Fire sales, price-mediated contagion and systemic risk.

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Joint work with Rama Cont\textsuperscript{a}

Imperial College London\textsuperscript{a}, Norges Bank\textsuperscript{b}

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Overview

1 Introduction: Price-mediated contagion and endogenous risk

2 Modelling fire sales

3 Empirical application: European Banking Network

4 Conclusion
Introduction: Price-mediated contagion and endogenous risk

**Stress testing 3.0**

- Stress testing 1.0: individual bank analysis

- Stress testing 2.0: macro stress test (same scenario for all banks)

- Stress testing 3.0: inclusion of endogenous feedback mechanisms and contagion dynamics.

→ Our focus: fire sales & price-mediated contagion

Goal: Develop models for macro stress testing that can quantify such second round effects in a realistic and robust way.
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  2. Heterogeneity in asset liquidity levels (Greenwood et al (2015), Kyle and Obizhaeva (2016))
  3. The number of iterations of the fire sales cascade (Duarte & Eisenbach (2015))
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Mechanism:
- **Shock** to illiquid assets
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Mechanism:
1. **Shock** to illiquid assets
2. **Deleveraging** of marketable assets by some institutions
3. **Feedback effects** via price-mediated contagion
   $\rightarrow$ potentially triggers more deleveraging (cascade).
## Model balancesheet

<table>
<thead>
<tr>
<th>Illiquid assets</th>
<th>Marketable assets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential mortgage exposures</td>
<td>Corporate bonds</td>
</tr>
<tr>
<td>Commercial real estate exposure</td>
<td>Sovereign debt</td>
</tr>
<tr>
<td>Retail exposures: Revolving credits, SME, Other</td>
<td>Direct sovereign exposures in derivatives</td>
</tr>
<tr>
<td>Indirect sovereign exposures in the trading book</td>
<td>Institutional client exposures: interbank, CCPs,…</td>
</tr>
<tr>
<td>Defaulted exposures</td>
<td></td>
</tr>
<tr>
<td>Residual exposures</td>
<td></td>
</tr>
</tbody>
</table>

**Table:** Stylized representation of asset classes in bank balance sheets.
A stress scenario is defined by a vector $\epsilon \in [0, 1]^K$ whose components $\epsilon_\mu$ are the percentage shocks to asset class $\mu$.

Gradual increase of the shock from 0% to 20%.

Four scenarios:

1. Spanish residential and commercial real estate losses
2. Northern Europe residential losses
3. Southern Europe commercial real estate losses
4. Eastern Europe commercial real estate losses
Figure: Leverage targeting response function (dashed) and two variants of the threshold (full and circles) response functions.
Price impact

The price of an asset undergoing a forced liquidation at $t$:

$$S_{t+1}^\mu = S_t^\mu \exp \left( -\delta_\mu^{-1} \sum_{j=1}^{M} \Pi_t^j \Gamma^j_{t+1} \right)$$  \hspace{1cm} (1)
Modelling fire sales

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**Figure:** Large variation in estimated liquidity of different assets.
Introduction: Price-mediated contagion and endogenous risk

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Fire sales losses and market depth

![Graph showing fire sales losses and market depth](image)
Empirical application: European Banking Network

Indirect exposures and stress test outcomes
Our model shows that losses are proportional to the liquidity weighted overlap

\[ \omega_{ij} := \sum_{\mu=1}^{M} \frac{\Pi_{i\mu} \Pi_{j\mu}}{\delta_{\mu}} \]  

(2)

This leads to a network of portfolio overlaps:

\[ \Omega := \Pi D^{-1} \Pi^\top, \]  

(3)

which can be studied with network analysis tools.
Figure: European banking system: liquidity weighted overlap network
Empirical application: European Banking Network

Figure: European banking system: Liquidity weighted overlaps
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**Figure:** European banking system: Nominal overlaps
Figure: $\log_{10}(\text{fire sales loss})$ for different scenarios and different model combinations.
### Sensitivity to initial stress scenario

<table>
<thead>
<tr>
<th>Scenario combination</th>
<th>Sample correlation coefficient</th>
</tr>
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<tbody>
<tr>
<td>1 &amp; 2</td>
<td>0.0840</td>
</tr>
<tr>
<td>1 &amp; 3</td>
<td>0.2130</td>
</tr>
<tr>
<td>1 &amp; 4</td>
<td>-0.1449</td>
</tr>
<tr>
<td>2 &amp; 3</td>
<td>-0.0509</td>
</tr>
<tr>
<td>2 &amp; 4</td>
<td>0.0394</td>
</tr>
<tr>
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**Table:** Sample correlations between the initial loss vectors from the stress scenarios. The four stress scenarios are very different in terms of which banks are hit by the corresponding shock.
Figure: The pairwise sample correlation between the fire sales loss vectors of different scenarios as a function of the initial shock. Threshold model full lines - leverage targeting dashed lines.
Sensitivity to initial stress scenario

Figure: The evolution of the pairwise sample correlation during the fire sales cascade for a given scenario. Threshold full - leverage targeting dashed.
Risk management for whales (Cont and Wagalath 2016)

Figure 6: 95% 5-month VaR for positions in CDX IG9 (size in Bn $).
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Seemingly innocent modelling choices on response functions and liquidity estimates have a significant effect on results!
Conclusions for modelling

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- Leverage targeting models produce counter-intuitive short term dynamics.
- Singular value decompositions of liquidity weighted overlap matrices can provide valuable information for monitoring purposes and policy responses.
Thank you!


Conclusion

Stability analysis of financial contagion due to overlapping portfolios.

Asset-based contagion models for systemic risk.
*Working Paper*.

Modeling financial systemic risk - the network effect and the market liquidity effect.
*Working Paper*.

Running for the exit: Distressed selling and endogenous correlation in financial markets.
*Mathematical Finance.*
Conclusion


