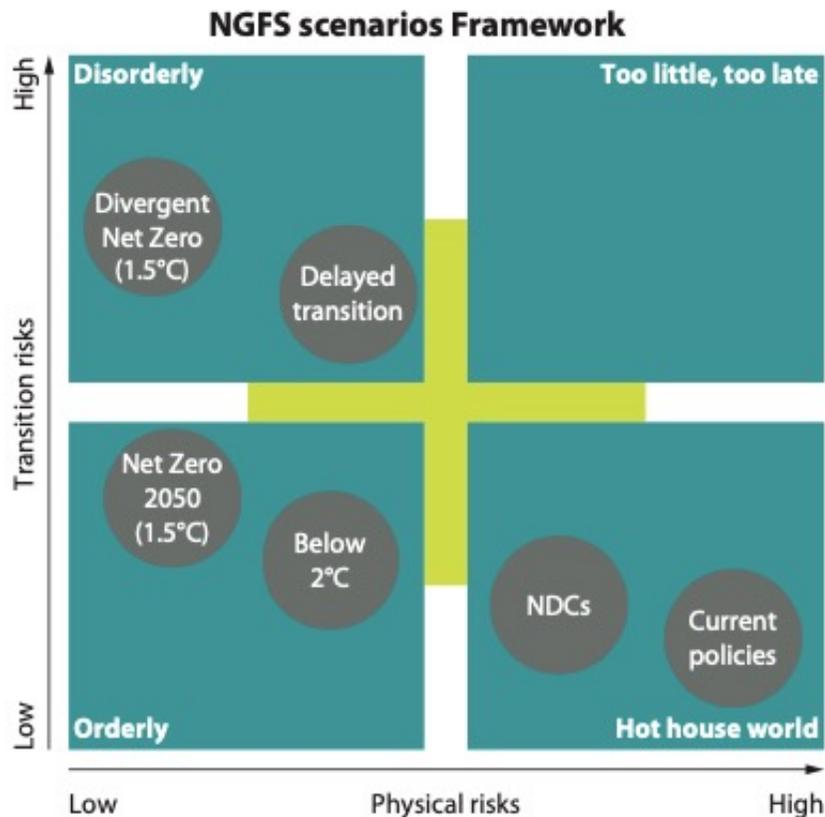
Questions addressed: what is the conditional worst-case loss (under a 2C scenario and some confidence level) due to transition risk? What is the “tail risk”?

## **Second step. Transition scenarios.**

# What are climate mitigation scenarios?

- Climate mitigation scenarios are not predictions. They describe what the economy and land use might look like in the next decades.
- Climate mitigation scenarios are paths forward to achieve mitigation goals in time, constrained by:
  - laws of physics (e.g., cumulative CO<sub>2</sub> emissions, i.e. terms of carbon budget until 2100 leading to global warming levels with associated probabilities)
  - by technological constraints (e.g. technological efficiency, limits to speed of technology deployment) and finite nature of the planet.
- Process-based, large-scale Integrated Assessment Models (IAM): used to develop long-term scenarios of emissions and socio-economic variables assessed by IPCC (*Mc Collum et al. 2018 Nat. Ener.*).

# What are climate mitigation scenarios?



Source: NGFS 2021

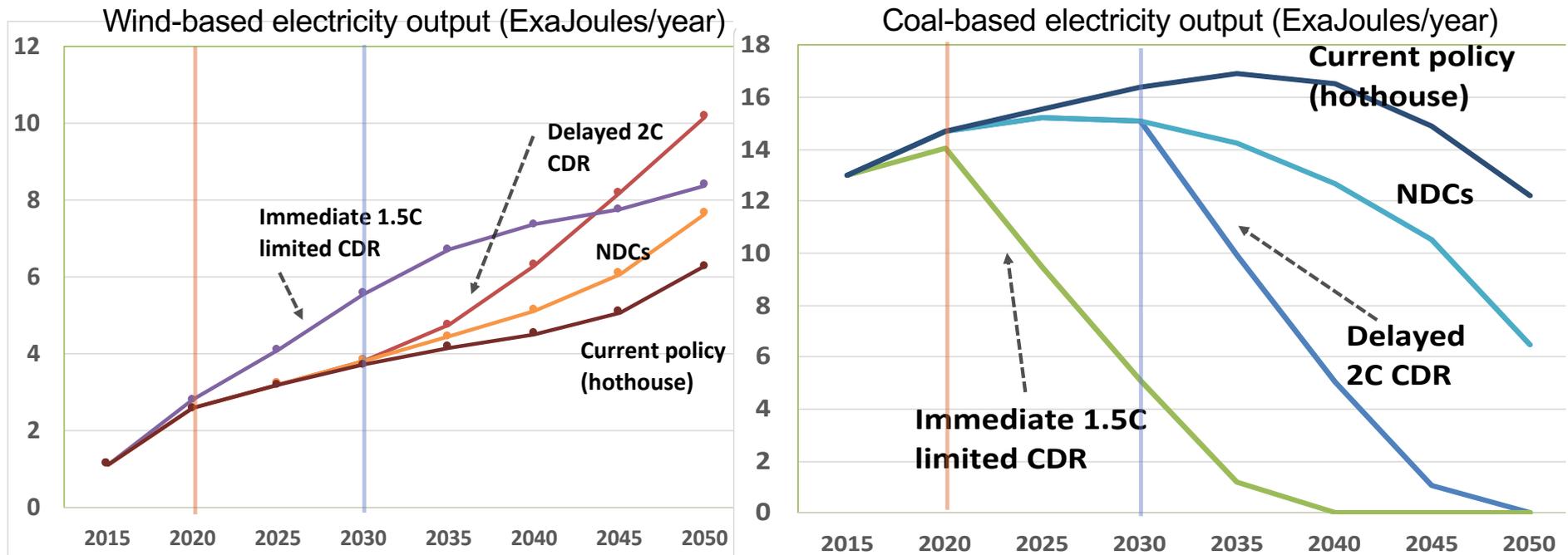
Set of archetypical IAM scenarios assessed by the IPCC (2013; 2018, 2022): distinct features of the transition

- timing of carbon price (2020, 2030)
- temperature target (1.5C, 2C)
- extent of reliance on Carbon Dioxide Removal (CDR)

NGFS has followed these dimensions to identify 4 high-level scenarios

# NGFS mitigation scenarios - Example

Output Electricity across NGFS scenarios (disorderly transition). Region: China, 2020-2050.  
Model: REMIND-Mag-Pie.



# Financial risk: climate transition risk analysis

**Concept:** translate IPCC climate mitigation scenarios into

- adjustment in valuation of financial contracts at counterparty level (Battiston ea. 2017)

## What is transition risk?

- Risk resulting from financial actors' expectations: adjustment from baseline transition scenario.

**Use:** approach widely used by supervisors (e.g. ECB, BoE) and practitioners (e.g. top consulting firms)

**Reference:** NGFS scenarios (2020; 2021), based on IPCC

## What are scenarios?

- Not predictions,
- Plausible future developments constrained by physics laws, technology, policy.

## IPCC scenarios characteristics

- Baseline scenario (current policies, NDC)
- Transition scenario:
  - Emission targets: 2C, 1.5C
  - Timing of climate policies: 2020, 2030
  - Carbon dioxide removal: low, medium reliance

**Third Step.**

**Quantitative assessment of transition risk losses**  
**Scenario analysis - Climate stress-test**

# Climate transition - financial risk analysis

## Counterparty level technological profile

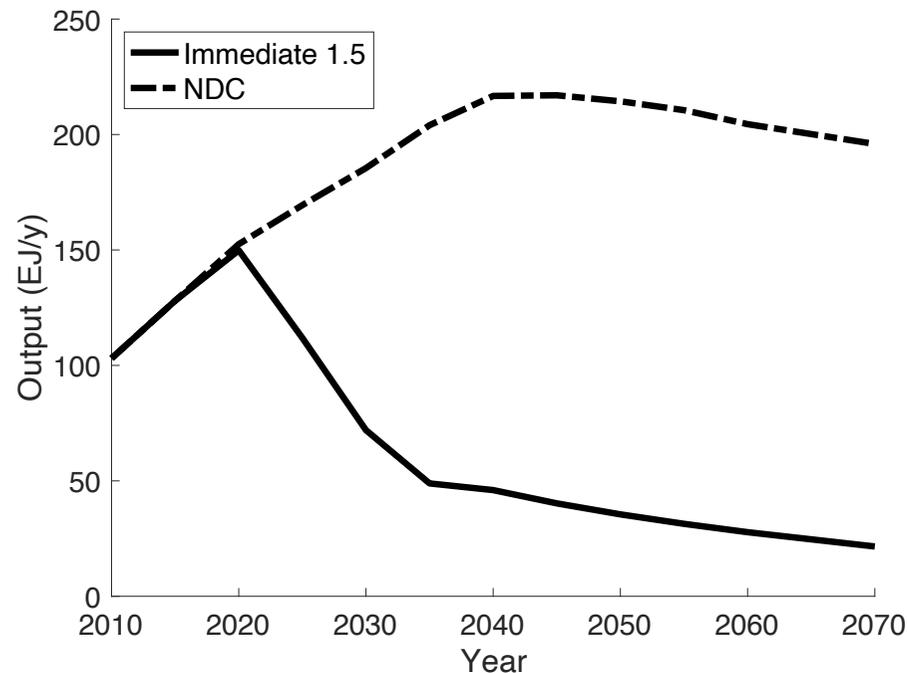
1. Analyse counterparty i's revenues share by **technology** across CPRS granular (e.g. coal vs wind based electr., ICE vs EV automotive)
2. Estimate current **market share** in each technology
3. Estimate i's future production trajectory in a given scenario X, based on **NGFS sector-level trajectory** and on i's market shares
  - NOTE: i's technology share endogenous!
4. Estimate i's future cashflows along the time trajectory, in each NGFS scenario

## Counterparty level financial valuation

1. Compute financial instrument valuation under baseline scenario B
  - Equity: standard valuation based on discounted future profits trajectory
  - Bonds and loans: compound future profits trajectory in a structural model of default
2. Calibration: possibly using counterparties PD, LGD provided by banks
3. Assume adjustment in investors' expectations about realization of transition scenario P.
4. Recompute financial valuation under scenario P to give valuation adjustment BP

## Transition risk: financial valuation procedure - example

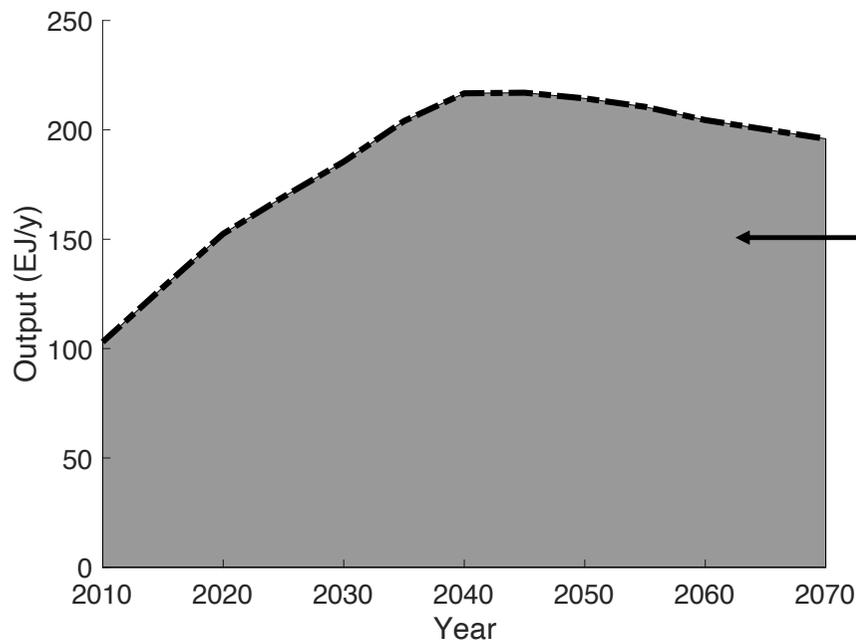
Trajectories at sector level Sector: fossil|gas. Model: REMIND-Magpie



- Comparison of examples of sector-level output trajectories (2010 – 2070):
  - B = Nationally Determined Contribution (NDC, baseline)
  - P= Immediate 1.5C with limited CDR (disorderly).
- For each trajectory, we carry out valuation today of financial instrument issued by a firm in the fossil|gas sector.

## Transition risk: financial valuation procedure - example

Trajectories at sector level Sector: fossil|gas. Model: REMIND-Magpie



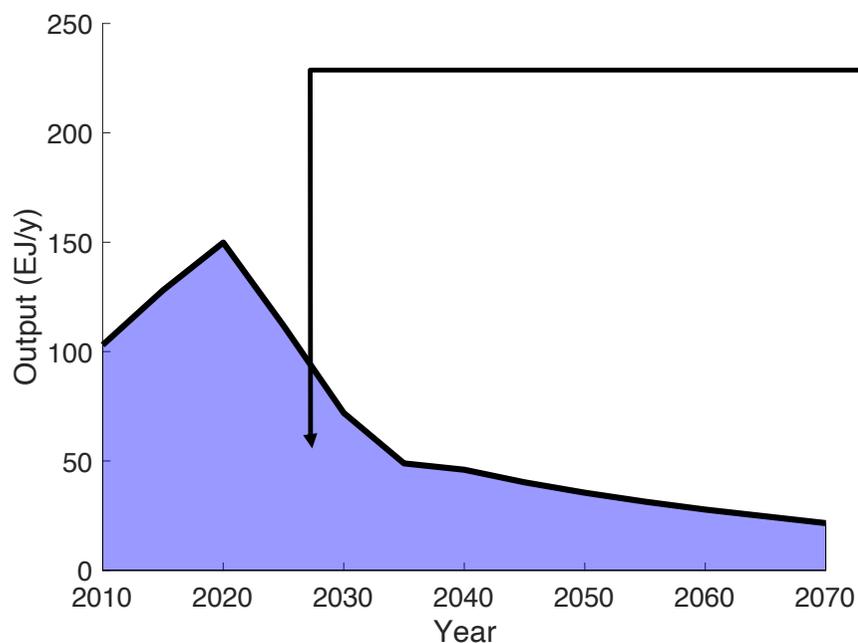
- Grey area represents cumulative output of companies active in the fossil|gas sector in scenario **B**.
- Valuation of financial instrument equity computed from discounted sum of dividends.
- Assumption: dividends depend on output  $O$  (via profits  $\Omega$ ) in scenario **B**.
- $r$  discount factor

$$V_{B,j}^{\text{equity}} = \sum_{t=t_0}^{t_{\text{max}}^{\text{equity}}} \frac{\text{div}_j(\Omega_{B,j,t}(O_{B,j,t}))}{(1+r)^{t-t_0}}$$

Source: Battiston, Mandel, Monasterolo, Roncoroni (2021), *Financial valuation under climate transition scenarios*, forthcoming.

## Transition risk: financial valuation procedure - example

Trajectories at sector level Sector: fossil|gas. Model: REMIND-Magpie



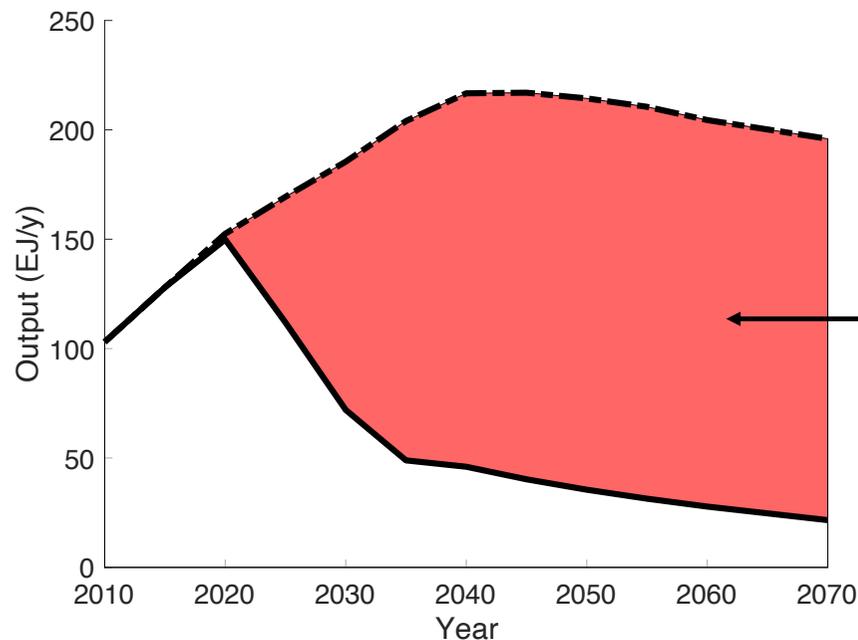
- Blue area represents cumulative output of companies active in the fossil|gas sector in scenario **P**.
- Valuation of financial instrument equity computed from discounted sum of dividends.
- Assumption: dividends depend on output (via profits) in scenario B.

$$V_{P,j}^{\text{equity}} = \sum_{t=t_0}^{t_{\text{max}}^{\text{equity}}} \frac{\text{div}_j(\Omega_{P,j,t}(O_{P,j,t}))}{(1+r)^{t-t_0}}$$

Source: Battiston, Mandel, Monasterolo, Roncoroni (2021), *Financial valuation under climate transition scenarios*, forthcoming.

## Transition risk: financial valuation procedure - example

Trajectories at sector level Sector: fossil|gas. Model: REMIND -Magpie



- The red area corresponds to the loss in output between the scenarios **B** and **P**.
- We then compute relative shock.
- It represents the change in valuation of the security **today**, after a change of agents' expectations on future scenario of output

$$U_{P,j}^{\text{equity}} = \frac{V_{P,j}^{\text{equity}} - V_{B,j}^{\text{equity}}}{V_{B,j}^{\text{equity}}}$$

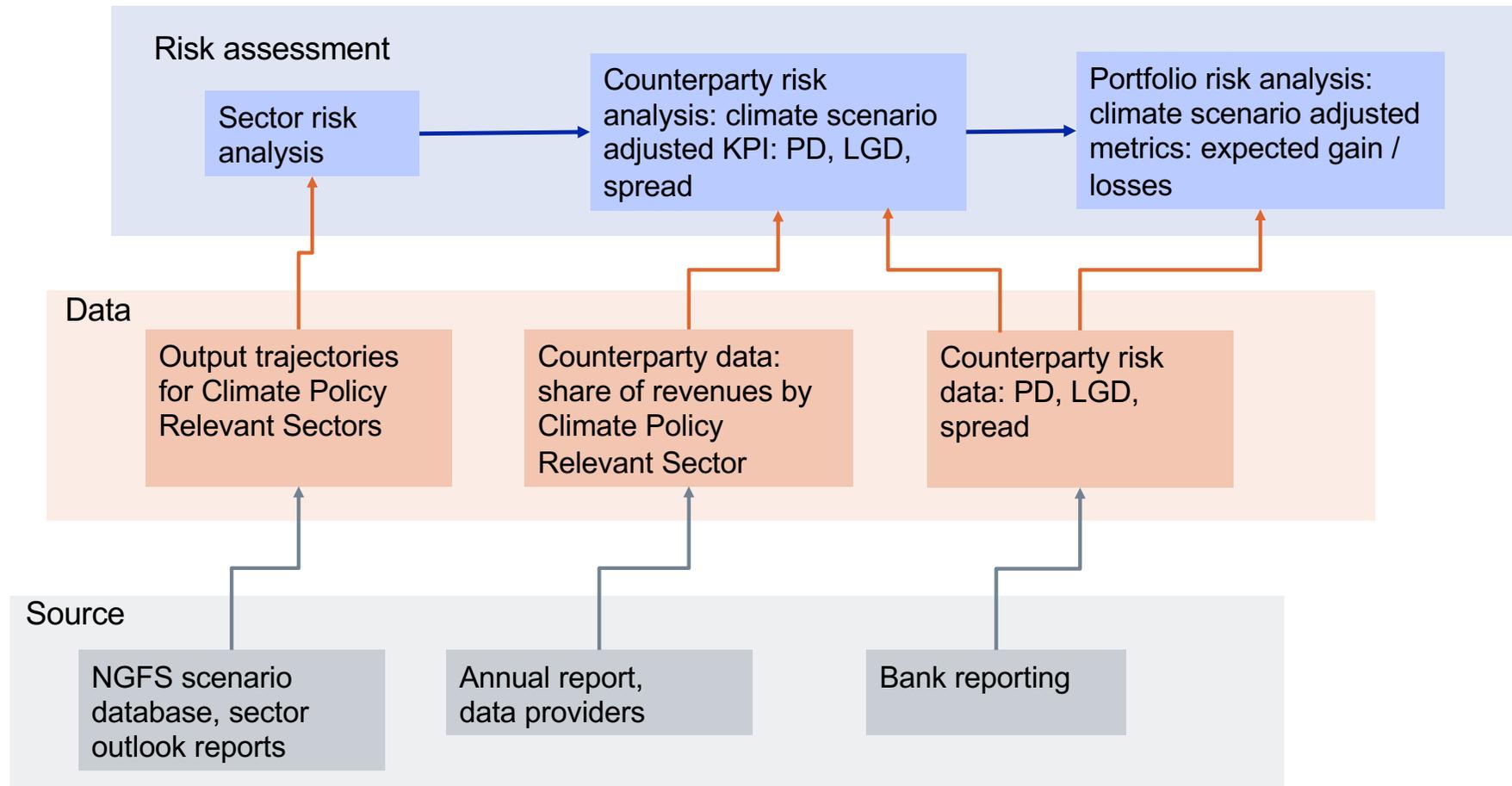
Source: Battiston, Mandel, Monasterolo, Roncoroni (2021), *Financial valuation under climate transition scenarios*, forthcoming.

## Transition risk: financial valuation procedure – bond and loans

- For bonds and loans: similar intuition but more complex model
- **Probability of default (PD)** and **Loss Given Default (LGD)** depend on:
  - projected compounded profits from valuation time until maturity, adjusted by climate transition shock
  - projected discounted profits from maturity onwards, adjusted by climate transition shock
  - volatility of idiosyncratic shocks on productivity
- More details available soon in:
  - report of climate transition risk analysis recently conducted with an NGFS member
  - model documentation and sensitivity analysis (Battiston et al. 2021b)

*Source: Battiston, Mandel, Monasterolo, Roncoroni (2021), Financial valuation under climate transition scenarios, forthcoming.*

## Transition Risk Analysis - workflow



Source: Battiston, Mandel, Monasterolo, Roncoroni (2021), *Financial valuation under climate transition scenarios*, forthcoming.

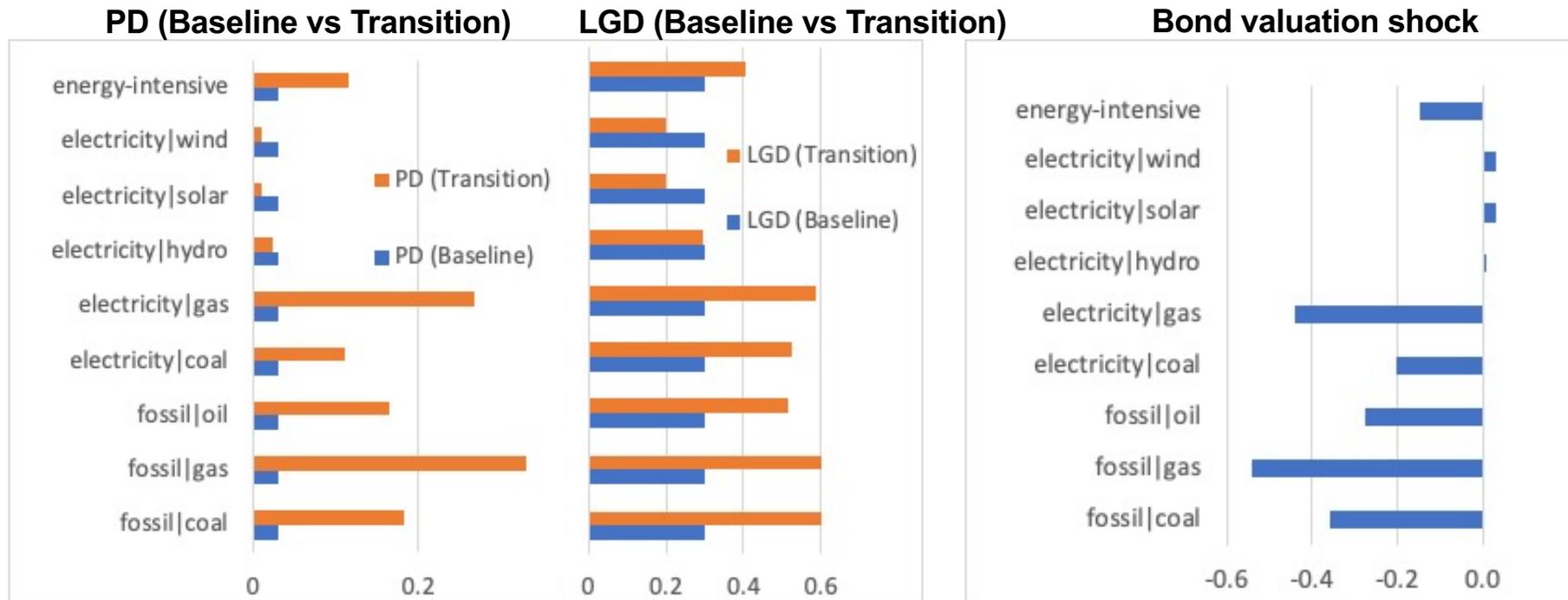
## Example output: shocks on bond valuation for selected sectors and parametrization

### Formulas

- Bond valuation:  $k = (1 - PD) + (1 - LGD) PD$
- Bond shock:  $(k(\text{Baseline}) - k(\text{Transition})) / k(\text{Baseline})$

### Results

- Bond shock varies across sectors and technology ( and climate transition scenario)



## **Fourth Step. Endogeneity of transition scenarios**

## Endogeneity of risk and macro-financial feedback loop: take home message

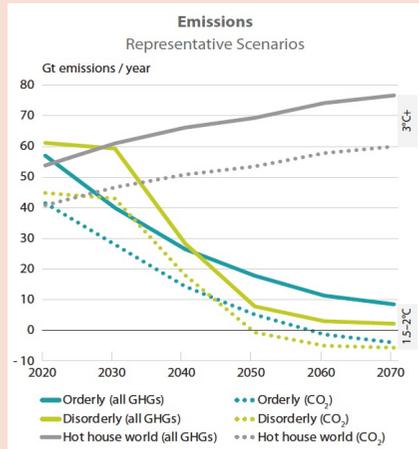
- NGFS climate mitigation scenarios are already a **reference** tool for investors
  - Scenarios can **shift markets' expectations**
  - But do **not account** for impact of financial actors' looking at the scenarios themselves.
- This missing feedback loop is key for financial stability and for climate targets, because it can lead to under-investing wrt to climate targets.
- **Missing endogeneity** in mitigation scenarios matters for **political economy** of the low-carbon transition. achieving or missing climate targets
- Opportunity: we introduce a framework to **model** interaction expectations-scenarios: it generates new transition scenarios that are more coherent with investment needs and climate targets (Battiston ea. 2021, Science)
- Key role for **policy credibility**, implications for **fiscal and financial policies**

Source: Battiston S., Monasterolo I., Riahi K., van Ruijven B.J., Accounting for finance is key for climate mitigation pathways, *Science*, 28 May 2021. DOI: 10.1126/science.abf3877

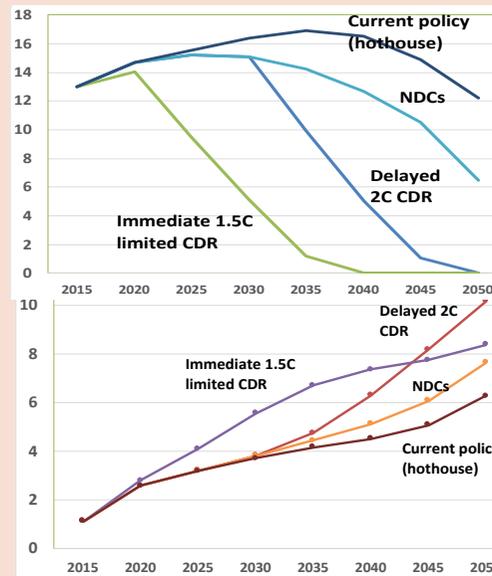
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# Macro-financial feedback loop is missing

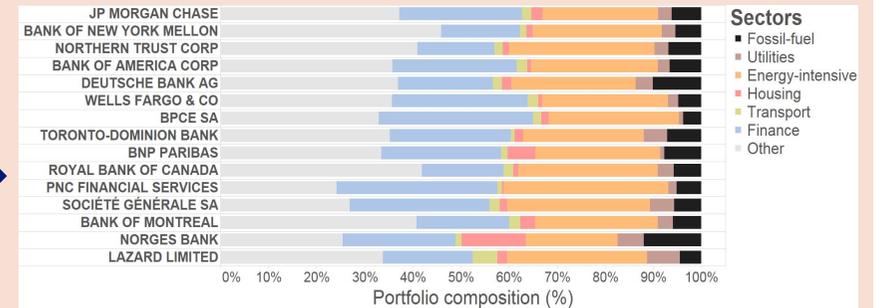
## Climate scenarios' (IPCC, NGFS)



## Economic scenarios (sector output, IAM)

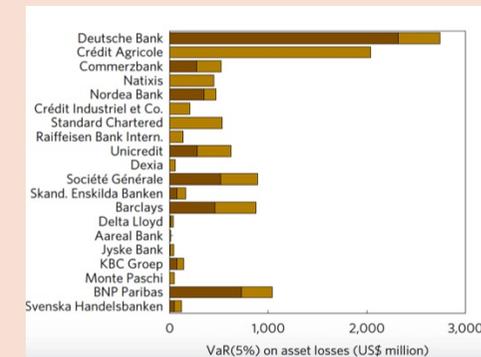


## Climate risk exposures (disclosure)



Battiston ea (2017)

## Climate-adjusted risk and asset valuation (climate stress-test)



Battiston ea (2017)



Missing!

**New investments and capital reallocation**



Missing!

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# Enabling or hampering role?

## Enabling:

Investors perceive high physical risk from missed transition/high opportunities successful transition (**credible climate policies**, Rogge ea. 2018)

→ They reallocate capital into low-carbon investments early and gradually and even anticipate policy impact: **climate sentiments** (*Dunz ea. 2021*)

## Hampering:

Investors interpret “orderly transition” as high-carbon firms only slightly more risky than low-carbon: expect firms to adjust tech mix and spread stranded assets over time because **climate policy not credible**

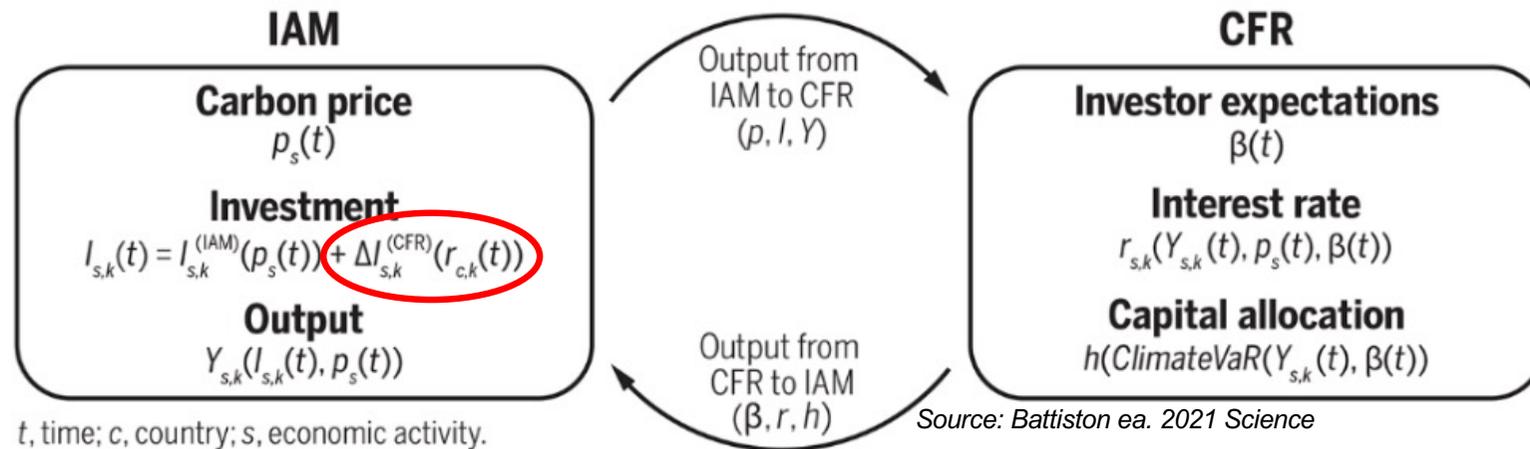
→ Capital reallocation not sufficient to fund investments assumed in scenario. Transition more costly for society due to abrupt reallocations of capital and price adjustments.

If a risk scenario is associate with too low-risk perception can make the scenario unfeasible

# IAM-CFR framework

A new IAM-CFR framework to link Integrated Assessment Models (**IAM**) and Climate Financial Risk model (**CFR**) in a circular way, applicable to various IAMs and CFR.

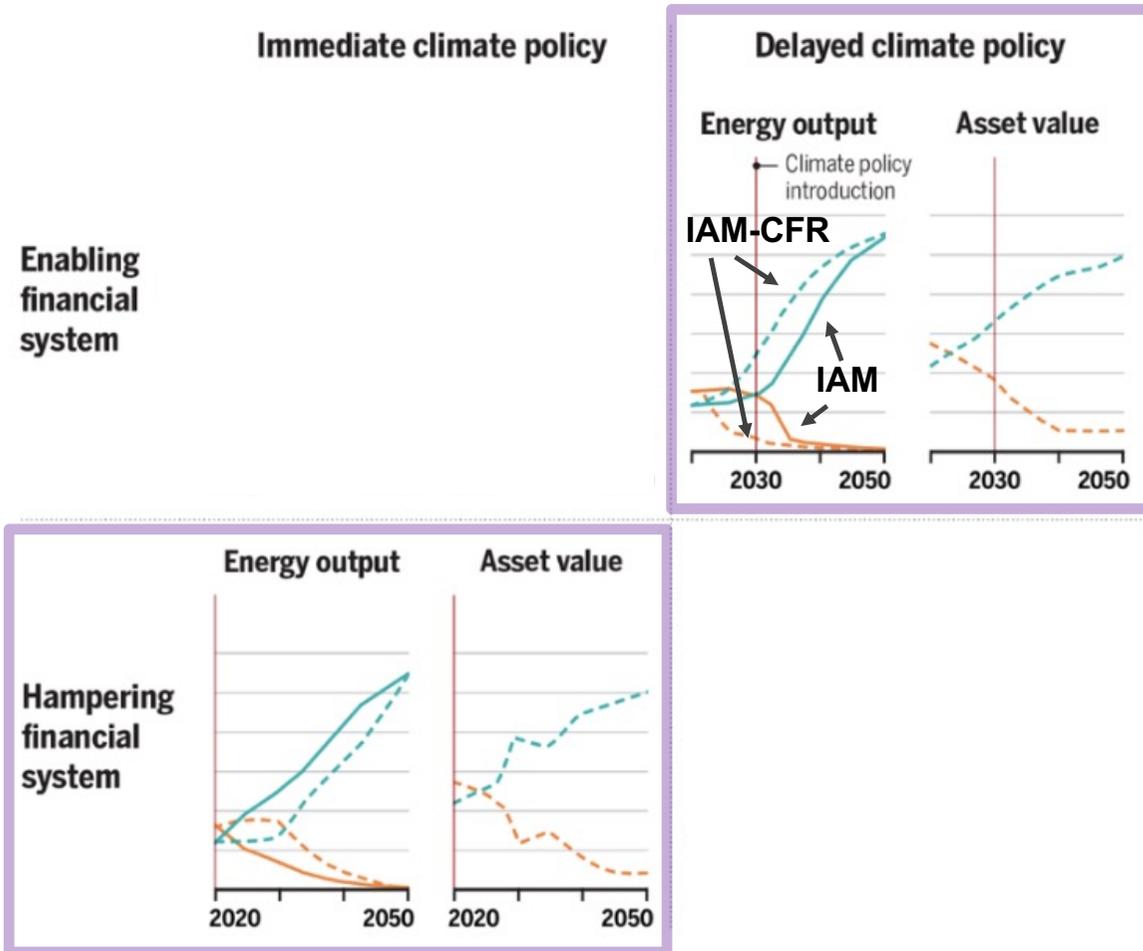
It captures interaction **expectations** – **scenarios** and generate new scenarios that can be more coherent with investment needs climate targets.



- Set of IAM climate mitigation scenarios →
- → CFR models financial risk of high/low-carbon firms along scenarios.
- → Interest rate fed back to the IAMs to compute new scenarios
- Repeat

*Source: Battiston S., Monasterolo I., Riahi K., van Ruijven B.J., Accounting for finance is key for climate mitigation pathways, **Science**, 28 May 2021. DOI: 10.1126/science.abf3877.*

# IAM-CFR framework



## Orderly/disorderly are endogenous

- An immediate transition to 2° C classified in NGFS scenarios as orderly. But in hampering case: delayed transition, large and sudden financial value adjustments as in a disorderly scenario.
- A delayed transition to 2° C classified disorderly. But in enabling case gradual price adjustments more consistent with orderly
- In hampering role: disorderly transition could also lead to higher risk than in NGFS disorderly

## Legend

Trajectories from IAM scenarios		Trajectories from IAM-CFR framework	
— Renewable energy	— Coal	- - Renewable energy	- - Coal

Source: Battiston ea. 2020, **Science**, DOI:10.1126/science.abf3877

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# Policy implications

- **Policy signal and policy credibility**
  - Role of policy credibility well-known in economics. Here: highlight its crucial role for low-carbon transition dynamics and for financial stability
- **Fiscal policies**
  - Neglecting role of finance implies **carbon price projections** could miss **emissions target** because mitigation scenario does not necessarily imply a risk perception by the financial system that leads to investment reallocation assumed by the scenario. Similarly, for carbon subsidies phasing out.
  - Thus, IAM-CFR framework could help IPCC community and NGFS to revise carbon price projections from climate mitigation models to be more consistent with role of financial system
- **Financial policies**
  - IAM-CFR could support financial authorities, within financial stability mandate, in encouraging investors' assessment of climate-related financial risk.
  - Limit underestimation of financial risk in climate stress-test exercises.
  - Implications for asset eligibility criteria in central banks' collateral frameworks and asset purchasing programs (e.g. Quantitative Easing)

## Conclusion

Assessment of transition risk requires a conceptual framework and a procedure:

1. Classification of economic activities to group assets into transition risk categories: Climate Policy Relevant Sectors
2. Transition scenarios: NGFS
3. Climate stress-test and risk measures
4. Awareness of endogeneity of scenarios: the role of the financial system

## References

- Battiston, Stefano, Irene Monasterolo, Keywan Riahi, and Bas van Ruijven. 2021. “Accounting for Finance Is Key for Climate Mitigation Pathways.” *Science*: 28 May 2021, 10.1126/science.abf3877. <https://science.sciencemag.org/content/early/2021/05/19/science.abf3877>.
- Battiston, Stefano, and Irene Monasterolo. 2020. “On the Dependence of Investor’s Probability of Default on Climate Transition Scenarios.” *ssrn* 3743647.
- Battiston, Stefano, Antoine Mandel, Irene Monasterolo, Franziska Schütze, and Gabriele Visentin. 2017. “A Climate Stress-Test of the Financial System.” *Nature Climate Change* 7(4):283–88.
- Dunz, Nepomuk, Asjad Naqvi, and Irene Monasterolo. 2020. “Climate Transition Risk, Climate Sentiments, and Financial Stability in a Stock-Flow Consistent Approach.” *JFS forthcoming*.
- Roncoroni, Alan, Stefano Battiston, Luis Onesimo Leonardo Escobar Farfan, and Serafín Martínez-Jaramillo. 2020. “Climate Risk and Financial Stability in the Network of Banks and Investment Funds.” *Journal of Financial Stability* 54.
- IPCC, “Global warming of 1.5° C. An IPCC Special Report on the impacts of global warming of 1.5° C above pre-industrial levels and related global greenhouse gas emission pathways”, (2018). <https://www.ipcc.ch/sr15/>
- Network for Greening the Financial System, (NGFS), “A call for action” (2019)
- Network for Greening the Financial System, (NGFS), “Guide for Supervisors Integrating climate-related and environmental risks into prudential supervision” (2020). <https://www.ngfs.net/en/guide-supervisors-integrating-climate-related-and-environmental-risks-prudential-supervision>
- UNEP-FI, “Decarbonisation and Disruption. Understanding the financial risks of a disorderly transition using climate scenarios” (2021). <https://www.unepfi.org/publications/banking-publications/decarbonisation-and-disruption/>

# Appendix

## Remark on the notions of CPRS and stranded assets

The term ***stranded assets*** refers to assets the value of which could decrease as a result of the introduction of climate policies or regulations that discourage the utilization of the fossil fuel in the context of climate change mitigation.

When it comes to a precise definition, there seem to be different uses of the term in the grey literature ranging from:

- oil and gas reserves and infrastructures for drilling
- the latter + financial assets of the firms that own the rights to use those reserves
- the latter + plus other activities related to fossil industry

No specific or detailed list of NACE codes. Thus it is difficult to compare estimates of stranded assets across countries or investors.

CPRS are identified based on general criteria, cover activities affected both in terms of risk and opportunities, it is based on a publicly available list of NACE codes.

## Resources

### CPRS

The table of correspondance NACE codes to CPRS is available for download at

<https://www.finexus.uzh.ch/en/projects/CPRS.html>

[EIOPA FSR December 2018.pdf](#)

[ECB https://www.ecb.europa.eu/pub/financial-stability/fsr/html/ecb.fsr201905~266e856634.en.html#toc1](https://www.ecb.europa.eu/pub/financial-stability/fsr/html/ecb.fsr201905~266e856634.en.html#toc1)