A climate stress test of development banks’ portfolios: insights from China and the Caribbean

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ESRM BBL, Inter-American Development Bank, 18 April 2018
5 take-home messages for today

1. Development banks are key to mobilize climate-aligned investments but lack projects’ financial metrics able to integrate climate risks factors.

2. Climate stress-test is important for 3 reasons: identify projects’ exposure to climate risks, alignment to mandate, portfolio’s rebalancing strategies for financial solvability.

3. We provide the first climate stress-test for development banks estimating:
   • Expected value today of a project loan maturing at T and subject to 2 shocks: *climate policy shocks* at t*, balance sheet shocks at T (t < t* < T).

4. Results: negative shocks are concentrated on fossil fuels projects, could induce losses (4-22% of portfolio’s value) significant in comparison to bank capital.

5. Metrics are important but not enough: projects’ data availability, preparedness of development banks’ risk management office staff is fundamental.
Assessing climate-finance risks: challenges and opportunities

• Recent debate on limits of traditional economic/financial (pricing) models:
  • Efficient financial markets Hp (gaps in long-term finance in particular in low-income countries)
  • Rational Expectations Hp (systematic mispricing of green/brown assets’ risk/return, Monasterolo ea. 2017)

• Attention on Post-Keynesian Stock-Flow Consistent models (Monasterolo & Raberto 2018) and financial network models (Battiston ea. 2012, 2016, 2017)
  • New financial macro-network model to assess climate policies’ impact on financial risk in presence of high leverage and recovery rate <1 (Stolbova ea. 2018).
Our climate stress-test for development banks

• **First tailored, modular methodology** applied to development banks’ portfolios:
  1. We take estimates of market share trajectories for green/brown energy sectors provided by 4 LIMITS Integrated Assessment Models (IAM)
  2. We compute the impact of climate policy shocks due to a switch from baseline of no policy to the introduction of (milder or stricter) climate policies on energy sectors’ market shares
  3. We assess project loans exposure to *climate policy* and *balance sheet shock*
  4. We introduce a *project-based climate Value at Risk (VaR)* to assess largest losses on portfolios (no joint probability distribution of shocks available)

• **Added value:** our climate-finance risk metrics are transparent (thus replicable), concise yet able to capture key dimensions for climate-finance decision making.

1. IPCC GHG emissions paths

2. LIMITS’ energy trajectories (2C target)

3. Climate policy shocks affect energy sectors’ market share trajectories (green/brown) by region

4. Two shocks’ transmission channels:
   - Policy shock (-/+ on loan/project Net Worth (by sector, region) affects probability of default on project \( p_j(P) \))
   - Balance sheet shock affects probability of default on borrower (\( r < 1 \))

5. Project-based Climate VaR to assess largest losses on portfolios
1st application: China policy banks’ energy portfolios

- Data: financial flows data (GEGI database), 199 overseas energy investments by two main Chinese policy banks (China Development Bank and Export-Import Bank of China), 2000-2018
- Value: $228.105 bn, 6 world regions (63 countries).
- Sectors reclassified from very brown (coal) to very green (solar) according to direct/indirect emissions.
- LAC: 26% of Chinese energy portfolio.

High losses on tot. loans’ portfolio value (4.2% - 22%). Max losses on projects: ¼ of portfolio
Negative shocks concentrated on fossil projects but vary across regions, models, scenario
Positive shocks could compensate negative ones – thus caution on policy implications...
Climate VaR ranges between - $3878 mln/- USD 711 mln (factor close to 5).
Shocks on loans by project’s sector and policy scenario

Model: GCAM, Climate policy scenario: RefPol500. Negative shocks in electricity from coal, oil and gas, positive shocks mostly in nuclear and hydropower (Nigeria, Nepal)

Moving to a stricter climate policy scenario (StrPol450) we see an amplification in the value of shocks (but sectors unchanged).

$ 9484 mln tot. loss

$ 21957 mln tot. gains

$ 13275 mln Tot. loss

$ 23742 mln tot. gains
Shocks on loans by sector and region

Model: WITCH. Negative shock spread on electricity generation from coal (India+, transition countries). Positive shock in hydro-power in India+ (Pakistan, Nepal, Cambodia), Africa (Nigeria, DRC), but also in nuclear and oil.

Moving to a stricter climate policy scenario we see an amplification in the value of shocks and sectors associated (both + and -).
Methodology developed during a capacity building activity in Barbados.

Key obstacles: Limited access to projects’ data, low awareness/preparedness of bank’s risk management office.

For each project we assess 2 dimensions:

- Exposure to climate risks (physical/transition, vulnerability index)
- Contribution to climate action (according to Nationally Determined Contributions)

<table>
<thead>
<tr>
<th>Contribution to adaptation</th>
<th>Exposure to climate risks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NA</td>
</tr>
<tr>
<td>CA</td>
<td>0</td>
</tr>
<tr>
<td>CV</td>
<td>0</td>
</tr>
<tr>
<td>NA</td>
<td>33</td>
</tr>
<tr>
<td>Total</td>
<td>33</td>
</tr>
</tbody>
</table>

In percentage of projects’ portfolios

- **Highest share** of loans to high climate risk projects that contribute to vulnerability (red, orange cells):
  - Avoidable risk: investments in fossil fuel plants, finance (secondary market mortgages), no adaptation plan

- **Lowest value** on low risk climate adaptive projects:
  - Win-win scenario: allow CDB to support climate-aligned development decreasing countries’ vulnerability while preserving its financial stability (repayment rates).
Bank’s loans to top 100 projects as a share of total bank’s projects portfolio

- Loans exposed for 46.77% of its value to projects that contribute to climate vulnerability (CV)
- Loans that contribute to adaptation (CA, the bright and light green cells): 12% of portfolio
- NA (grey cells): 41.15% of bank’s loans value.

Added value of this approach:
- Moves from concept of climate risk to opportunity
- *Shows to what extent portfolios’ rebalancing is needed to deliver on mandate and guarantee financial solvability.*
Loans allocation on top 100 projects from 2000

- Most loans allocated to medium-high climate risks projects and Contribute to Vulnerability (CV, red). Only a minority contributes to Climate Adaptation (CA)

**RISK DIMENSION:**

- **High risk:** investments in M/H climate risks and high CV (e.g. utility brown)
- **Medium risk:** projects with L-M climate risk and don’t have good adaptation.
- **Low risk:** climate-aligned investments (e.g. renewables, drop irrigation), good adaptation

✓ **Highest share of CDB’s loans NA:**
  - Project description doesn’t allow to understand type of activities supported (financial projects, policy-based loans).
Portfolio’s contribution to vulnerability/adaptation by country

- **Highest exposure to projects NOT contributing to adaptation in Jamaica** (50%) but more than half projects (in value) in Jamaica could not be classified.
- **Jamaica followed by Barbados**: 2/3 of projects CV, the rest could not be classified.
- **Highest CA** on total country’s portfolio in Dominica, Grenada and Trinidad and Tobago.
Conclusion

• We introduced climate stress-tests tailored to development banks’ portfolios
• Our approach provides (i) the magnitude and sign of the change in loans’ value, conditional upon climate policy and operative shocks, and (ii) insights on portfolios’ rebalancing to minimize risks/maximize impact.
• Results are deeply influenced by:
  • Information availability on individual projects
  • Limited awareness/ preparedness of risk management office staff
  • Forecasts on energy sectors’ market shares and IAMs climate policy scenarios
• Capacity building could help to identify and address challenges at governance level (intra-organizational coordination and preparation) and project-level (project data collection) for mainstreaming climate risk/impact metrics in development banks’ projects pipeline.


THANK YOU!

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Interactive dashboards of results:
https://simpolproject.eu/2018/03/28/china-overseas-climate/
Additional material: China policy banks
Challenges for climate-aligned development finance

• For development banks to have impact, beneficiary countries need to be committed on climate-aligned policies and programming

• For development banks to deliver on their sustainability mandate and to preserve financial soundness, they need to (i) assess projects’ loans exposure to climate risks, (ii) leverage impact on countries’ alignment to climate goals
  • Beneficiary’s economy carbon lock-in could hit sovereign bonds value, credit rating and ability to repay loans (r<1)

• Time horizon: climate long-term impact vs short-term maturity of bonds

• Limits of traditional climate economic models (e.g. IAMs’ estimate of green/brown market shares) and financial (pricing) models:
  • Not adequate to identify individual projects and financial contract’s exposures to climate risks, and to assess climate-financial risks’ amplification and propagation.
Two channels of shocks’ transmission on project/bank

• **Climate policy shocks** imply a shock in the project sector’s market share that causes, in turn, a shock on the expected value of a loan today $A_{i,j}(t)$, affecting the probability of default $p_{j}(P)$ associated to the project $j$.

• **Balance sheet shock** $\eta_j$ on the borrower side occurring at time $T$ and led by operative fluctuations on companies delivering on the project (i.e. idiosyncratic), affecting the probability of default on borrower $p(\eta_j)$.

• **Assumptions (but working on it):**
  • Relative change in market share of borrower's project sector is equal to the relative change in value of project $j$’s net worth $E_j$ at time $t^*$
    • Being net worth the integral over time of profit, over a time period they coincide
  • Uniform probability distribution of operative shock $\eta_j$ on all $n$ projects’ net worth $E_j$ for a given model $M$, region $R$ and sector $S$. 
<table>
<thead>
<tr>
<th>Region Specification</th>
<th>Country list (as in our working paper)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHINA+</td>
<td>Cambodia, Vietnam, Laos and Myanmar</td>
</tr>
<tr>
<td>EUROPE</td>
<td>Bulgaria, Italy, United Kingdom.</td>
</tr>
<tr>
<td>INDIA+</td>
<td>Bangladesh, India, Nepal, Pakistan and Sri Lanka.</td>
</tr>
<tr>
<td>LATIN_AM</td>
<td>Argentina, Bolivia, Brazil, Chile, Ecuador, Guyana, Peru and Venezuela.</td>
</tr>
<tr>
<td>MIDDLE_ EAST</td>
<td>Iran and Jordan</td>
</tr>
<tr>
<td>PAC_OECD</td>
<td>Australia</td>
</tr>
<tr>
<td>REF_ECON</td>
<td>Russia, Belarus, Bosnia &amp; Herzegovina, Kazakhstan, Kyrgyzstan, Serbia, Tajikistan, Turkmenistan, Ukraine and Uzbekistan.</td>
</tr>
<tr>
<td>RREST_ASIA</td>
<td>Fiji, Indonesia, Malaysia, Papua New Guinea and Philippines.</td>
</tr>
</tbody>
</table>
# Climate policy scenarios according to LIMITS

<table>
<thead>
<tr>
<th>Scenario Name</th>
<th>Scenario Class</th>
<th>Target before 2020</th>
<th>Target between 2020 and 2100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base</td>
<td>No climate policy</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>RefPol-450</td>
<td>Countries Fragmented, Immediate Action</td>
<td>Lenient</td>
<td>450 ppm: 2.8W/m2 in 2100, overshoot allowed</td>
</tr>
<tr>
<td>StrPol-450</td>
<td>Countries Fragmented, Immediate Action</td>
<td>Strengthened</td>
<td>450 ppm: 2.8W/m2 in 2100, overshoot allowed</td>
</tr>
<tr>
<td>RefPol-500</td>
<td>Countries Fragmented, Immediate Action</td>
<td>Lenient</td>
<td>500 ppm: 3.2W/m2 in 2100, overshoot allowed</td>
</tr>
<tr>
<td>StrPol-500</td>
<td>Countries Fragmented, Immediate Action</td>
<td>Strengthened</td>
<td>500 ppm: 3.2W/m2 in 2100, overshoot allowed</td>
</tr>
</tbody>
</table>
## 1. New country vulnerability index weighting physical risks and quality of adaptation (NDCs)

<table>
<thead>
<tr>
<th>Country</th>
<th>Floods</th>
<th>Landslide</th>
<th>Storms</th>
<th>Hurricanes</th>
<th>Droughts</th>
<th>Adaptation</th>
<th>Vulnerability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anguilla</td>
<td>L</td>
<td>n.a.</td>
<td>L</td>
<td>n.a.</td>
<td>H</td>
<td>A</td>
<td>M</td>
</tr>
<tr>
<td>Antigua and Barbuda</td>
<td>L</td>
<td>n.a.</td>
<td>L</td>
<td>H</td>
<td>H</td>
<td>A</td>
<td>H</td>
</tr>
<tr>
<td>Bahamas (The)</td>
<td>L</td>
<td>n.a.</td>
<td>L</td>
<td>M</td>
<td>L</td>
<td>A</td>
<td>M</td>
</tr>
<tr>
<td>Barbados</td>
<td>n.a.</td>
<td>n.a.</td>
<td>L</td>
<td>n.a.</td>
<td>H</td>
<td>G</td>
<td>M</td>
</tr>
<tr>
<td>Belize</td>
<td>L</td>
<td>n.a.</td>
<td>H</td>
<td>H</td>
<td>L</td>
<td>P</td>
<td>H</td>
</tr>
<tr>
<td>Cayman Islands</td>
<td>n.a.</td>
<td>n.a.</td>
<td>H</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>H</td>
</tr>
<tr>
<td>Dominica</td>
<td>H</td>
<td>M</td>
<td>H</td>
<td>M</td>
<td>L</td>
<td>A</td>
<td>M</td>
</tr>
<tr>
<td>Dominican Republic</td>
<td>H</td>
<td>n.a.</td>
<td>H</td>
<td>M</td>
<td>H</td>
<td>A</td>
<td>H</td>
</tr>
<tr>
<td>Grenada</td>
<td>L</td>
<td>M</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>A</td>
<td>M</td>
</tr>
<tr>
<td>Guadeloupe</td>
<td>L</td>
<td>n.a.</td>
<td>L</td>
<td>n.a.</td>
<td>n.a.</td>
<td>A</td>
<td>L</td>
</tr>
<tr>
<td>Haiti</td>
<td>H</td>
<td>H</td>
<td>H</td>
<td>n.a.</td>
<td>L</td>
<td>A</td>
<td>H</td>
</tr>
<tr>
<td>Jamaica</td>
<td>L</td>
<td>n.a.</td>
<td>H</td>
<td>M</td>
<td>L</td>
<td>G</td>
<td>M</td>
</tr>
<tr>
<td>Saint Kitts and Nevis</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>M</td>
<td>n.a.</td>
<td>A</td>
<td>M</td>
</tr>
<tr>
<td>Saint Lucia</td>
<td>L</td>
<td>H</td>
<td>L</td>
<td>L</td>
<td>M</td>
<td>A</td>
<td>M</td>
</tr>
<tr>
<td>Saint Vincent and Grenadines</td>
<td>L</td>
<td>M</td>
<td>L</td>
<td>L</td>
<td>M</td>
<td>A</td>
<td>M</td>
</tr>
<tr>
<td>Trinidad and Tobago</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>n.a.</td>
<td>L</td>
<td>A</td>
<td>L</td>
</tr>
<tr>
<td>British Virgin Islands</td>
<td>M</td>
<td>L</td>
<td>M</td>
<td>L</td>
<td>P</td>
<td>M</td>
<td></td>
</tr>
<tr>
<td>Guyana</td>
<td>M</td>
<td>n.a.</td>
<td>L</td>
<td>n.a.</td>
<td>H</td>
<td>A</td>
<td>M</td>
</tr>
</tbody>
</table>

- G (Good): adaptation plan in place and implemented
- A (Average): adaptation plan exists but no implementation
- P (Poor): adaptation plan not in place
- H (High): at least 2 H risk score and A or P adaptation
- L (low): most L and no H risk scores, G or A adaptation

We don’t use existing vulnerability indexes (e.g., ND-GAIN) because resource focused (food) and lack of country-specific comparable data (projected pop change)
Additional material:
Caribbean Development Bank
2. Classification of 100 projects

- According to their (i) contribution to adaptation, (ii) contribution to vulnerability (based on exposure to climate physical/transition risk).
- We consider projects’ sector and location.

<table>
<thead>
<tr>
<th>Sector/Location</th>
<th>Project</th>
<th>Contribution to Adaptation</th>
<th>Climate Physical Risk</th>
<th>Climate Policy Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy-intensive</td>
<td></td>
<td>Does the project have a feasible/implemented plan on promoting resilience in energy intensive sector on the following: use of renewable fuel based electricity production, energy-intensive investments in areas not exposed to climate physical risk</td>
<td>Does the project finance investments in a location specifically exposed to climate physical risks?</td>
<td>Does the project finance investments in sectors specifically exposed to climate policy risks?</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CA = yes, the project targets explicitly adaptation measures</td>
<td>NA = the project description does not provide suitable information on its contribution to adaptation</td>
<td>H = information is available and the location is known to be highly exposed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NA = there is no adaptation plan, and/or the project contribute to increases vulnerability of the country/sector to climate change.</td>
<td>NA = there is no specific information</td>
<td>H = information is available and the sector is known to be highly exposed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CV = no, there is no adaptation plan, and/or the project contribute to increases vulnerability of the country/sector to climate change.</td>
<td>NA = there is no specific information</td>
<td>NA = there is no specific information</td>
</tr>
<tr>
<td></td>
<td></td>
<td>L = information is available and the location is known to be little exposed.</td>
<td>L = information is available and the location is known to be little exposed.</td>
<td>L = information is available and the location is known to be little exposed.</td>
</tr>
</tbody>
</table>