Non-banks contagion and the uneven mitigation of climate risk

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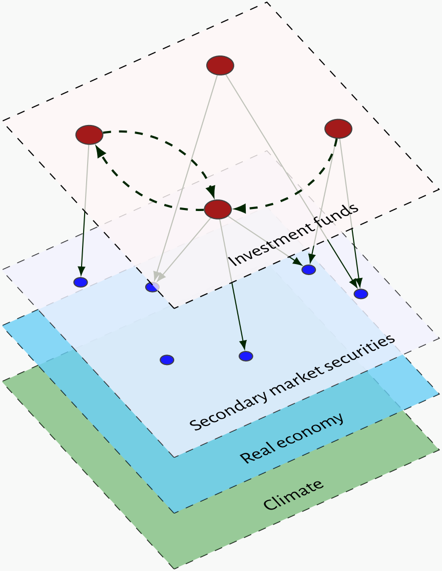
Introduction

- Investment funds are now major players of the financial system by their size, but less monitored than banks.
    - Less mature stress testing methodology.
- Most existing models mostly fail to take into account the joint effect of the two main risk transmission channels:
    1. The overlapping holdings of marked-to-market securities.
    2. The cross-holdings of fund shares.
- Funds would be key to financing a green transition, but their behaviour so far has been ambiguous → greenwashing, lack of sensible exclusion criteria, labels not well understood, etc
- Short-term climate shocks may increase the instability of the financial system if not mitigated.
    - Few results available regarding funds reaction to climate shocks.

Investment funds network



Key steps of the simulation

Our model is suited for short-term contagion dynamics (time horizon of several weeks), with the following steps:

1. **Adjustment of total net assets** (TNA) after a shock on assets: finds equilibrium prices given interlinkages from cross-holdings and endogenous defaults due to holdings of fund shares.
2. **Redemption shock**: external investors redeem part of the shares that they hold, possibly as a function of the market shock. We integrate the feature of a lesser sensitivity of sustainable funds investors.
3. **Fire sales**: funds determine the level of cash they want to have and sell *or buy* securities.
4. **Price impact**: sales and purchases shift prices, thus affecting marked-to-market securities in all portfolios

Notation

- n investment funds invest in m tradable assets;
- $\mathbf{A}$: matrix of tradable assets portfolios;
- $\mathbf{R}$: matrix of fund shares cross-holdings;
- C, L, B: cash, loans (debt) and sum of other assets respectively.
- Total net assets (TNA), i.e. equity of funds:

$$\forall t, \quad E(t) = \mathbf{A}(t) \cdot \iota_m + \mathbf{R}(t) \cdot \iota_n + C(t) + B - L\,.$$

We consider a period $[t_1, t_2]$ where marketable assets can change value or be traded (but without fund flows).

Market shock and TNA adjustment

If the equity E_i of a fund i changes as a result of a market shock, this impacts the value of its shares held by external investors, but also the value $\mathbf{R}_{j,i}$ held by fund j.

- *Problem 1*: There can be a mutual feedback between two funds that are linked in both ways by investment relations.
- *Problem 2*: Investment funds that are leveraged can default in the process as the value of other funds they hold decrease, causing their own equity to become negative.

Definition

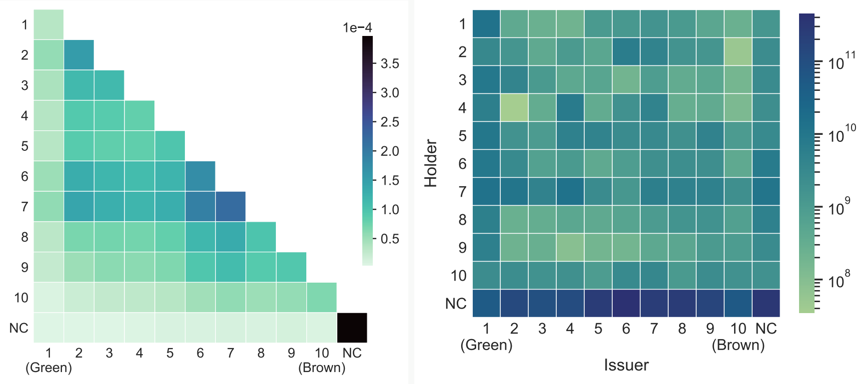
The network of funds is said to be *regular* if there exists no set $\mathbb{X} \subset \{1, \ldots, n\}$ such that each fund in $\mathbb{X}$ is fully owned by other funds in $\mathbb{X}$.

→ variation of the Eisenberg and Noe (2001) framework.

Data

- For **funds**: monthly holdings and static information from Refinitiv: 23,216 funds worldwide for end 2019.
- Security and firm-level information from the CSDB and RIAD databases.
- **Carbon intensity** of securities provided by Urgentem (scope 1 and 2 emissions).
- **Physical risk** of firms based on data from 427. Firm ratings aggregate over different categories of risk: floods, wildfires, water stress, etc.
- Carbon intensity and physical exposure of investment funds as a weighted average of their assets.

Potential for contagion based on carbon intensity



(a) Portfolio overlap by average cosine similarity

(b) Cross holdings (nominal values)

Figure 1: Connections between subsets of funds based on their carbon intensity.

Investment funds are pooled into deciles based on their carbon intensity. Those with less than 50% of their portfolio scored are placed in the NC group. Sources: Urgentem, Refinitiv and authors' calculations.

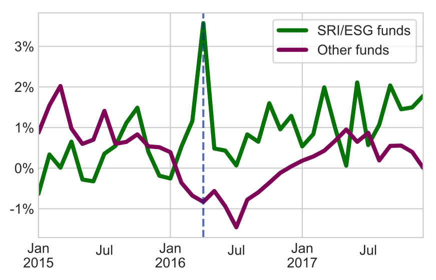
Input shocks used

The types of shocks considered are:

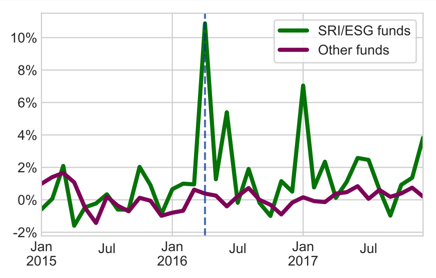
1. **uniform shocks**: benchmarking of the model and reference to compare other shocks to (in the appendix);
2. shock from the **redemptions** of investors, supposing that they acquire more information on the carbon intensity of fund portfolios and withdraw from the most polluting ones;
3. **transition risk market shock**: affects assets based on the carbon intensity of issuers;
4. **physical risk market shock**: affects assets based on the physical risk exposure of issuers;
5. **extreme weather events** materializing across several countries.

The default month used for simulations is December 2019.

Redemption shock by carbon intensity – Motivation



(a) Equity funds



(b) Bond funds

Figure 2: Flows from investment funds to the euro area centred around the signature of the Paris Agreement, separating bond funds and equity funds, with a decomposition between those that classify as ESG/SRI and the rest. Vertical lines correspond to the signature of the agreement (April 2016).

Source: EPFR and authors' calculations.

Results from a redemption shock by carbon intensity

We suppose that investors react to newly assessed exposures of funds by modifying their asset allocation.

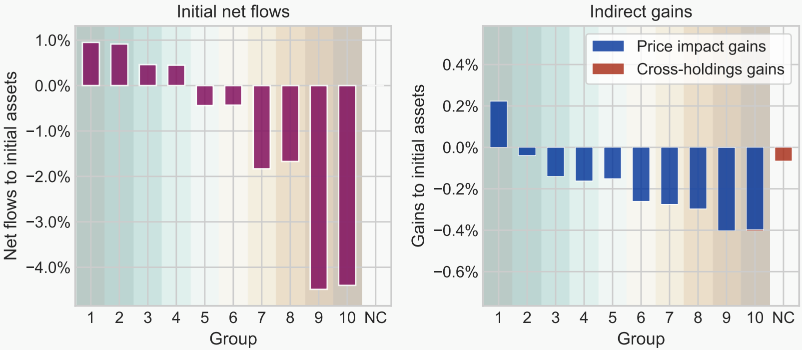


Figure 3: Investment funds reaction to an initial shock on their liability side.

Results from a market shock by carbon intensity (1)

Shock generation: the carbon intensity of securities are mapped to quantiles that are used to sample the parametric distribution of past returns.

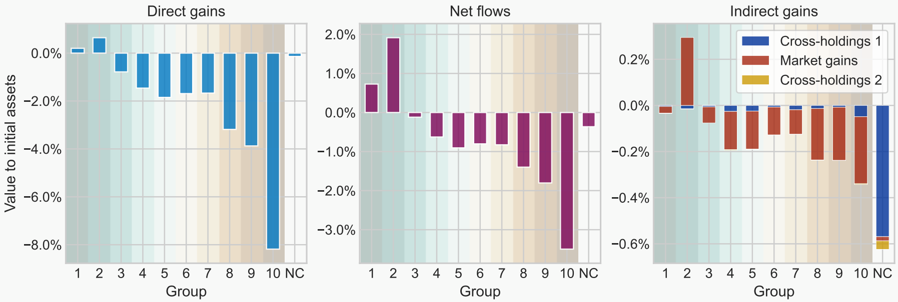


Figure 4: Results from the application of our base transition risk market shock, using the December 2019 system of investment funds.

Results from a market shock by carbon intensity (2)

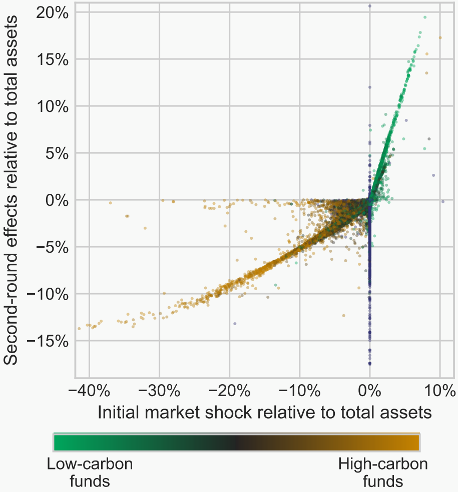


Figure 5: Scatter plot of results by investment funds for a transition risk market shock. On both axis, the values used for each fund are normalized by the funds initial equity. For each fund, the colour of the corresponding dot is determined by the weighted average of its portfolio carbon emissions, with low-carbon funds more green and high-carbon funds more brown. Funds whose portfolios have too much missing carbon emission data are given a dark blue colour.

Results from a market shock by physical risk

Shock generation: the physical risk exposures of securities are mapped to quantiles that are used to sample the parametric distribution of past returns.

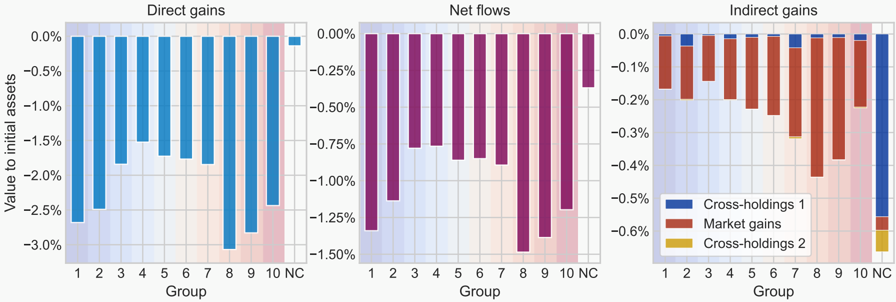


Figure 6: Results from the application of our base physical risk market shock, using the December 2019 system of investment funds.

Results from the realization of climate shocks

Shock generation: shocks are generated to reflect the materialization of events, with components by country and firm, building on exposure data.
They can have different initial impacts, e.g. when one large economy has a high random factor, so the indirect severity is the most neutral benchmark.

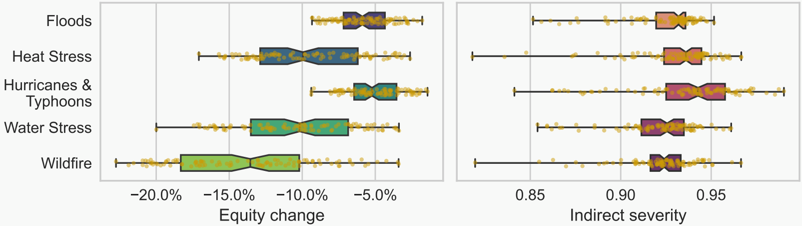


Figure 7: Simulation results with 200 Monte Carlo shocks for each type of physical risk.

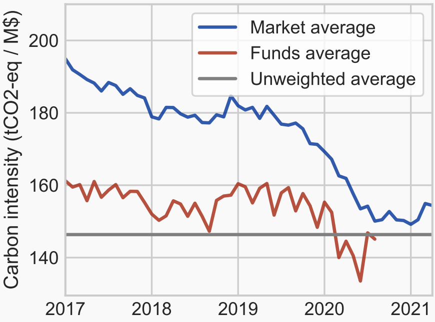
Results are similar on average to the market physical shock, with a dispersion including a non-negligible tail risk.

Conclusion

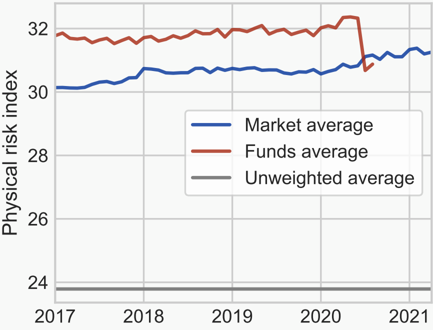
- Investment funds have portfolios that are tilted toward riskier assets compared to a general real economy sample:
  - especially more exposed to physical risk,
  - financial markets in general are not a neutral benchmark.
- In general second-round effects are of moderate magnitude but still material when initial shocks are large.
- Transition shocks are somewhat absorbed, but this is less the case for shocks from physical risk: **no natural joint risk mitigation**
- More distant **future extreme weather events** would still occur and propagate over a short time frame: importance of monitoring such contagion dynamics
- Double materiality implications with **horizon complementarities**: stability now matters to support longer term transition path
- Further work is needed to get more robust data and anticipate evolutions of the financial system

Appendix

Relative risk bias of funds and markets



(a) Transition risk



(b) Physical risk

Figure 8: Relative carbon intensity and physical risk exposure of different benchmark series. The red line is the unweighted average over all firms present in the data, the blue line is the average weighted by total market value, and the orange line is the average weighted by funds' aggregated holdings of securities.

Uniform shocks

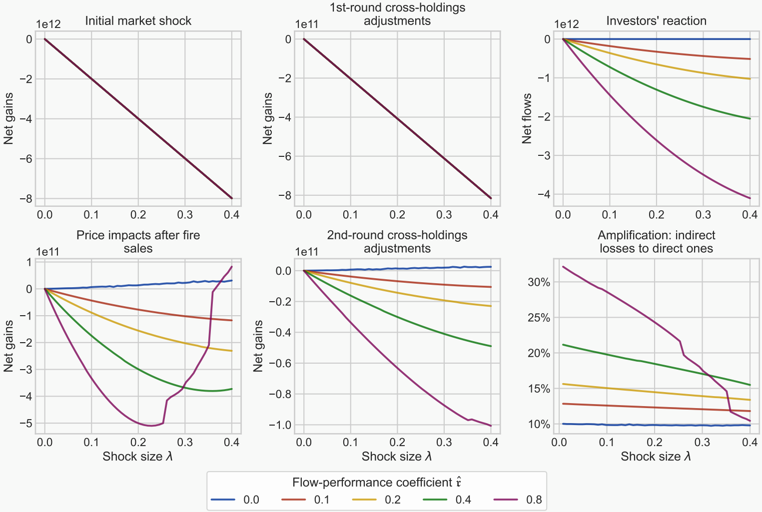


Figure 9: Results of uniform shocks of different intensities

Transition risk market shock

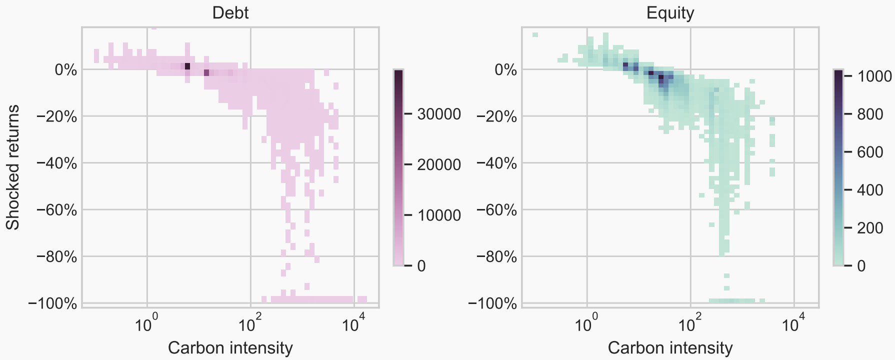


Figure 10: Bi-dimensional histogram of the market shocks, with a decomposition between asset types. The *x*-axis gives the carbon intensity of the assets while the *y*-axis gives the shocked returns.

Physical risk market shock

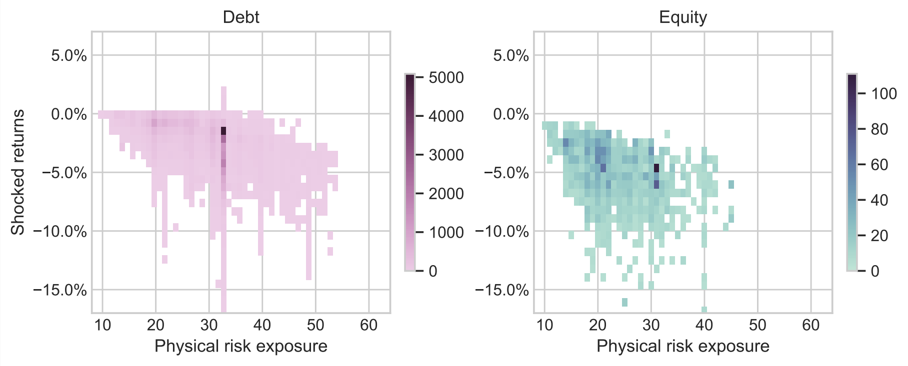


Figure 11: Bi-dimensional histogram of the market shocks, with a decomposition between asset types. The *x*-axis gives the carbon intensity of the assets while the *y*-axis gives the shocked returns.

TNA adjustment – Calculation

Denote $\gamma \in \{0,1\}^n$ the solvency vector such that $\gamma_i = 0$ if i defaults and $\gamma_i = 1$ otherwise. Let

$$\mathbf{r}(\gamma) = \mathbf{R}(t_1) \cdot \mathrm{Diag}\left(\gamma / E(t_1)\right)$$

the modified matrix of relative inter-funds holdings taking defaults into account.

Proposition

If the network of funds is regular, then:

(i) $\mathbf{I}_n - \mathbf{r}(\gamma)$ is nonsingular for all $\gamma \in \{0,1\}^n$,

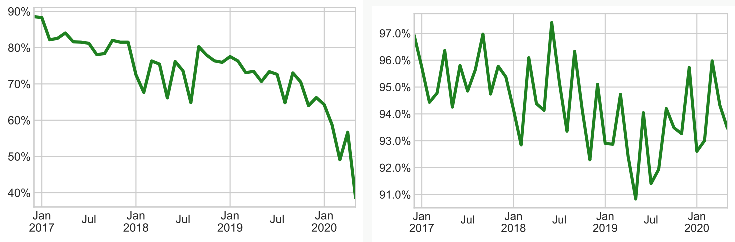
(ii) there exists a unique internally consistent solvency vector γ^* such that $\forall i, \gamma_i^* = \mathbf{1}_{[0,\infty)}(E_i(t_2))$, with the equilibrium vector of TNAs at t_2 given by

$$E(t_2) = \left(\mathbf{I}_n - \mathbf{r}(\gamma^*)\right)^{-1} \cdot \left(\mathbf{A}(t_2) \cdot \iota_m + C(t_2) + B - L\right) .$$

Indirect severity of market shocks

Indirect severity: ratio $g_2(\Lambda)/g_2(u(\Lambda))$, where:

- g_2 is the function giving the second-round losses of a market shock Λ,
- u is the function associating to a given market shock the uniform market shock (same return on all securities) that causes the same first-round losses, i.e. $g_1(u(\Lambda)) = g_1(\Lambda)$.



(a) Transition risk market shock

(b) Physical risk market shock

Figure 12: Time series of indirect severity.