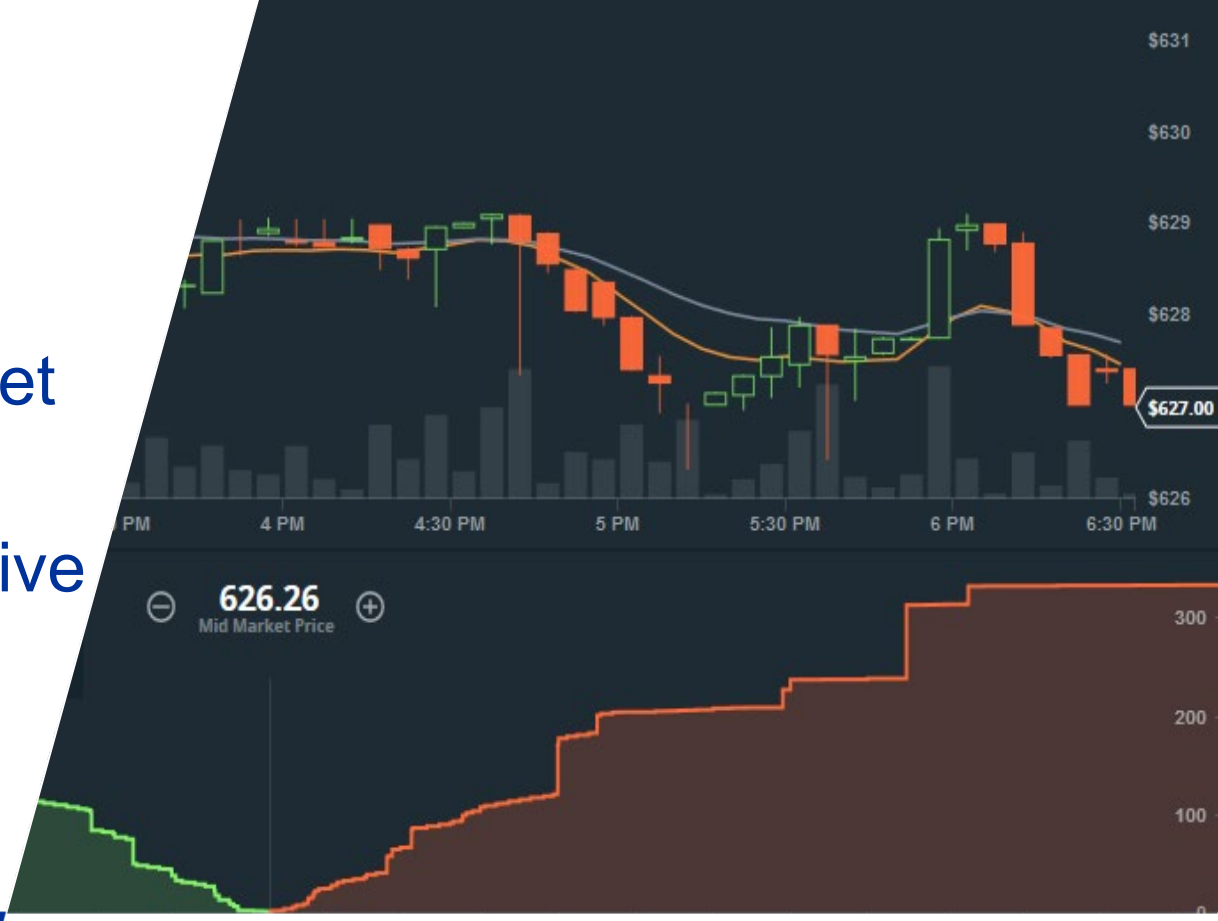
EUROPEAN CENTRAL BANK

EUROSYSTEM

Contagion from market price impact: a price-at-risk perspective



7th Annual Workshop
ESCB Research Cluster 3

24 November 2023

Matthias Sydow (ECB)

joint work with Gábor Fukker (ECB), Michiel Kaijser (DNB) and Luca Mingarelli (ECB)

Disclaimer

The views expressed in this presentation are those of the authors and do not necessarily represent the views of the European Central Bank and the Eurosystem.

www.ecb.europa.eu ©

Why do we care?

Financial institutions

- Agents' **overlapping portfolios** can provide a channel of **contagion**
- The **risk** stemming from this channel cannot be considered by any counterparty in the system: the regulator can capture the full picture
- In crisis situations, modelling of **asset deleveraging** requires a *notion* of **price impact**

Central bank

- Revisions in expectations about the **monetary policy** stance may, e.g., trigger an abrupt **repricing of sovereign bonds**, which may spill over to other asset classes and give rise to financial stability risks

www.ecb.europa.eu ©

Why is there price impact?

Three possible approaches

Agents **successfully forecast** short term price movements and trade accordingly;

Private information causes trades, which cause other agents to update their valuations, thus leading to a price change;

Statistical effects due to order flow fluctuations.

Reference: Bouchaud (2017).

www.ecb.europa.eu ©

How to model price impact?

Kyle's model

$$p_t = p_{t-1} + \lambda v, \qquad \text{giving } \mathrm{R(T)} = \lambda E[v]$$

Where v is the change in observed volumes and λ is known as *Kyle's Lambda* and it represents the impact parameter. The linear representation of the impact model provides a **good estimation for small volumes**, while overestimating for larger volumes.

Metaorder square-root model

$$R(T, v) \propto \sigma_T \left(\frac{Q}{V_T}\right)^{\delta}$$

Where Q is the total volume of the metaorder, σ_T is the volatility, V_T is the total market volume traded at time T.

Reference: Kyle (1985), Bouchaud (2017).

www.ecb.europa.eu ©

How to model price impact?

Exponential specification

Impose the sublinear relationship of the volume on price impact

$$R(v) = B_\mu \left(1 - \exp\left(-\frac{v * \lambda}{B_\mu}\right)\right)$$

To avoid the price to drop arbitrarily close to zero, a boundary $B_\mu > 0$ can be introduced. Consistent with the Kyle model for small volumes.

References: Schnabel and Shin (2002), Cifuentes et al. (2005), Cont and Schaanning (2017).

www.ecb.europa.eu ©

How to model price impact?
Quantile regression

Expanding the exponential model: calibrate a wider range of impact severities levels, while keeping the converging nature of the exponential function.

$$R(v)^q = \beta_0^q(1 - \exp(-sV)) + \beta_1^q R_{sys}$$

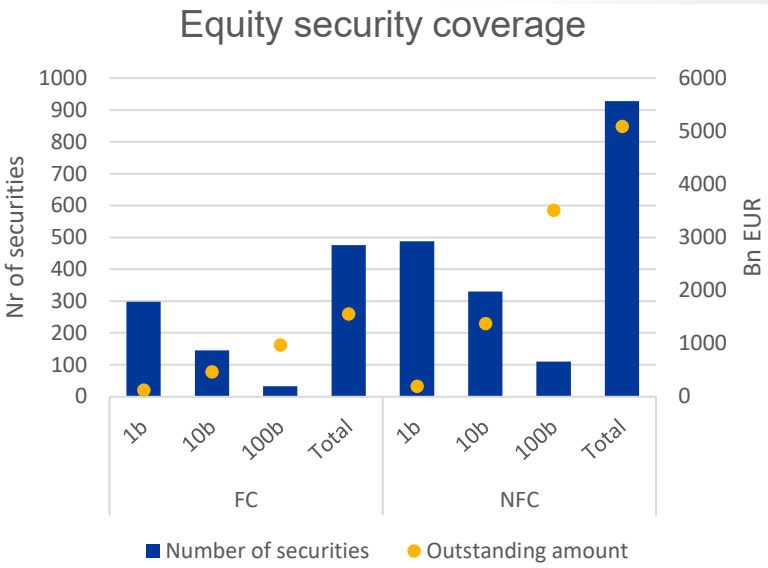
where $s = \frac{\lambda}{\beta_0}$, from which we can derive λ, and q is the estimated quantile.

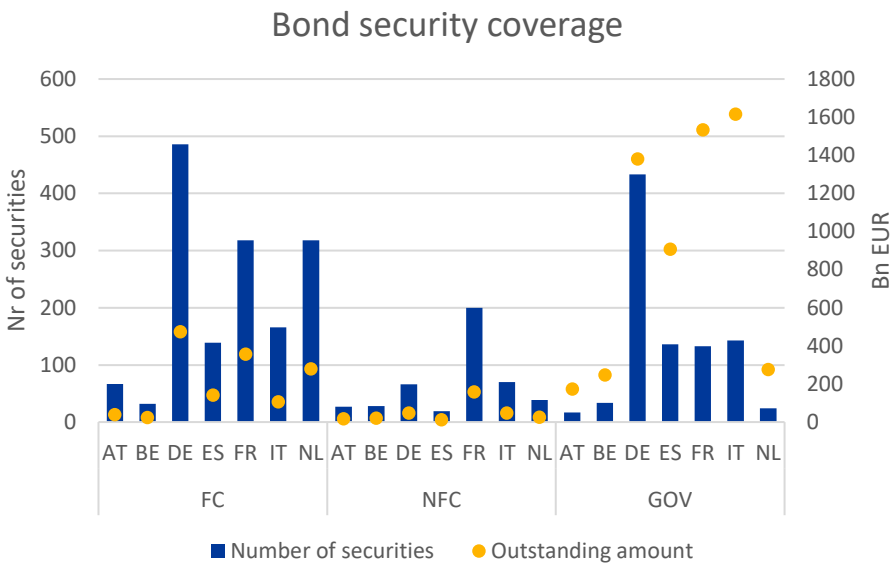
Furthermore, a system-level component R_{sys} has been introduced to account for price changes due to changes in the market (can also be scenario-driven).

References: Adrian, Brunnermeier CoVaR (2016), Engle, Manganelli CaViaR (1999) and Fukker et al. Price-at-risk (2022), ECB Working Paper, No. 2692: https://www.ecb.europa.eu/pub/pdf/scpwps/ecb.wp2692~e290ddd247.en.pdf

www.ecb.europa.eu ©

Data coverage





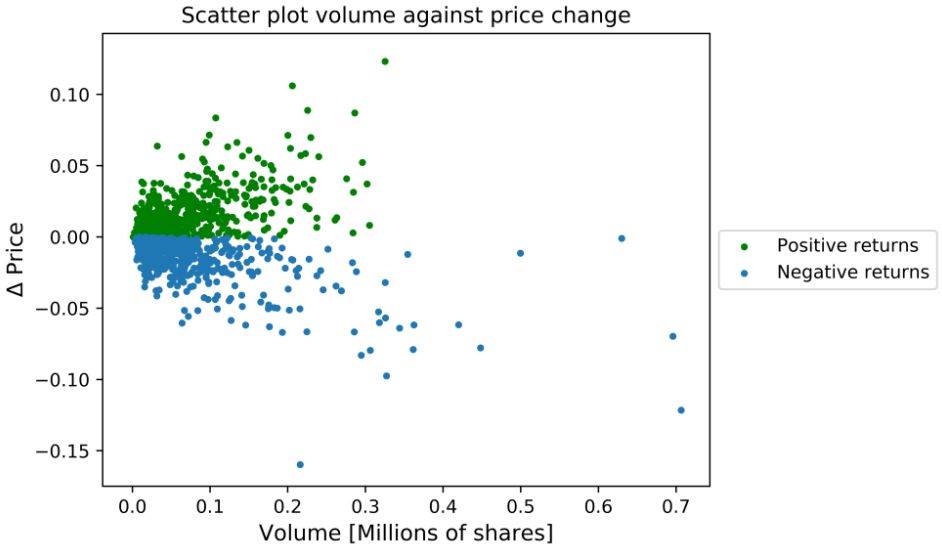
The dataset contains an as wide as possible range of equities and bonds, including different sectors, sizes, and euro area countries amounting to 7 trillion euro equities and 7.9 trillion euro bonds.

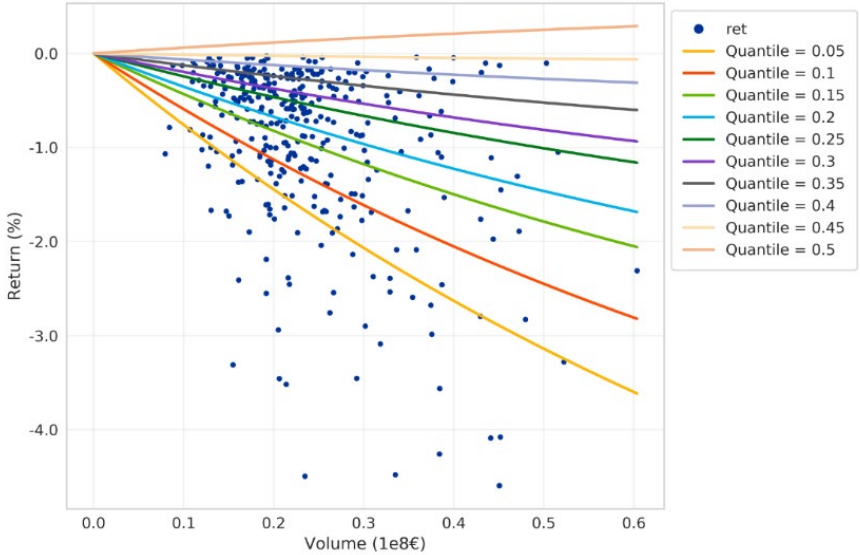
Source: Fukker et al. (2022).

www.ecb.europa.eu ©

Visualization of price calibration on empirical data

Empirical data shows that returns diverge as volumes increase (left hand side). The quantile regression approach on the negative impacts allows to evaluate risk at different intensity levels (right hand side)





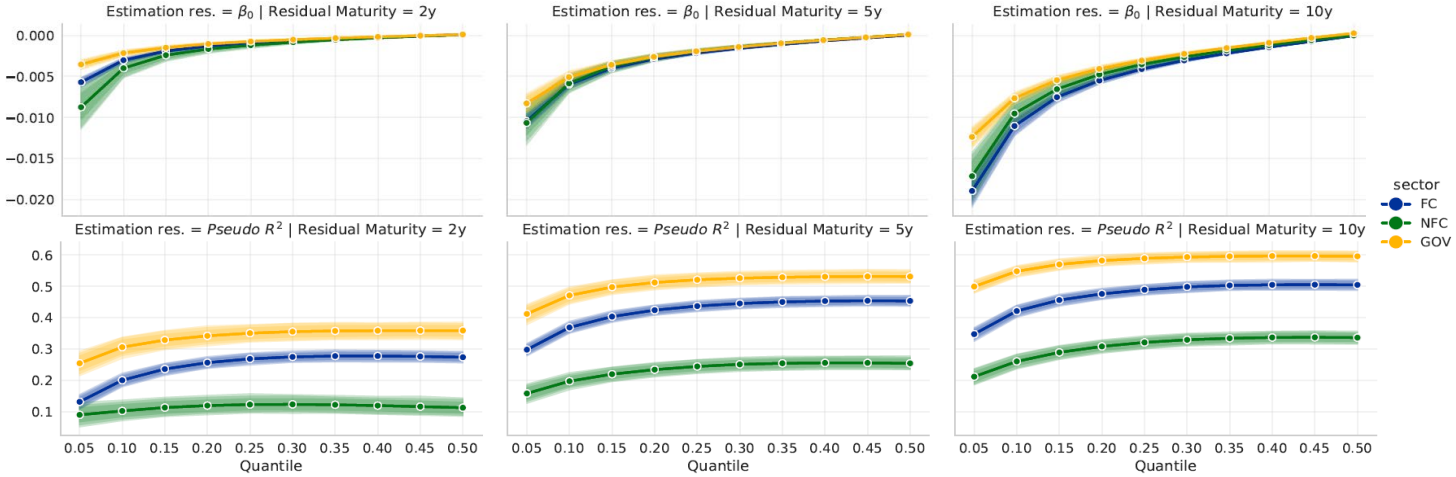
Source: Refinitive (Eikon).

www.ecb.europa.eu ©

Estimation results

Bonds

Positive correlation between market impact and residual maturity



Government bonds show to be least impacted, proving their relatively low risk level.

Source: Fukker et al. (2022).

www.ecb.europa.eu ©

Security level impact size

Bonds - direct market price impact from fire sale of individual bonds

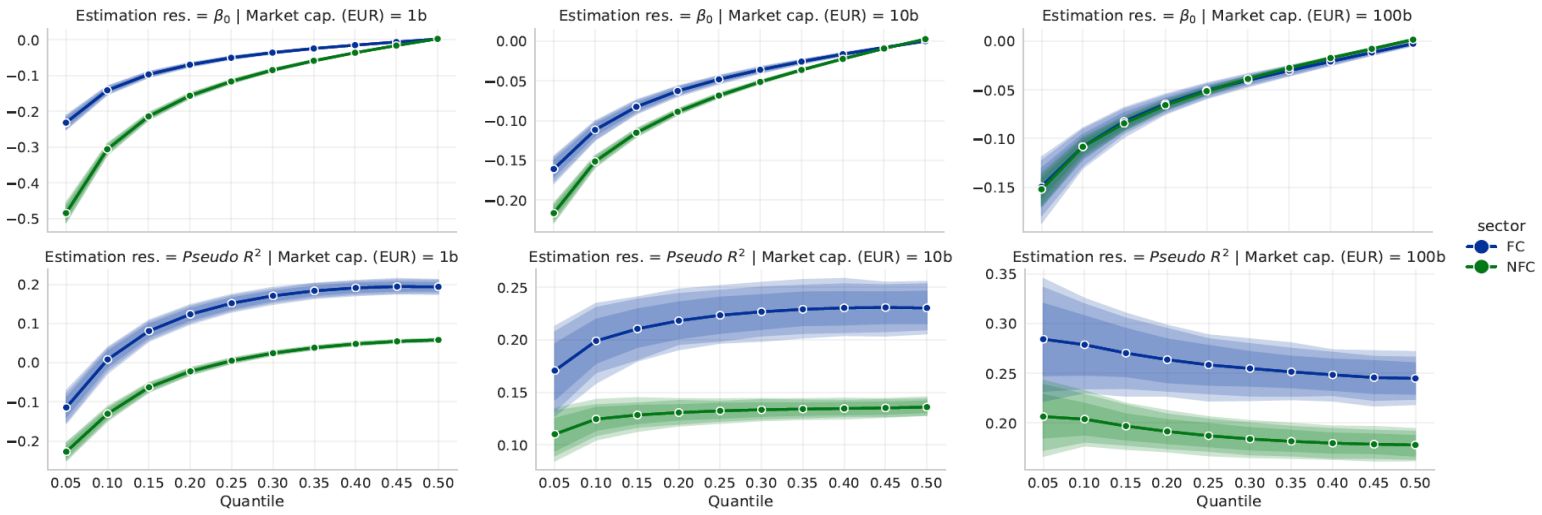
Source: Fukker et al. (2022).

www.ecb.europa.eu ©

Estimation results

Equities

Compared to bonds, equity impact are several times more impactful.



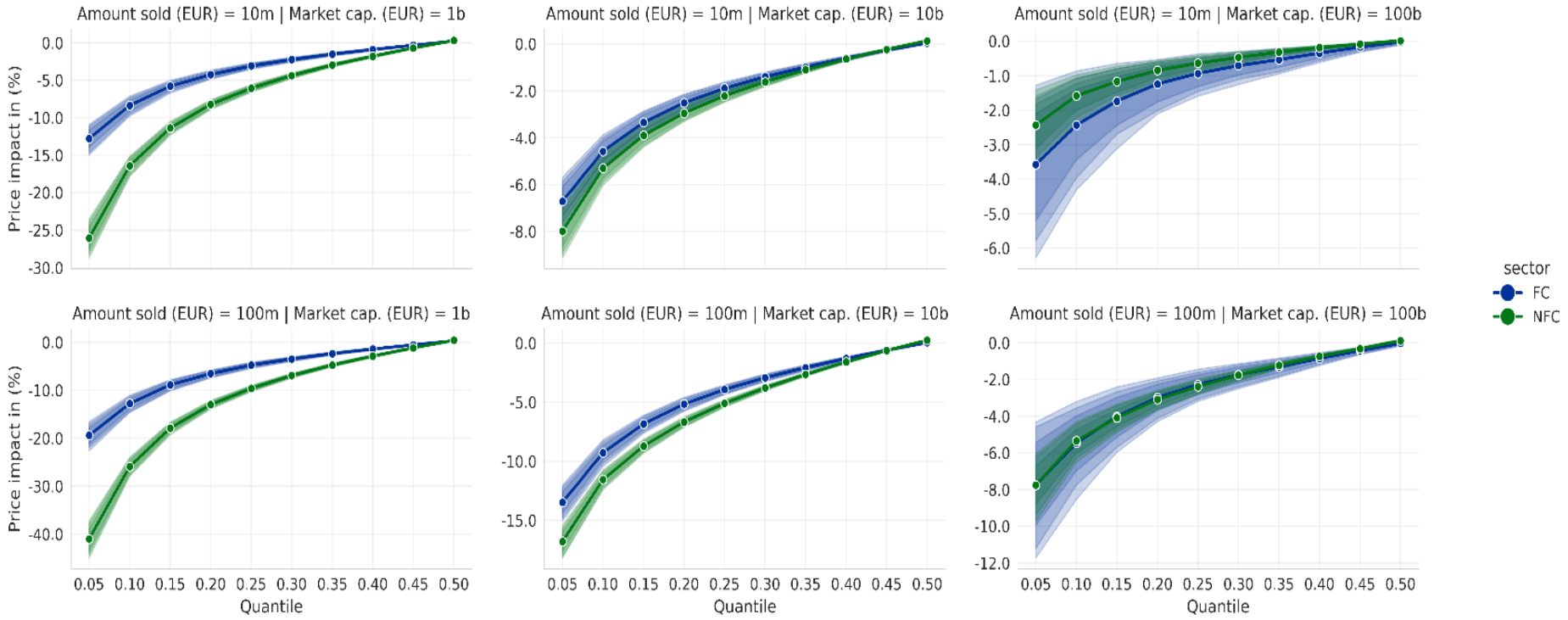
Moreover, large companies tend to absorbed shocks much more than smaller companies.

Source: Fukker et al. (2022).

www.ecb.europa.eu ©

Security level impact size

Equities - direct market price impact from fire sale of individual equity



Source: Fukker et al. (2022).

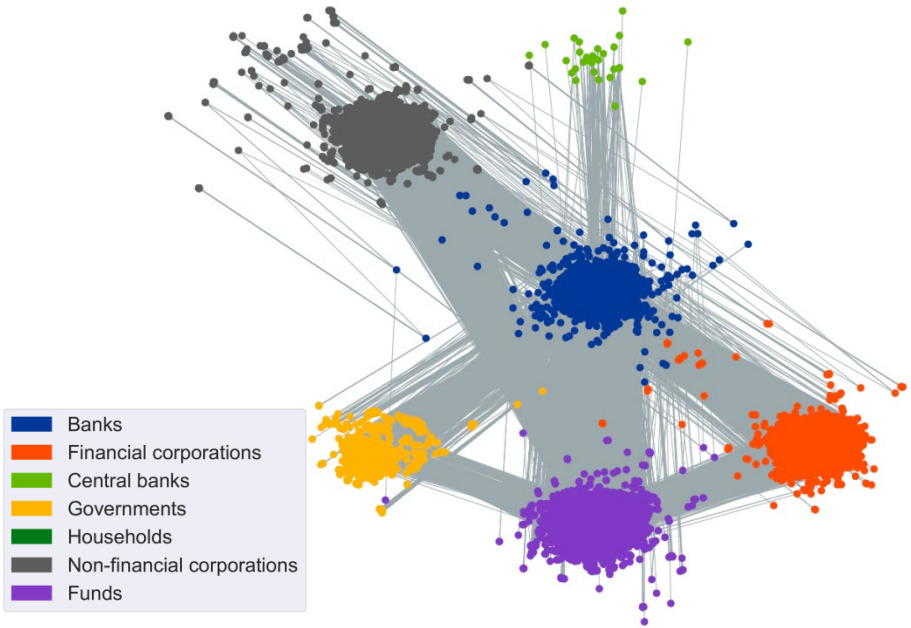
www.ecb.europa.eu ©

Fire sale simulations (I)

- **Using SWST model** (Sydow et al., 2021) for the system of banks and investment funds
- **Driven by liquidity shortfalls:** banks/funds cover their liquidity shortfalls by selling their tradable assets
- **Pro rata approach:** amounts sold are proportional for all securities held
- **Price equilibrium:** price impacts re-calculated until no further change in market values of holdings

Reference: Sydow et al. (2021), ECB Working Paper, No. 2581 and Journal of Financial Stability, forthcoming.

Securities holdings



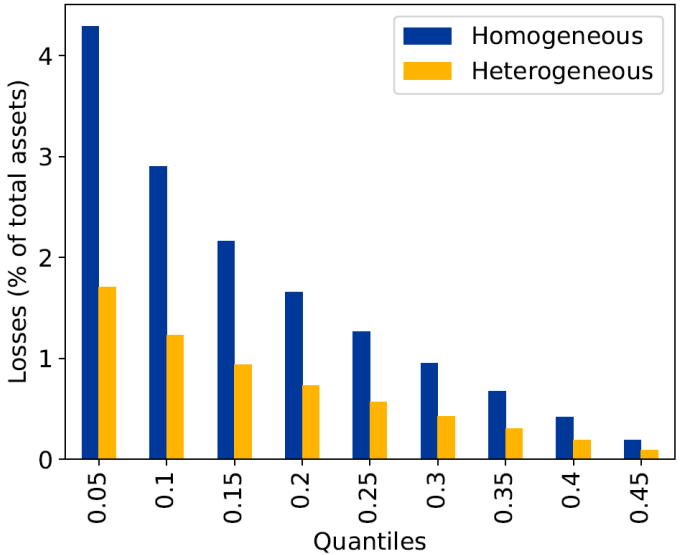
An edge shows that a bank/fund holds assets issued by another entity in a given sector. Granular securities data are covering 7% of total bank assets.

www.ecb.europa.eu ©

Fire sale simulations (II)

- **Redemption shock** for investment funds to trigger fire sales of all securities in their portfolios
- **Banks and funds** suffer fire sale losses upon endogenous price drops
- Fire sale losses **largely depend** on the applied price impact parameters
- Heterogeneous impact parameters reveal **more limited risks** as opposed to homogeneous parameters

Comparison to homogeneous price impacts



Assumed initial redemption shock for investment funds is -5%.

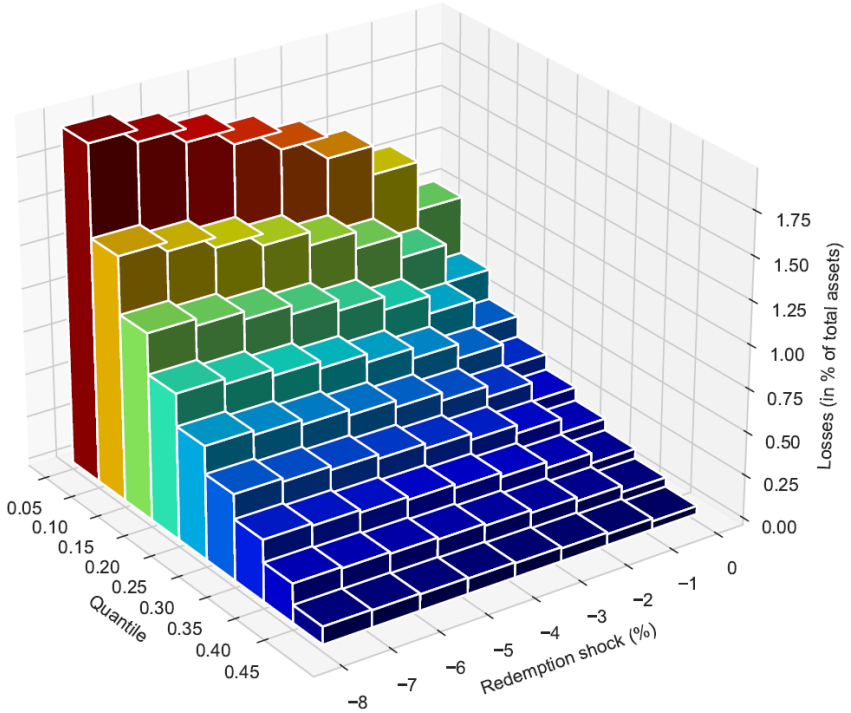
Source: Fukker et al. (2022).

www.ecb.europa.eu ©

Fire sale simulations (III)

Sensitivity analysis shows a sub-linear increase in system-level losses with the increase of redemptions for different price impact quantiles

Losses for different redemption shocks and quantiles



Source: Fukker et al. (2022).

www.ecb.europa.eu ©

Conclusion

- We estimated **security-level quantile price impact** parameters for different, arbitrary amounts sold, which is a useful complement to standard ‘average’ price impact parameters used in the literature
- Taking into account the **heterogeneity** across securities alleviates some of the risks shown by fire sale models that apply **homogenous** price impact parameters
- **Historical data** cannot explain the future, but former crisis episodes can provide an **indication** of the severity of **future** price movements affecting the liquidity of all agents in the financial system
- In addition to **sector-specific** stress testing exercises, it is important to conduct scenario-based **multi-sector, system-wide** stress testing exercises, with granular network information, to shed light on possible pockets of vulnerability in the financial system as a whole

www.ecb.europa.eu ©

Achievements and next steps

Achievements

- **ESMA CCP stress test 2021/2022**: ECB price-at-risk estimates were used as top-down benchmark to validate CCP bottom-up concentration risk results
- **Financial stability and monetary policy link**: Price-at-risk parameters used for the evaluation of possible changes in bond yields at the tail conditional on changes in the ECB monetary policy stance

Next steps

- Increase security **coverage**
- Introduce **intraday** calibration
- Improve **direction** identification

www.ecb.europa.eu ©

Thank you!

www.ecb.europa.eu ©