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Assessing Climate Risk on the European Financial System: A Multi-Scenario Analysis

Based on Assessing Climate Risk on the European Financial System: A Multi-Scenario Analysis (2025), Giacchetta, Giacometti & Torri submitted to Annals of operations research-second round

Executive Summary

This paper investigates the **impact of climate risk on the stability of the European financial system**, with a particular focus on both transition and physical risk dimensions. Given the long-term and uncertain nature of climate-related risks, traditional econometric methods often fall short in capturing their systemic implications.

To address this challenge, we develop a scenario-based framework grounded in realistic projections consistent to the theoretical framework of the Network for Greening the Financial System (NGFS), encompassing **three climate pathways: orderly transition, disorderly transition, and hot house world**. We model the relationship between climate risk drivers, European companies, and the financial system using vine copulas, enabling a flexible representation of complex dependencies. The effects of these scenarios on financial institutions are evaluated through **key risk metrics (expected return, value at risk, and expected shortfall) conditioned on each climate scenario**.

Our results offer insights into how climate transition risks propagate through the financial system, with practical implications for financial stability assessment and systemic risk management. **The primary contribution lies in integrating both transition and physical climate risks into a coherent and tractable risk assessment framework**, offering valuable tools for policymakers, regulators, and financial practitioners. Results show a significant dependence of European financial system to brown companies and, thus, sizable losses in the disorderly transition scenario.

Background

Financial supervisors distinguish between two key categories of climate risk: transition risk, stemming from policy, technology, and market changes; and physical risk, arising from extreme weather events and long-term climatic shifts. While most prior studies treat these separately, this separation can underestimate their compounded effects on systemic

stability. Our study jointly considers both risks in a unified stress-testing framework. The analysis is based on 43 major European banks observed between 2014 and 2023, representing a substantial share of the European financial system's capitalization. The climate stress test is conducted considering NGFS-aligned climate pathways: orderly transition, disorderly transition, and hot house world scenarios.

BOX1: NGFS-aligned climate scenarios

1. **Orderly transition scenarios**: Climate policies are introduced early and tightened gradually. Both transition and physical risks remain relatively low.
2. **Disorderly transition scenarios**: Policies are delayed or inconsistent across countries. Transition risks rise sharply due to abrupt policy shifts and higher carbon prices, while physical risks remain moderate.
3. **Hot house world scenarios**: Global efforts are insufficient to curb warming. Critical thresholds are exceeded, resulting in severe physical risks and irreversible climate impacts.

Methodology

Transition risk is proxied by the relative performance of green, neutral, and brown companies within the STOXX Europe 600, classified by quintiles of greenhouse gas emissions. Physical risk is measured using the European Extreme Events Climate Index (E^3CI), which aggregates seven weather indicators (temperature, droughts, precipitation, winds, hails, and forest fires) across 37 European countries.

The statistical approach employs vine copulas to model dependencies between banks and climate risk factors, capturing nonlinear relationships and fat-tailed distributions. Four key systemic risk measures are computed under each climate scenario:

- **Climate-Expected Return** (C-ER)
- **Climate-Value-at-Risk** (C-VAR)
- **Climate-Expected Shortfall** (C-ES)
- **Climate CRISK** (capital shortfall conditional on climate stress)

This probabilistic approach enables the quantification of climate-induced vulnerabilities without requiring highly granular data on individual bank exposures, thus offering a transparent and replicable framework.

Findings

The analysis provides several important insights into the resilience of European financial institutions. In particular:

1. **European banks' exposure to brown firms dominates:** the average beta to brown companies equals 1.53, pointing to systemic vulnerability if decarbonization accelerates.
2. Scenario outcomes differ markedly:
   a. Disorderly transition: abrupt policy changes and rapid repricing of brown assets trigger systemic losses and **significant bank-level capital shortfalls**.
   b. Orderly transition: smoother adjustments still produce **material shortfalls** as portfolios rebalance away from carbon-intensive sectors.
   c. Hot house world: **short-term financial stability appears stronger**, but escalating physical risks (captured by E^3CI) undermine medium- to long-term resilience.
3. Systemic concentration: Capital shortfalls are unevenly distributed, with a small number of large banks carrying the majority of systemic exposure.
4. Market pricing: Evidence suggests investors may undervalue the compound effect of transition and physical risks, particularly the long-term implications of physical hazards.

Policy Implications

The results are particularly relevant for authorities and central regulators, since:

1. they need a quantitative analysis of the impact of climate change on the financial system;

2. the existence of capital shortfalls, when a specific climate scenario occurs, motivates policy actions taken by the regulator;

3. CRISK offers valuable insights into the current state of the European financial system by identifying the banks most vulnerable to adverse climate scenarios and, when necessary, indicating the need for additional capital injections.

Conclusion

This study demonstrates that European banks face substantial, though heterogeneous, climate-related vulnerabilities. **Capital shortfalls are particularly acute under disorderly transition scenarios**, where systemic risk is amplified by abrupt repricing of carbon-intensive assets. While the hot house world scenario offers short-term relief from transition losses, escalating physical risks will increasingly erode financial stability. The findings highlight that climate-related risks are not only measurable but already material to the resilience of the European financial system.

Stronger prudential regulation, enhanced disclosure, and proactive portfolio alignment with sustainability objectives are crucial to safeguard stability and align financial systems with Europe's decarbonization pathway.