Understanding the role of finance for the low-carbon transition: lessons learned and steps ahead

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Greenfin

CLIMEX

cascades
Cascading climate risks: Towards adaptive and resilient European Societies

Climate change and financial stability

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1. **Climate-**related **financial** risks:
   - Climate physical risk, transition risk: *disorderly transition* (NGFS 2019)
2. **Finance** as a source of risk for the low-carbon transition:
   - Investors are highly exposed to climate risks (Battiston ea 2017, ECB 2019, EIOPA 2019). Financial interconnectedness can amplify losses
3. **Compounding shocks** (COVID-19 and natural hazards) can amplify risk and induce systemic effects on public and private debt sustainability (Dunz ea 2020)

➢ *Understanding **under which conditions** finance can affect the low-carbon transition is crucial to inform decision makers (Monasterolo 2020a)*

➢ *Do we have the right tools?*

Understanding finance implies challenges for climate (macro)economic models

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1. *Impact of climate risks* go beyond aggregate GDP impacts and monetary value
2. Consider *financial assets* (not only economic assets)
3. Embed finance and its complexity, *avoiding shortcuts*: finance not simply carbon price but actors deciding to invest/not in the transition (Battiston ea 2020)
4. Assess how risk generates in agents' balance sheets: *risk transmission channels, drivers of reinforcing feedbacks* (Dunz ea 2020)
5. *Shorten the time horizon* of policy analysis: investors decisions do not reach 2050
6. **Consider the 2nd best world we live in**: depart from one optimal policy and explore *policy complementarity* (and conditions)

1. Understanding risk across scenarios

Nature of climate risks for finance

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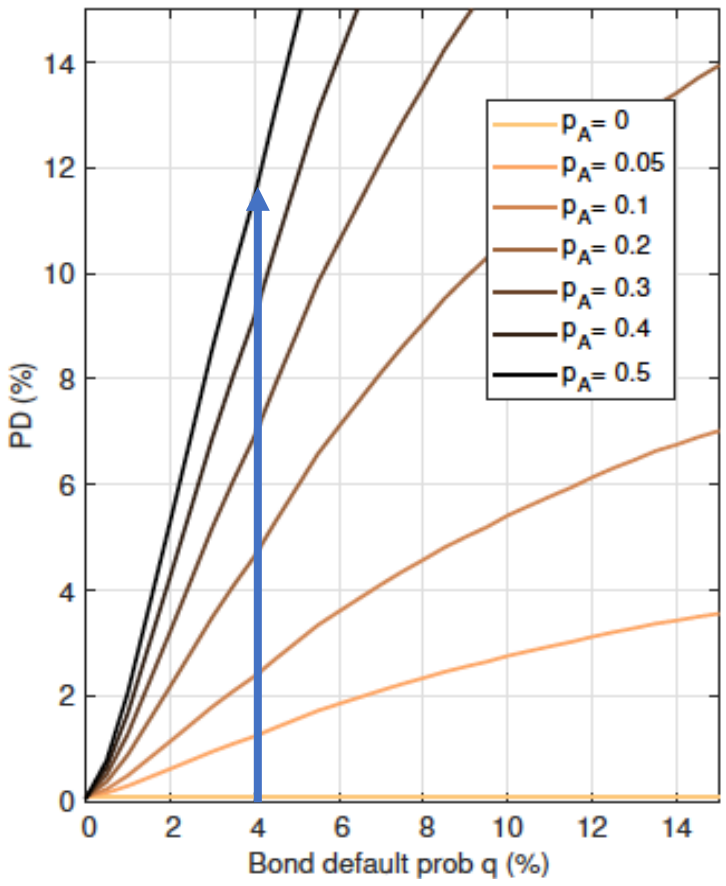
- **Deep uncertainty:** climate forecasts and impacts contain irreducible uncertainties
  - Tail events (Weitzman 2009) and tipping points (Solomon ea. 2009) that may trigger domino effects (Lenton ea. 2019).
  - Non-monetary values (key to assess negative externalities)
- **Non-linearity:** distribution of extreme weather events (heat/cold waves) is highly non-linear (Ackerman 2017) and makes historical data poor proxy of future risk
- **Forward-looking** nature of risk: largest climate impacts are expected in mid to long term while time horizon of investment and policy is shorter (months for investors)
- **Endogeneity:** successful transition depends on governments and firms' investment decisions. But both decisions depend on agents' adaptive expectations about climate risk and affect the occurrence of climate risk scenarios (Battiston 2019)

Source: Monasterolo (2020b)

Financial risk is highly sensitive to scenarios' selection

- NGFS recommended a set of these scenarios for climate stress testing, including one *disorderly transition* scenario (NGFS 2020). **What are the implications for understanding financial risk?**
- Consider a financial investor, with assets financed with leverage (e.g. 20), and a portfolio of corporate bonds, with individual bond probability of default q and with correlation r.
- Scenario Mild: fixed q = 1%
- Scenario Adverse: varying q
- p_A = prob of occurrence of scenario adverse
- Small variations across scenarios imply large changes in investors' solvability

➢ Thus, need to stress test portfolios against wide range of scenarios to avoid to underestimate losses and investors' moral hazard



Source: Battiston & Monasterolo (2019)

2. Harmonized classification of financial assets is crucial to guide investors decisions (before green finance tools)

Challenges with existing definitions of sustainable/unsustainable activities

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- **Carbon stranded assets:** powerful metaphor to conceptualize climate risks in the economy and finance (Caldecott and MacDonnel 2014, Cahen-Fourot ea 2019, van der Ploeg and Rezai 2020)
- **But 3 challenges** for climate finance assessment:
  1. Lack of standardized definition thus poor comparability of analyses
  2. No identification of activities at risk at a level of disaggregation that is relevant for financial analysis
  3. Only negative connotation shadows green opportunities (risk return)
- **Green side: EU Taxonomy to identify sustainable activities**
  - List of admissible NACE codes, threshold based on metrics (emissions), Do not do harm
  - Only sustainable; no financial risk consideration

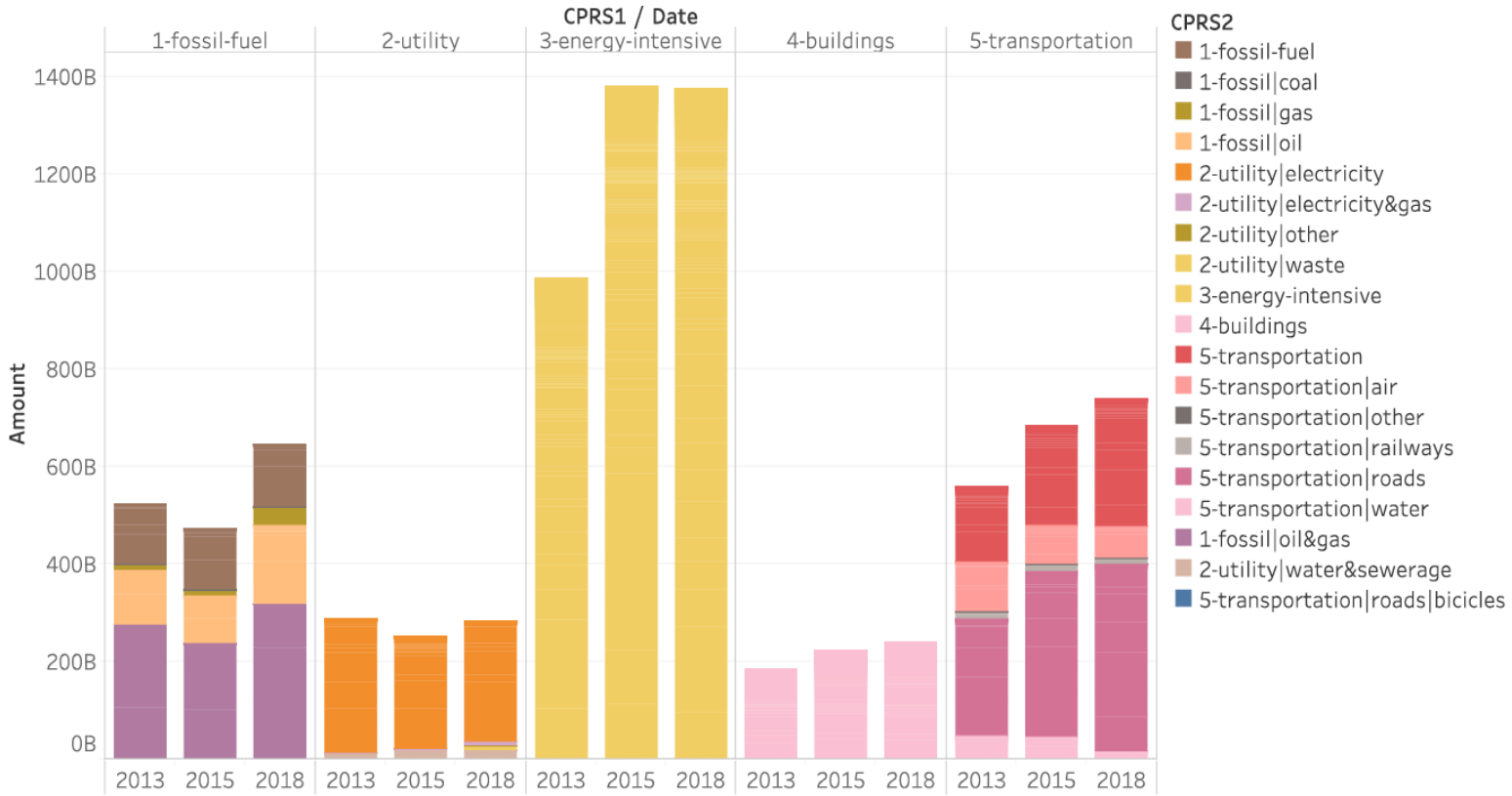
Climate Policy Relevant Sectors

- 5 Climate Policy Relevant Sectors (CPRS, Battiston et al. 2017) mapped in list of NACE codes (4-digit sector): both risks and opportunities

Criteria for identification:

1. GHG emissions (Scope 1,2,3)
2. Role of activity in energy supply chain
3. Business revenue model
4. Sensitivity to change in policy/regulation (costs)

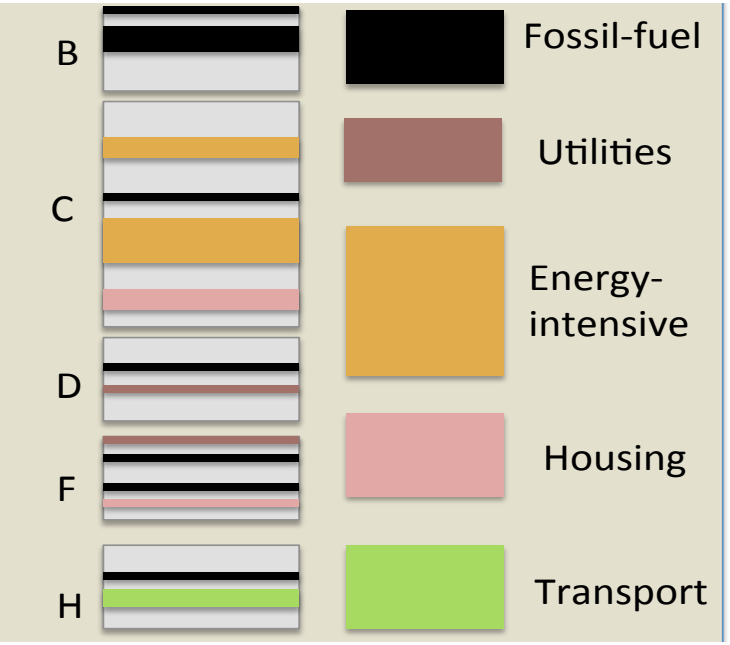
CPRS currently used by several EU financial institutions (ECB 2019, EIOPA 2019, EBA ongoing, OeNB, etc).



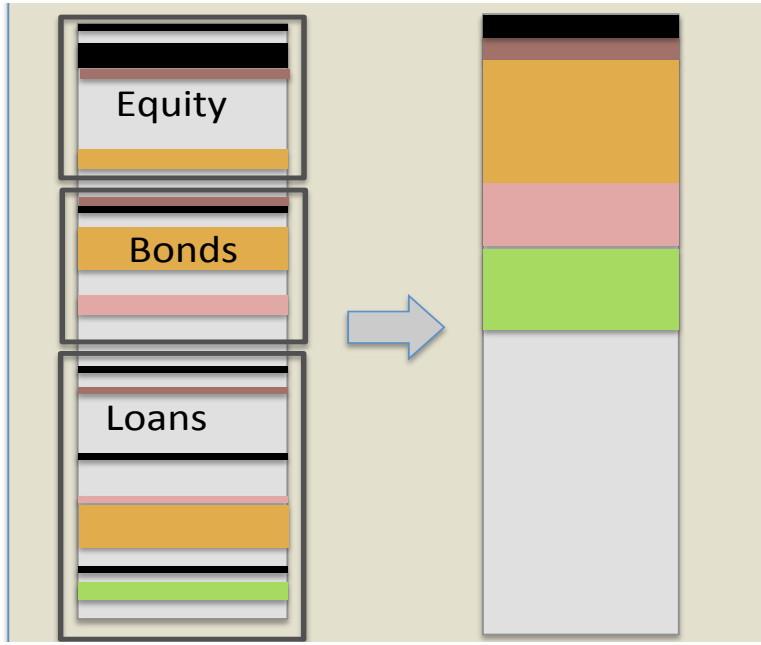
Source: Alessi et al. (2019) financial impact assessment of the EU Taxonomy

Reclassification from NACE Rev. 2 into CPRS

Reclassification of economic sectors from NACE Rev2 into CPRS

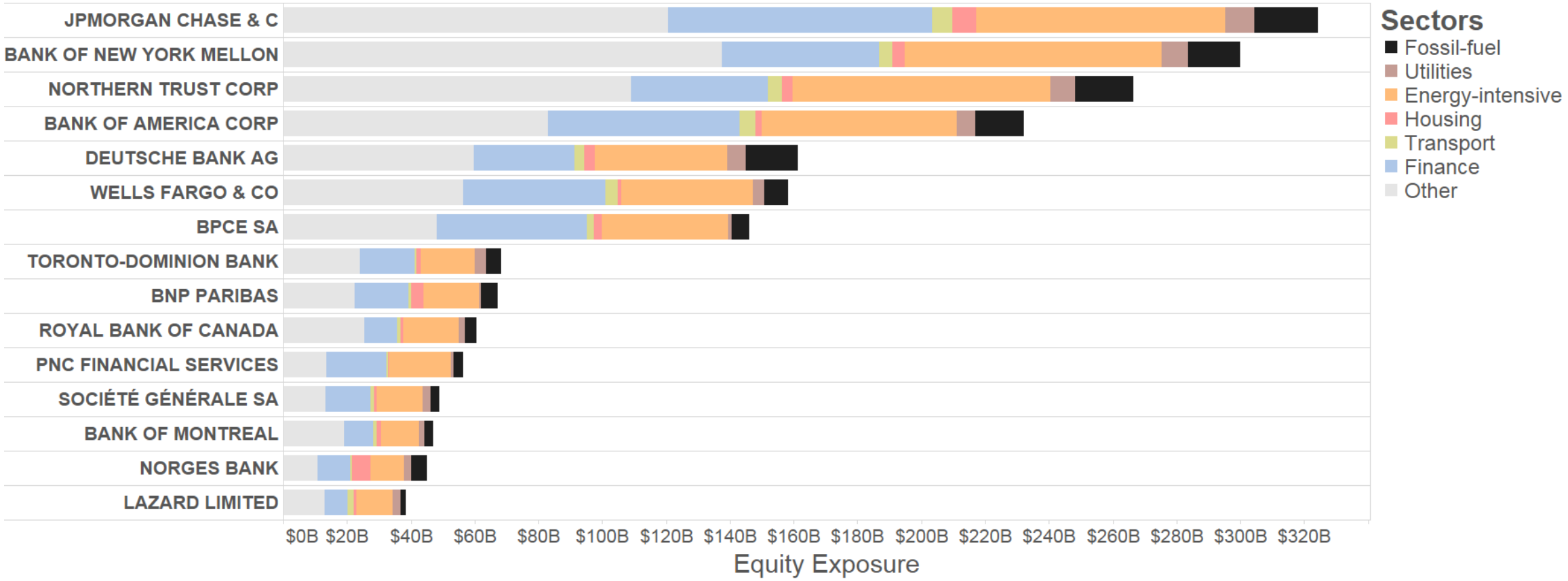


Classification of financial assets according to instrument and CPRS



Source: Battiston ea (2017)

CPRS exposure of top world-wide banks: CPRS exposure

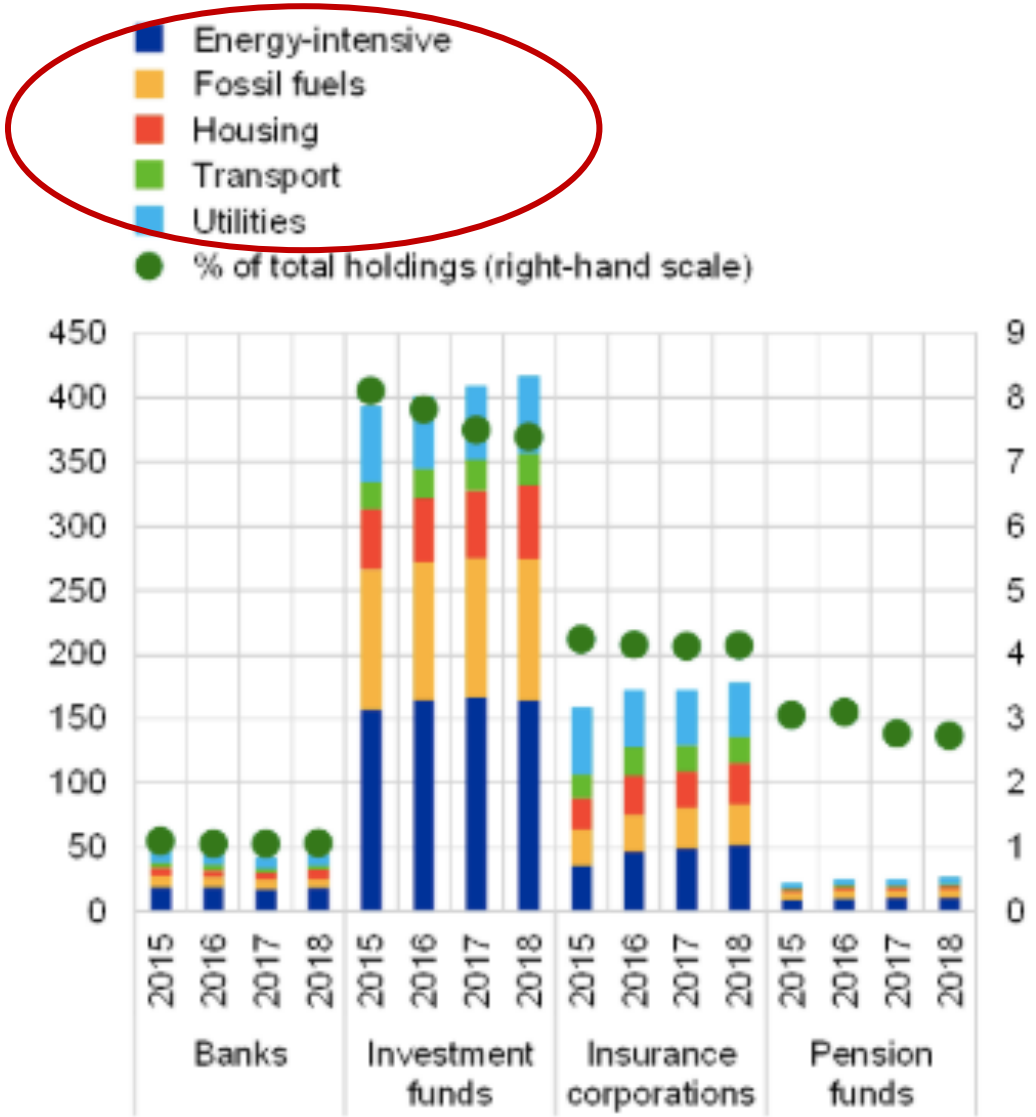


Large yet heterogeneous investors' exposure to CPRS and portfolio allocation.

Source: Battiston ea (2017)

ECB's climate financial risk analysis of the Euro Area market

- **European Central Bank** (2019)'s **"Climate change and financial stability"** (in Financial Stability Review (May 2019):
  - Analysis of the exposure to climate transition risk of euro area financial institutions based on the CPRS classification by Battiston et al. 2017



https://www.ecb.europa.eu/pub/financial-stability/fsr/special/html/ecb.fsrart201905_1~47cf778cc1.en.html

3. Embed finance and its complexity in risk management strategies: climate stress test

Internalizing climate risks and opportunities in investment decisions

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- In 2017, **Climate Stress-test** embedded for the first time IAMs' forward-looking climate scenarios in a stress test of individual portfolios and the financial system:

1. Shocks are obtained from differences in sectors' output between IAMs' trajectories (*BAU* and *P*) by energy technology, region, time, or within trajectories
2. **Asset price and risk adjustment** of individual financial contracts/securities: scenario-adjusted Probability of Default (PD)
3. **Climate financial risk analytics** for investors' portfolios, i.e. the Climate Value at Risk, Expected Shortfall, Climate Spread (for bonds), conditional to the scenarios.
4. **Assessment of the largest losses** for individual portfolios, considering risk amplification driven by financial interconnectedness (2nd, 3rd round, etc) and implications on systemic financial risks.

CLIMAFIN framework for Climate Stress test

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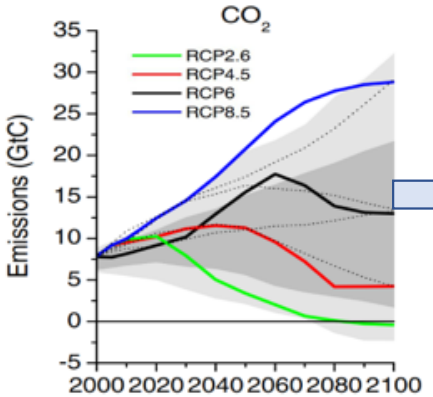
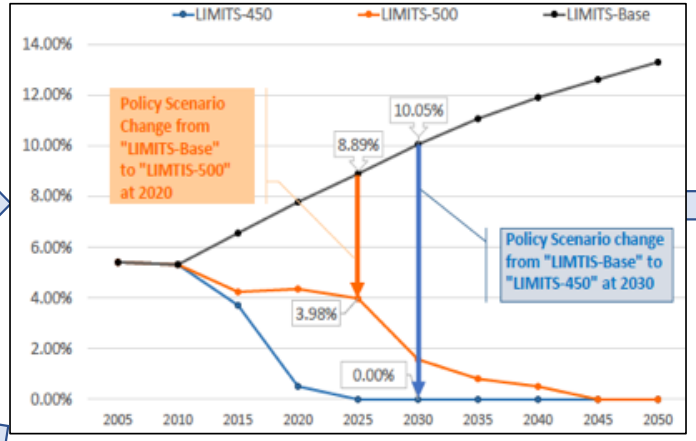
M1: CLIMATE SCENARIOS (EMISSIONS TARGETS)



(IPCC 2014)

M2: SHOCKS ON SECTORS' FORWARD-LOOKING TRAJECTORIES (market shares, GVA)



M3: SHOCK ON FIRM'S CASH FLOWS AND FISCAL REVENUES

Utility: 10TWh generation

3 TWh from coal

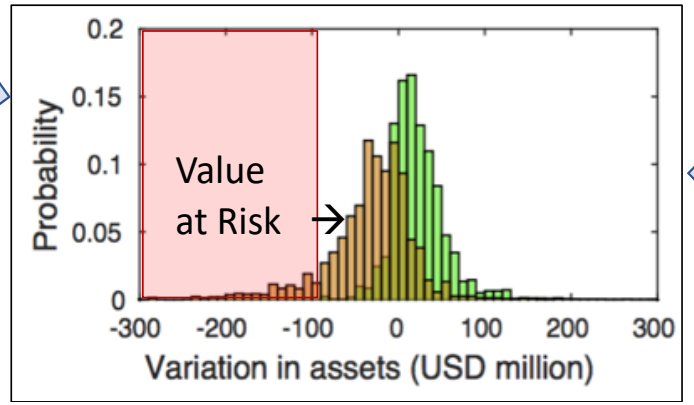
7 TWh from renewables

M3: SHOCKS ON PD AND PRICE OF FINANCIAL CONTRACTS

Country	WITCH: bond shock (%)	WITCH: yield shock (%)
Austria	1,3	-0,16
Australia	-17,36	2,45
Canada	-5,21	0,67
Norway	-14,82	2,05
Poland	-12,85	1,75

Sources: Battiston & Monasterolo 2019, Monasterolo ea 2018

M4: CLIMATE VAR AND CLIMATE STRESS TEST CONDITIONED TO CLIMATE SCENARIOS

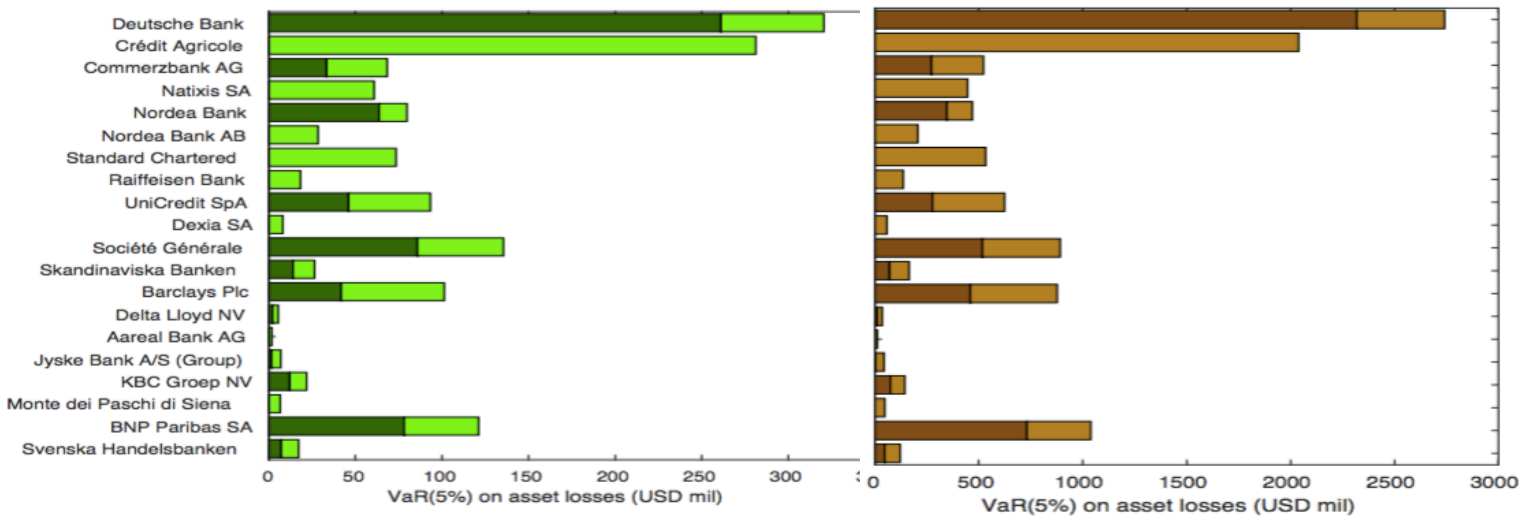


FEEDBACK ON ECONOMIC STRUCTURE

Source: Monasterolo and Battiston 2020

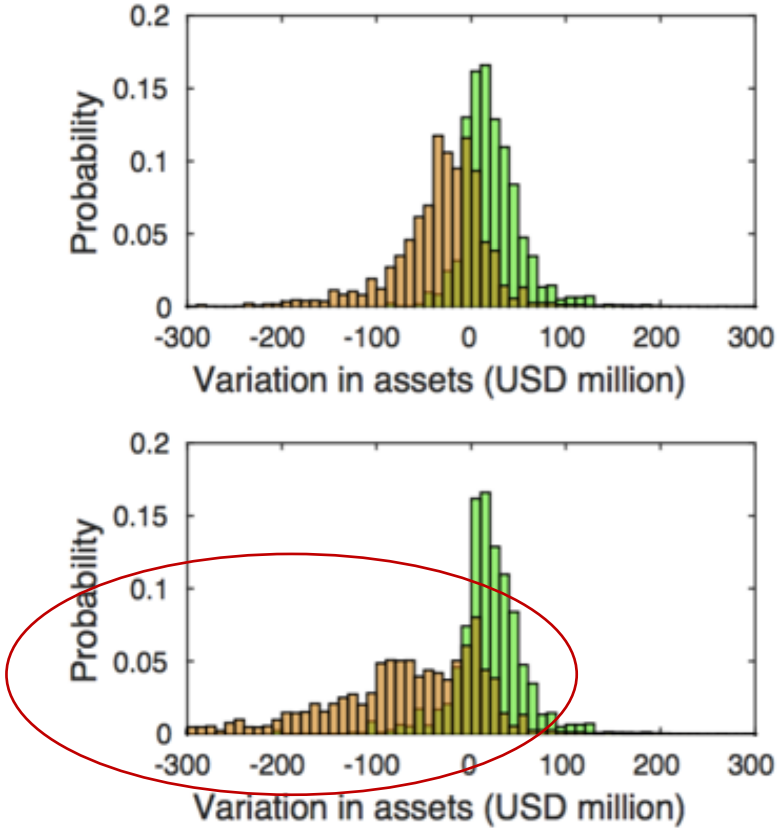
2017: Climate stress-test and its lesson

- **Investors' exposure to Climate Policy Relevant Sectors and their indirect financial exposures** (2nd round via interconnectedness) matter for climate stress testing



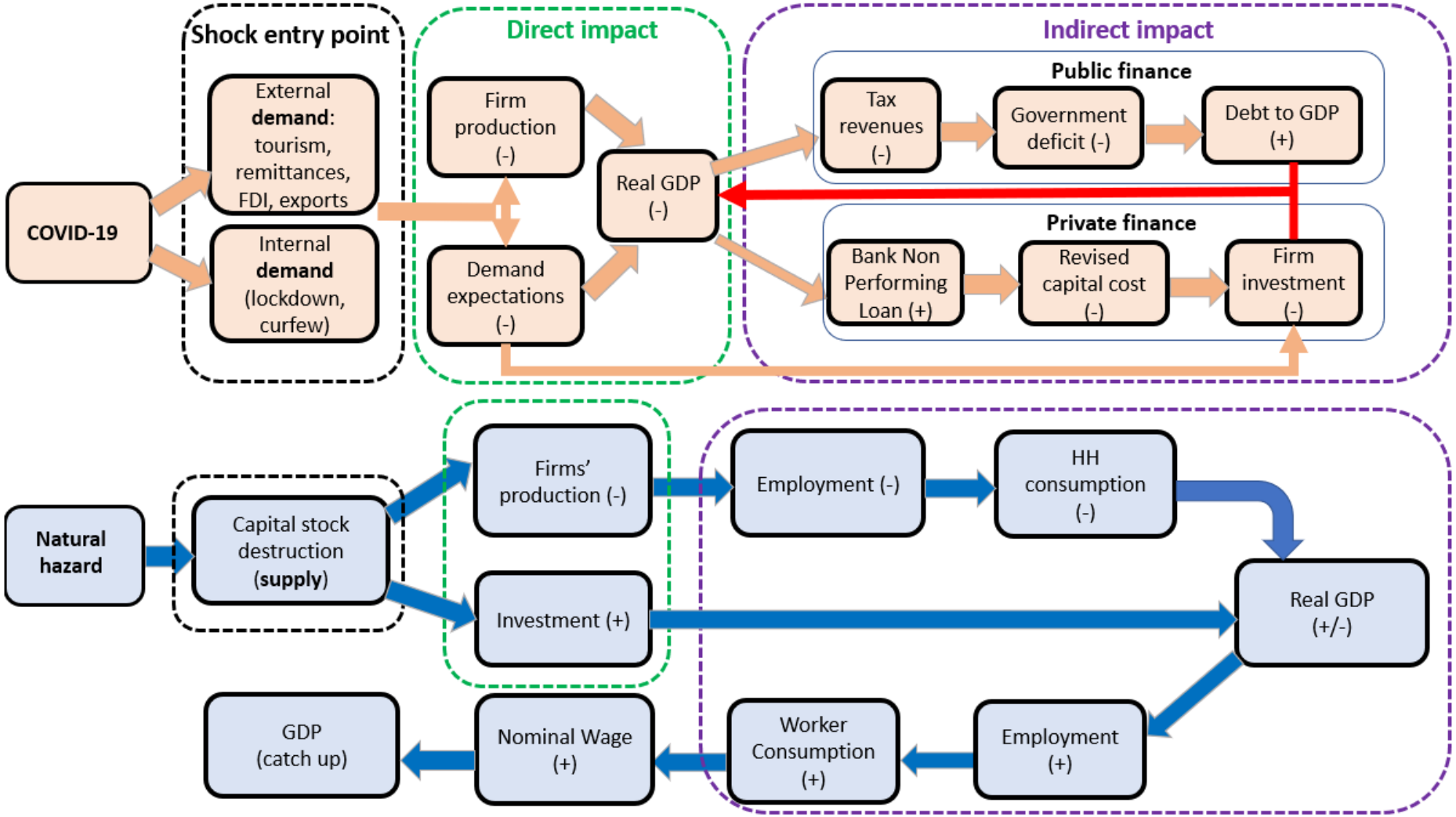
Value at Risk *(5% significance) on equity holdings of* ***20 most affected EU banks*** *under scenario of green (brown) investment strategy. Dark/light colors: first/second round losses. Source: Battiston et al. (2017)*

1st round (top): brown bank incurs more losses.
Adding 2nd round (bottom) polarizes distribution of losses.



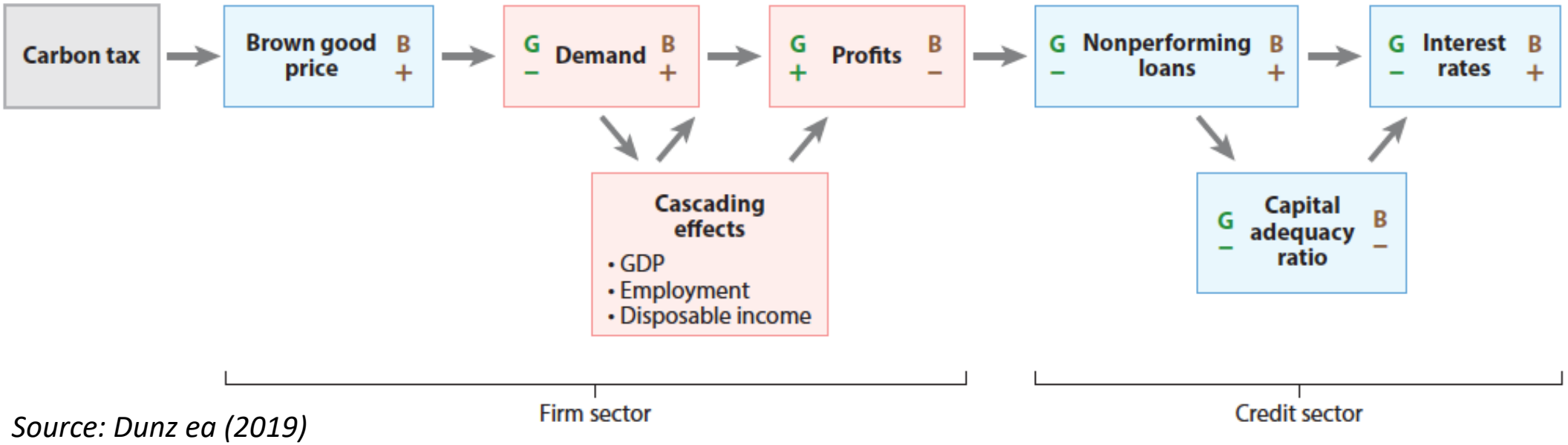
4. Macro-financial risk transmission channels: physical, transition and pandemic risk

Examples of risk transmission channels: COVID-19 and climate physical risk



Source: Dunz ea (2020)

Example of climate transition risk transmission: unanticipated carbon tax



Source: Dunz ea (2019)

- Carbon tax (CT) can be transferred to households via mark-up pricing, affecting demand
- CT may induce a relative price effect in favour of green capital goods, lowering their demand
- Both channels contribute to decrease the profitability of brown firms, weakening their loan service
- Non-Performing Loans (NPL) risk in bank's balance sheet affecting capital ratio and lending conditions

Research challenges in climate finance: compound risk

EIRIN: macroeconomic model of the open economy

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- **Heterogeneous agents/sectors** as a network of interconnected balance sheets
  - Interact through set of markets: labour, energy, cons/capital goods, trade, financial
  - Consumption/production goods characterized by energy intensity (**emissions**)
- **Stock-Flow Consistent**: each agent/sector represented by its balance sheet entries
- Independent **real and monetary flows** (endogenous money creation)
  - Central Bank sets the interest rate according to a Taylor-like rule
  - Bank's Regulatory Capital Adequacy Ratio (CAR)
- **Adaptive expectations**: agents can depart from perfect foresight in context of deep uncertainty (climate risk and policy), market power, mispricing
- **Firms' portfolio choice** (labour/capital intensive, debt financing):
  - No perfect substitution: different relative prices and cost of technology
  - Investment decision endogenous and based on Net Present Value (NPV)

Learn more at: www.greenfin.at

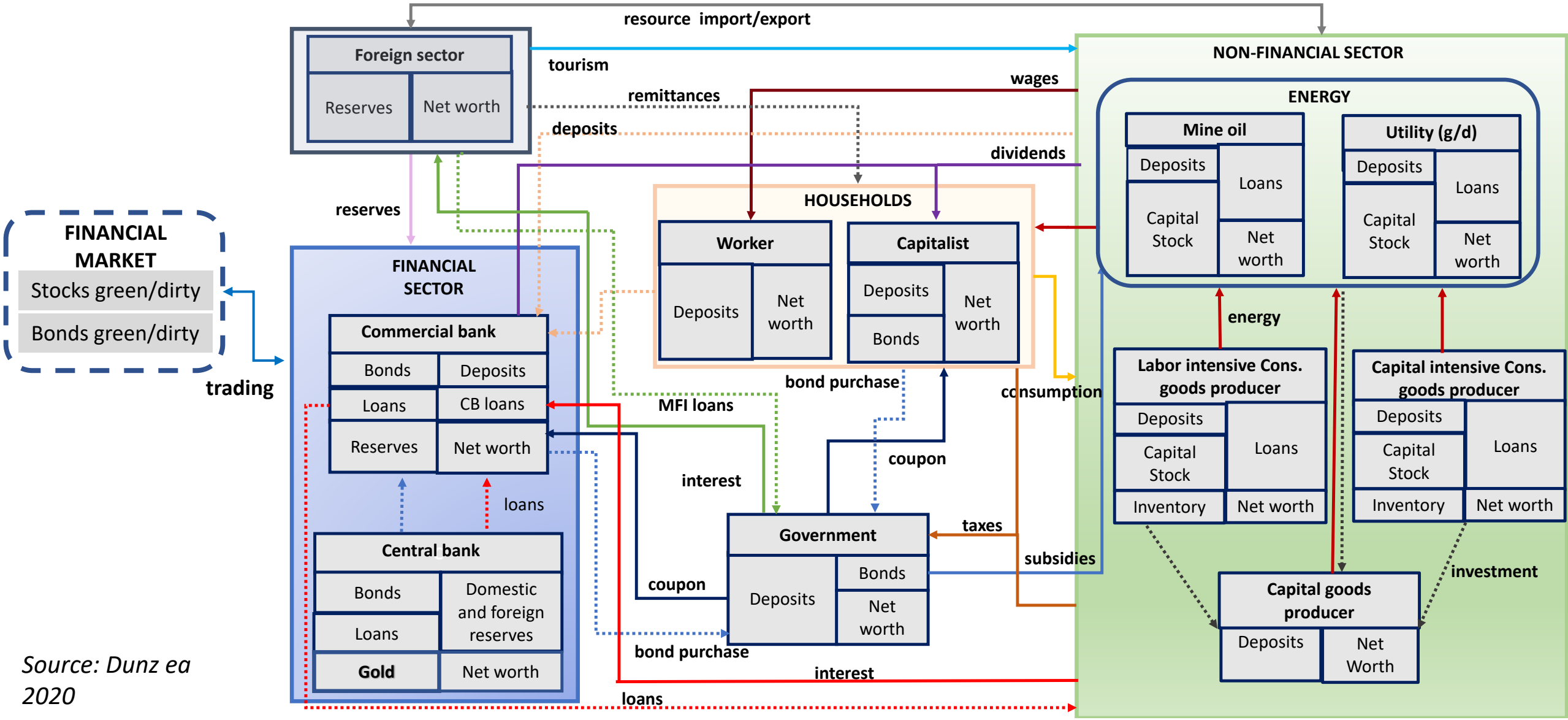
NPV's formulation

$$NPV_j = -p_k I_j + \underbrace{\frac{\widehat{\Delta q_j^C}\, p_j}{r_D^j - \pi_j^{C,e}}}_{\text{Capital goods}} - \underbrace{\frac{\Delta N_j\, w_j}{r_D^j + \varsigma_j}}_{\text{Labour m.}} - \underbrace{\frac{\Delta q_j^R p_R}{r_D^j - \pi_R^e}}_{\text{Nat. res.}} - \underbrace{\frac{\Delta q_j^E\, p_{EN}}{r_D^j - \pi_{EN}^e}}_{\text{Energy}}$$

- 4 cash flows:
- 1 Positive: additional sales due to investment
- 3 negative: (i) additional labor costs required to match the need for increased production capacity; (ii) additional raw materials costs to produce the additional output; (iii) additional energy requirements for producing additional output
- NPV's sign determines whether the agent makes the decision to invest

Source: Monasterolo and Raberto 2018

EIRIN structure: capital (dot)/current (solid) account



Source: Dunz ea 2020

EIRIN: advantages for climate stress testing

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1. Transparent and rigorous accounting framework: equilibrium conditions substituted by accounting identities that hold irrespective of behavioral assumptions

2. **Flexible in terms of geographical and sectoral coverage**:

- Depending on research question/application to climate physical and transition risk in industrial and developing countries (e.g**. carbon tax, green QE, macropru**)

3. Allows to depart from strong assumptions on equilibrium and prices:

- This is key to **understand the endogenous drivers of non-linearity** that give rise to mispricing and Climate "Minsky Moments" (Minsky 1983) in a disorderly transition

4. Calibrated on national accounts, controllable dynamics (statistical sensitivity analysis) to assess the drivers of impacts and causality links, **computationally efficient**

Example of applications: compound COVID-19 and climate physical risk

3 objectives of the study

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1. Understand how COVID-19, climate change and public finance risks interact and affect a country‘s economic recovery and financial stability
   - Case study countries: Jamaica, Philippines, Kenya, Indonesia, Sierra Leone

2. Analyse **risk transmission channels** across sectors, identification of drivers of **reinforcing feedback** loops (amplification effects)
   - Focus on **tourism, remittances, export, FDI,** considering government and central bank‘s responses

3. **Results to support** the design of COVID recovery measures for building resilience to future pandemics, aligning the economy to the climate targets and preserving public debt sustainability (i.e. avoid debt crises)

Mexico case study

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- High integration in global value chain (GVC) via US (76% of ME export) expose it to COVID-19 shocks on external demand and FDI; role as shock propagation in GVC
- **COVID-19** infected (697.663) and deaths (73.493) high (21 Sept.)
- **External shock**: role of trade, FDI, tourism, remittance flows:
  - Export (cars, oil, intermediate, etc.): 39% of GDP, expected to drop by 9% in 2020
  - FDI: expected to drop by 30% in 2020
  - Remittances flows (3% of GDP) expected to drop by 19% in 2020
  - Revenues from tourism sector (2% of GDP) expected to drop by 50% in 2020
- **Internal shock**: domestic consumption (67% of GDP) expected to drop by 8% in 2020 (lock-down and curfews affected HH' consumption decisions)
- **Government** fiscal measures: 1.2% of 2019 GDP, but planned austerity measures
- **Central bank** reduced the policy rate by 250bsp and injected equivalent of 3% of 2019 GDP billion of additional liquidity into the financial market

Model dimensioning and calibration

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- **Dimensioning** to replicate Mexican macro-financial characteristics
- **Initialization** using official data
- **Simulated values** computed in 5-year calibration time window (quarterly) to compare EIRIN's outcomes with the real Mexican data
- For most variables, simulated values are close to real ones
- *Consistency between simulated/real data **emerges endogenously from the model simulations**. It is not set a priori (we do not constrain the model to obtain simulation values close to real data)*

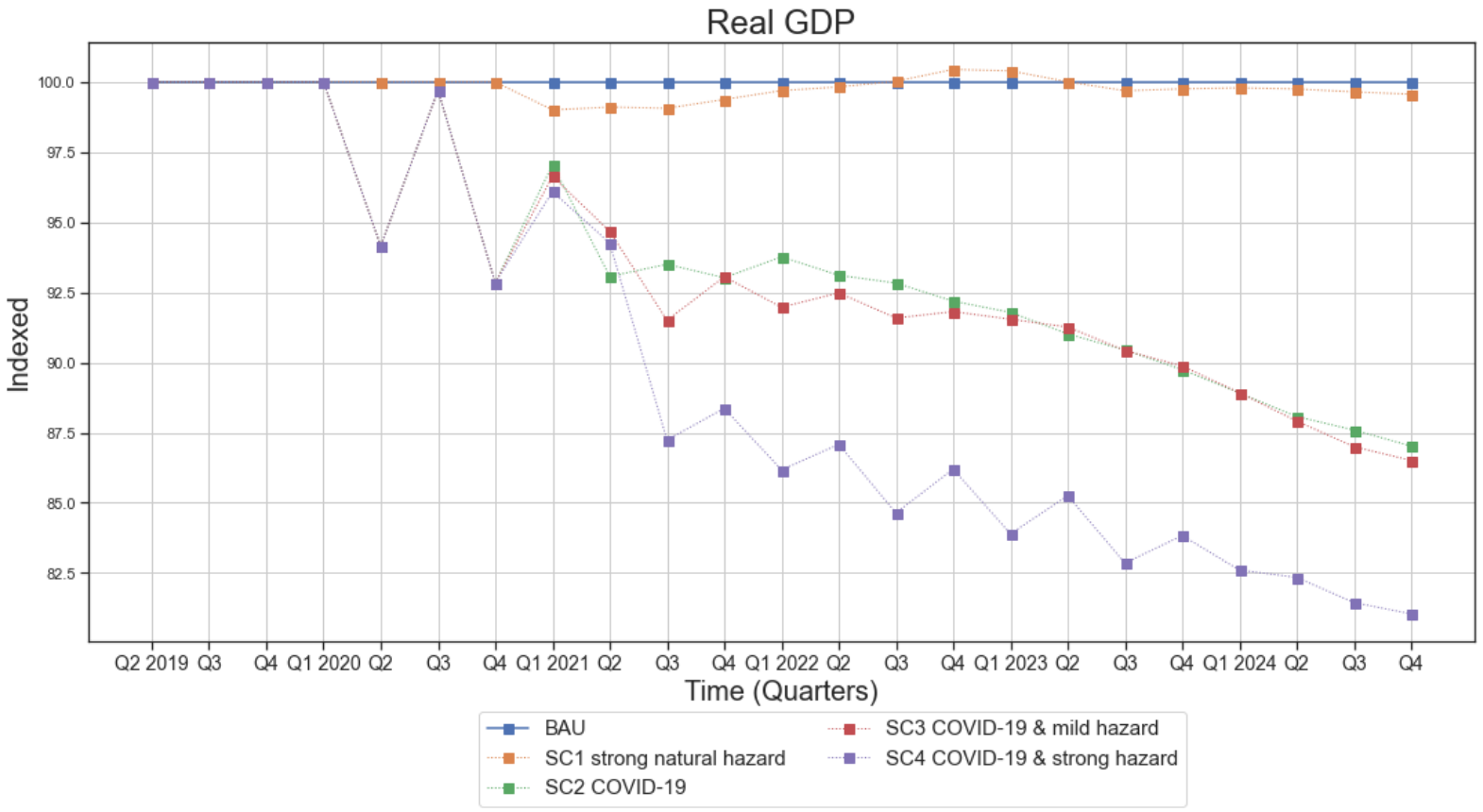
Variable	Mean of SIMULATED values (5 years)	Standard deviation of SIMULATED values (5 years)	Mean of REAL values (5 years)	Standard deviation of REAL values (5 years)
Real GDP growth rate (%)	2.13	0.03	2.06	1.33
Inflation rate (%)	3.41	0.08	4.02	1.43
Unemployment (%)	4.07	0.35	4.51	0.1
Public debt/GDP (%)	40.74	3.26	45.94	1.51
Value Added of service sector (% of GDP)	61.15	0.09	63.92	0.32
Value Added of industry (% of GDP)	28.38	0.03	30.28	0.59
Remittances (% of GDP)	2.31	0.01	2.74	0.32
Tourism (% of GDP)	8.45	0.03	8.68	0.11
Imports (% of GDP)	36.52	0.12	39.08	1.63

Mean and the standard deviation of simulated and real values for Mexico, 5 years. Source: Dunz ea (2020)

Long-lasting negative impact on real GDP

Worst case : compound risk (SC4)

- Exogenous shock on exports and strong natural hazard trigger investment (firms) and consumption (households) dynamics that contribute to reverberate and amplify the shock
- Limited recovery (Q3/2020) due to gov. intervention and end of lockdown
- Even assuming optimistic export recovery **in 2021**, the economy stagnates and faces another recession in 2023 due to hysteresis. **Thus, our results are conservative**



Real GDP (5 years time). x-axis: timeline of simulation until 4th quarter in 2024 on quarterly basis. y-axis: Real GDP indexed against BAU considering no COVID-19 nor disaster (BAU = 100).

Impact of government spending on GDP recovery

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- **Government spending supports households' demand** during the crisis and the economic recovery by avoiding the loss of productive capital and productive structure.

- Increasing government spending during the COVID-19 shock (from 0 to 3%) contributes to **mitigate negative economic impact**, stimulating GDP in 2020 and in the following years, allowing a better recovery

		2020	2021	2022	2023	2024
BAU		100	100	100	100	100
COVID-19	Low (0% of GDP)	96.15	96.32	96.03	94.90	93.52
	Baseline (1.2% of GDP)	97.06	96.88	96.57	95.46	94.14
	High (3% of GDP)	97.68	97.61	97.26	96.16	97.68
COMPOUND: MILD HAZARD	Low (0% of GDP)	95.89	97.50	96.45	95.04	93.76
	Baseline (1.2% of GDP)	96.80	97.94	96.93	95.60	94.34
	High (3% of GDP)	97.41	98.53	97.63	96.28	97.41
COMPOUND: STRONG HAZARD	Low (0% of GDP)	95.45	97.04	97.13	95.26	93.56
	Baseline (1.2% of GDP)	96.36	97.38	97.63	95.82	94.16
	High (3% of GDP)	96.97	97.90	98.31	96.52	96.97

Yearly GDP level across scenarios characterized by different government spending during the crisis (0, 1.2% , 3% of GDP). Results of scenarios are indexed against BAU.

Results

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1. COVID-19 changes underlying structural characteristics of the economy affecting HH's consumption and firms' post disaster investments decisions via direct and indirect **losses**, and agents' **expectations**
2. **Shocks hit firms' capital stock and production triggering self-reinforcing supply and demand dynamics.** These affect investment/consumption decisions, employment, GDP, balance of payment, debt to GDP
3. **When COVID-19 compounds with hurricanes,** shocks are amplified: economy doesn't fully recover to a pre-COVID-19 level after 5 years, even assuming optimistic lifting of COVID-19 containment measures on exports
4. **Timely government intervention** is important to mitigate the negative impact of the COVID-19 shock on households' demand and thus on the productive capital, and to support a smooth recovery

Take home messages for financial supervisors: how to enable the role of finance in the transitio

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1. Assess investors' exposure and relevance to climate risks using standardized classifications of economic activties (going beyond emissions)
2. Consider several disorderly transition scenarios (not delayed) to account for deep uncertainty and endogeneity of climate risk:
   - *A single disorderly transition scenario can lead to underestimate risks for indivual/systemic financial stability and drive moral hazard and no transition*
3. Macroeconomic models of climate change can evolve to embrace the characteristics of climate and financial risks and their uncertainty, departing from a first best, optimal policy world
4. Climate stress testing: financial interconnectedness matter for systemic risk analysis

A climate fight club?

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- Nobel Laureate Nordhaus at ECB (20.10.2020) pointed out that while green finance was desirable, it would prove insufficient without decisive action from policy-makers, and envisaged climate change-fighting ‘club’
- The first rule of this fight club should be to talk (and act) more about it, starting from research-policy collaboration
- Filling these knowledge gaps is crucial for credible, sustainable and effective climate policies:
- Exploring complementary modelling approaches can be a promising way ahead

FINANCIAL STABILITY

Nobel laureate envisages climate change-fighting ‘club’

Green finance will not be enough to halt climate change, says William Nordhaus

Central Banking Newsdesk

20 Oct 2020

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