A carbon risk assessment of central banks' portfolios under 2°C aligned climate scenarios

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Implementing the Sustainable Finance Action Plan (SFAP) brings both opportunities and challenges:

- Redirect finance towards sustainable investments
- Competitiveness and financial risks for Member States with high-carbon GDP

But traditional models unable to price investments’ 2°C-(mis)alignment

- Metrics and methods needed to assess climate-related financial risk and incorporate climate risks into banks' risk management

We fill the methodological gap with a Climate Stress-test to price climate transition risk in the value of equity, loans, corporate, sovereign bonds:

- Building on Battiston ea. 2017 (equity), Monasterolo ea. 2018 (loans)

Review of the state of the art

- Analysis of investors’ exposure to climate-related financial risks and pricing of climate risks has recently attracted research attention
- But results have been not conclusive so far:
  - Dutch Central Bank’s Climate Stress-test: limited in scope (e.g. risk/country/investor)
  - Kling et al. (2018): highly climate vulnerable low-income countries (V20) already show a slightly higher cost of debt. But caveats (e.g. peculiarity of sovereign bonds’ markets in low-income countries)
  - Crifo et al. (2015): high country’s ESG ratings are associated with low borrowing costs (spread), in particular for short-maturity bonds.
Our research questions

1. Can we measure portfolios’ exposure to climate transition risk at the level of individual assets?

2. Can we price risks/opportunities of 2°C (mis)alignment in the value of individual financial contracts?
Take home messages

1. Our **Climate Stress-test** prices climate *transition* risk in individual contracts (equity, bonds, loans):
   - **Sources of risk:** *sector-specific* gains/losses from 2°C *(mis)alignment*
   - **Channels of risk transmission:** unanticipated shocks on market share of climate-relevant sectors/firms (e.g. energy) → shocks on GVA and GDP → shock on revenue streams of securities → shocks on portfolio’s value

2. **Climate sovereign spread shows that** (Battiston & Monasterolo 2018):
   - Investments’ alignment to 2°C trajectory can strengthen fiscal/financial position
   - In contrast, misalignment to 2°C trajectory can increase sovereign bond yield

3. **Results relevant for SFAP’s implementation** ((EU)2016/2341), **Central banks’ mandate, Capital Markets Union** (Capital Requirements Regulation and Directive)

Methodology: why a Climate Stress-test?

Traditional cost-benefit analyses and financial pricing models are not fit to assess:

1. Value of individual public/private investors’ exposures to climate risks
2. Climate shocks’ propagation throughout the financial network and amplification effects
3. Implications on individual and systemic risk (micro/macroprudential)

- Financial network models widely used also by central banks to disentangle financial interconnectedness-stability nexus,
- Applied here to disentangle the climate - financial stability nexus
How? By introducing finance into climate trajectories

- Modular Climate Stress-test, works with micro-level portfolio data:
  1. Compute portfolio’s exposure to individual financial contracts (country, sector, year)
  2. Estimate changes in market share trajectories for low-high carbon sectors using Integrated Assessment Models, under 2ºC scenarios by 2030
  3. Assess climate shock’s transmission on the change in value of assets through new asset-specific models
    - *climate spread* to introduce climate in bonds’ yields/spread by country
  4. Identify the largest gains/losses on central bank’s portfolio’s value:
    - *climate Value at Risk (VaR)* to assess largest losses on portfolios
Portfolio analysis, step 1: mapping economic sectors into 5 climate-policy relevant sectors (CRS)

- Reclassification of NACE sectors (4 digit) into climate-relevant sectors according to their contribution to emissions (Scope 1,2, firm-level data) and EC carbon leakage classification.

Source: Battiston ea. 2017
Step 2: reclassify portfolios based on exposures to CRS (e.g. Blackrock Inc.)
Step 3: micro-level approach to assess heterogeneity in direct/indirect portfolios’ exposures to CRS

Direct exposures to climate-relevant sectors of 15 top banks worldwide by size of equity portfolio

1st round: direct losses. 2nd round: indirect losses due to devaluation of counterparties' debt obligations on interbank market (DebtRank)

Source: Battiston ea. 2017
Step 4. Compute sectors’ shocks based on forward looking trajectories

Method 1: longitudinal: along trajectories, computed every 5 y. (Battiston ea. 2017 NCC)

Method 2: cross-sectional: across trajectories (Monasterolo ea. 2018; this presentation)

Results influenced by the change in market share of energy, electricity sectors (fossil vs. renewable technology) estimated using IAM by 2030
Step 5: Estimate shock on security’s revenue stream. Sovereign bonds

- Payment of bond’s coupon at maturity depends on GDP growth and debt (Alesina ea. 1992)
- Climate policy shocks affect risk premia by impacting on sectors’ GVA and GDP
- For simplicity, we assume a linear negative relation between risk premia and GDP, i.e. risk premia on sovereign bonds increase with a decrease in GDP

\[ \Delta r \sim -\chi \frac{\Delta GDP}{GDP} \] (1)

\( \chi \): elasticity of 10y bonds’ int. rate to changes in GDP growth affected by climate shocks

- In line with standard evaluations, the value of the sovereign bond \( V_{sb} \) can be written as

\[ V_{sb} = \frac{M}{(1+r)^T} \] (2)

\( M \): bonds’ notional value, \( r \): interest rate, \( T \): maturity

*[Battiston&Monasterolo in preparation with OenB]*
Introducing climate transition risk

- Climate policy shock (i.e. moving from business-as-usual to a 2ºC scenario) hits the market share of sector $j$
- Negative shock leads to lower GVA of high-carbon sectors. We define:

\[
\Delta r = -\chi \frac{\Delta GDP}{GDP} = -\frac{\chi}{GDP} \sum_j \Delta GVA_j = -\frac{\chi}{GDP} \sum_j \frac{\Delta GVA_j}{GVA_j} GVA_j = -\frac{\chi}{GDP} \sum_j u_j GVA_j
\]

(3)

GVA’s relative changes are proportional to relative changes in $j$’s market share: $u_j = \frac{\Delta GVA_j}{GVA_j}$

- $\Delta r$: change in int. rate due to a climate policy shock on country’s GD: climate spread

- Change $\Delta r$ in the value of sov. bond rate induces a change in NPV of the sov. bond as:

\[
V_{sb} = \frac{F_{sb}}{(1+r+\Delta r)^T}
\]

(4)

where $F_{sb}$: face value, $r$: interest rate, $\Delta r$: climate spread
Result 1: impact of climate policy shock on sovereign bonds value and yields (climate spread)

- **Positive shocks on yield correspond to negative shocks on sovereign bond’s value**

<table>
<thead>
<tr>
<th>Geo region</th>
<th>Models’ region</th>
<th>WITCH: bond shock (%)</th>
<th>WITCH: yield shock (%)</th>
<th>GCAM: bond shock (%)</th>
<th>GCAM: yield shock (%)</th>
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<tbody>
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</table>

- **Largest negative shocks** on individual sov. bonds associated to Pacific, Scandinavia, EU countries (highest yields i.e. climate spread)

- Shocks led by i) large contribution to GVA and GDP of fossil fuel-based primary and secondary energy sources, ii) IAMs’ forecast of the market share of specific sectors (e.g. nuclear)

- **Positive shocks** led by the growing shares of renewable energy sources

2°C-aligned climate policy scenario (RefPol-450)

Battiston & Monasterolo (2018)
Result 2: Impact of climate policy shock on Central bank’s portfolio

**You think shocks are small? Just consider:**

- Tighter climate policy scenarios could be considered to achieve 2ºC (global emissions increasing)
- Even few decimal points of GDP growth change could impact sov. bonds’ yields due to markets’ expectations and sentiments (IT)

**Thus, our results are conservative**

<table>
<thead>
<tr>
<th>Model</th>
<th>Scenario</th>
<th>Region</th>
<th>Asset Shock (%)</th>
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Magnitude of the climate policy shocks in a tight 2ºC climate policy scenario, on central bank’s portfolio in percentage points (i.e. 1=1%), WITCH model. Battiston & Monasterolo (2018)
Conclusions

1. Climate transition risk could change financial risk positions:
   - GDP carbon intensity (timely low-carbon transition) can negatively (positively) affect sovereign bonds’ spread

2. Our Climate Stress-test can price climate transition risks into individual assets and assess climate impact on sectors’ competitiveness

3. Advantages for central banks and financial regulators:
   - Identify which actors are *vulnerable yet relevant* to climate risks
   - Assess portfolios’ exposure to climate risk and losses/gains from (mis)alignment
   - Reflect opportunities/risks related to SFAP’s implementation that could affect the CMU’s implementation.
Research steps ahead

- We are working with financial econometric models to provide punctual estimates of the causal relation between climate trajectories’ (mis)alignment to 2ºC and change in sovereign bonds’ spread (06.2019)

- Main limits are represented by the lack of:
  - Standardized green taxonomy to allow distinguish the “shades of green”
  - Emissions at NACE 4 digit level
  - Unique and standardized ESG ratings
  - Transparency on central banks’ assets’ purchase (e.g. CSPP under QE).


Climate targets (under various scenarios) imply economic sectors’ trajectories. Late alignment to 2°C implies shock on market shares of firms in country/sector. SHocks on revenue streams of securities: largest losses (gains) on value of financial instrument and investors’ portfolio.
Growing central banks (CBs)’ awareness of impact of climate physical and transition risks on financial stability (Carney 2015, ESRB 2016, Draghi 2017)

CBs recognizing that climate risks pertain their mandate (Coure’ 2018) and need for new forward-looking stress tests (NGFS 2018)

CBs’ disclosure is key because CBs can influence the timing and magnitude of sustainable investments:
- Market signaling (assets purchase programs, monetary policy operations, macroprudential regulation)
- Particularly relevant in EU Member States with weaker fiscal and debt positions