Interbank asset-liability networks with fire sale management

Zachary Feinstein [1] Grzegorz Hałaj [2]

[1]Stevens Institute of Technology [2]European Central Bank

When prices are sensitive to trading volumes, funding shocks can destabilize prices through interconnected balance sheet of financial institutions

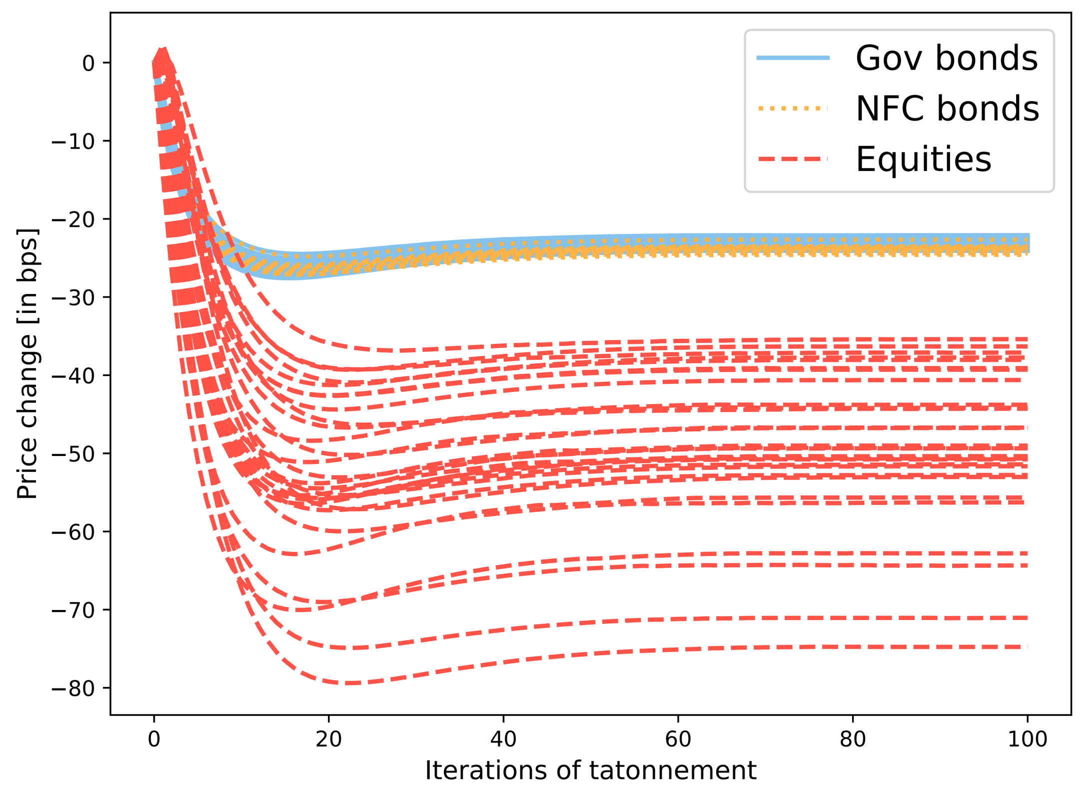

Figure 1. A system-wide shock to the wholesale funding. Lines represent an evolution of prices, one line per asset class, following a tatonnement process related to banks strategic restructuring of portfolios after the funding shock.

- **Equilibrium**: Prices converge and stabilize after ∼60 steps.
- **Heterogeneous impact**: Assets with prices most sensitive to transacted volumes experience the deepest decline in equilibrium.
- **Non-monotonic prices**, i.e. after the initial trough prices bounce back and stabilize.

Regulator stabilises price by market interventions

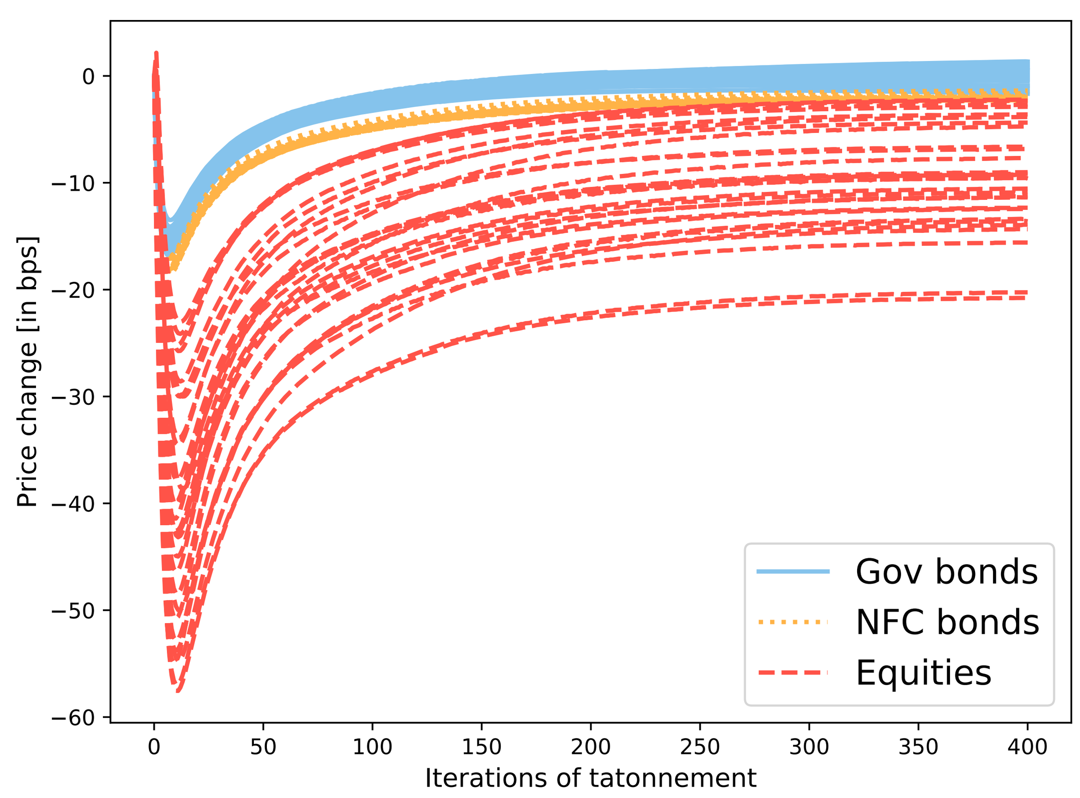

Figure 2. Only highest quality assets purchased by the regulators. Lines represent an evolution of prices, one line per asset class, following a tatonnement process related to banks strategic restructuring of portfolios after the funding shock.

- **Price stability**: Regulator fully stabilizes prices for high-quality assets.
- **System-wide benefits**: As the highest-quality assets are no longer subject to the fire sales, the banks are healthier and have less need to liquidate other, lower quality, assets.
- **Speed of transacting**: In the tâtonnement process the financial agents – both banks and the regulator – transact only a fraction of what the theoretically optimal buying or selling is prescribed, the funding shock pushes the prices down before they recover.

Elevator pitch

We propose a model to study contagion effects in the banking system capturing network effects of direct exposures and indirect effects of market behaviour that may impact asset valuation. By doing so, we can embed a well-established fire sale channel into our model. We relax a typical assumption of an exogenous pecking order of how banks would sell their assets, contributing to a vivid discussion on how financial agents may react to stress.

1. **Follow mechanics of the market to compute market prices in equilibrium**. rather than focusing solely on clearing equilibria, the modelling and simulations consider the procedure in which markets reach clearing through the tâtonnement process.
2. **Crucial role of regulator**, can stabilize asset prices by offsetting transactions of commercial banks, however, regulator's preferences regarding the quality and volume of assets it is willing to buy matters for the dynamics of the prices and the effectiveness of the interventions.
3. **Strategic interactions must be considered when talking systemic risk**. help to reduce negative impacts on the prices since they allow banks to internalize other banks' impacts on the asset prices.

Simulations helpful to assess risk in a highly complex financial system

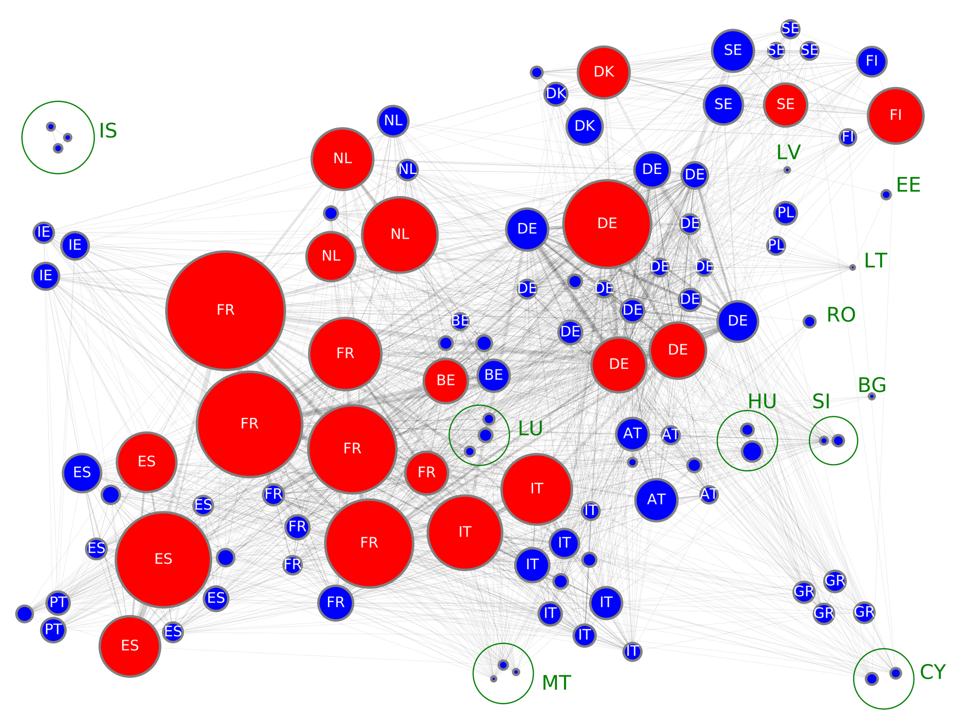

Figure 3. Network of interbank exposures in which nodes indicate banks, the width of edges are proportional to a logarithm of the exposures between the connected banks, i.e., exposures to risk related to interbank lending, debt instruments or derivatives.

Significance of the contribution

Contribution (extensions of [1, 2])

- **Strategic management actions of banks in a networked financial market**: banks are assumed to be utility maximizers who may choose to fully rebalance their portfolios considering externalities of their decisions in the interbank network of exposures.
- **Joint modelling of both default and price-mediated contagion**: Notably, by straightforward modification of portfolio constraints, the model can be set up to study the price impact of either reinvestment decisions (i.e., rebalancing of assets) or optimal liquidation strategies (i.e., selling of assets).
- **Generality of the framework**: Agents with various objectives can easily be embedded, which flexibility allows us to study the impact of a market regulator on financial stability.

Significance

A framework built to shed light on the optimal selection of liquidated types of assets, i.e., considering, jointly, immediate price impact of the sales and resulting revaluation of securities holding, expected risk and return realized on the post-liquidation portfolios, and risk appetite.

Mathematical details of the model

Portfolio optimisation of every bank in the system

Bank i seeks to maximize the concave utility $u_i(y_i, y^*_{-i})$ risk-adjusted return on assets. Consequently, bank i is a portfolio optimizer solving for quantities y with budget constraint of liquidity that can be raised given a vector of prices q and a matrix of the interbank network of exposures π

$$y_i^\dagger(y^*, q) = \arg\max \left\{ u_i(y_i, y^*_{-i}) \mid y_i \in \mathcal{A}_i(q) \right\}$$

$$\mathcal{A}_i(q) = \left\{ y_i \in \mathbb{R}^M_+ \;\middle|\; q \cdot y_i \le \left[a_i + q \cdot x_i + \sum_{j=1}^N \pi_{ji} p_j^*(q) - \bar{P}_i \right]^+ \right\}.$$

Note: y is a matrix of exposures where banks are in columns and asset classes in rows.

Equilibrium exists

Clearing is joint in prices q^* and portfolio holdings y^* given price-impact function f:

$$q^* = f\left(\sum_{i=1}^N [x_i - y_i^*] \right) \quad , \quad y^* = y^\dagger(y^*, q^*). \tag{1}$$

Banking system data

The EU-wide Transparency exercise conducted by the European Banking Authority complements banks' own Pillar 3 disclosures, as laid down in the EU Capital Requirements Directive. EBA discloses detailed bank-by-bank data, in a comparable and accessible format, for 120 banks across 25 EEA / EU countries data, June 2021 snapshot.

core/periphery		mean	q25	median	q75
c	ta [billion €]	897.7	516.8	651.0	1321.1
	cash	0.3	0.1	0.2	0.4
	gov	6.1	2.8	5.2	8.7
	nfc	2.9	1.4	2.1	4.0
	equities	1.0	0.5	0.7	1.2
	iba	8.0	3.9	5.5	8.5
	loans	59.8	55.0	60.8	68.6
	wf	22.9	19.7	23.0	25.6
	ibl	5.6	3.1	4.2	6.3
p	ta [billion €]	82.2	31.6	56.5	96.8
	cash	0.5	0.0	0.2	0.6
	gov	11.2	4.0	8.1	16.4
	nfc	5.2	2.1	3.9	7.0
	equities	0.6	0.1	0.4	0.7
	iba	8.4	3.0	5.2	10.3
	loans	58.8	51.8	61.5	66.9
	wf	20.9	12.6	19.9	27.4
	ibl	4.6	0.8	2.3	5.2

Table 1. Statistics of data used to parameterize the model. 'c' – core banks, with total assets > 300bn €, 'p' – periphery banks, with total assets ≤ 300bn €. Categories mapped to FINREP/COREP as follows: ta=total assets; cash=Cash, cash balances at central banks and other demand deposits; gov=Debt sec, including at amortised cost and fair value, general governments; nfc=Debt sec, including at amortised cost and fair value, credit institutions, other fin. and non-fin. corporations; equities=Equity exposure; loans=Loans and advances; wf=wholesale funding, incl. other fin. institutions and non-fin. corporations; ibl=Interbank funding. All variables other than total assets are reported as a % of total assets.

References

[1] L. Eisenberg and T.H. Noe. Systemic risk in financial systems. *Management Science*, 47(2):236–249, February 2001.

[2] Zachary Feinstein. Obligations with physical delivery in a multi-layered financial network. *SIAM Journal on Financial Mathematics*, 10(4):877–906, 2019.

[3] Zachary Feinstein and Grzegorz Hałaj. Interbank asset-liability networks with fire sale management. *ECB Working Paper*, (No. 2023/2806), 2023.