SUERF
The European Money and Finance Forum

SUERF Policy Brief
No 466, November 2022

Price-at-risk: systemic risk from price-impact induced contagion*

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Keywords: Price impact, fire sales, indirect contagion, overlapping portfolios, quantile regression.
JEL codes: G01, G12, G17, G23, G32.

A source of systemic risk of paramount importance is found in the combination of overlapping portfolios across the financial system, creating indirect interconnections through which financial contagion generated by large scale asset deleveraging can spread. The understanding and ability to describe such effects, allows systemically important financial institutions such as banks and CCPs, as well as regulators, to monitor and prepare for potential threats to the stability of the financial system. We describe the interconnected behaviour of markets by means of a non-linear price impact quantile regression approach, where price impacts are calibrated at the level of individual securities.

Introduction

Overlapping portfolios constitute a well-recognised source of risk, providing a channel for financial contagion induced by the market price impact of asset deleveraging. We introduce a novel method to assess the market price impact on a security-by-security basis from historical daily traded volumes and price returns. Systemic risk within the euro area financial system of banks and investment funds is then assessed by considering contagion between individual institutions' portfolio holdings under a severe stress scenario. As a result, we show how the bias of more homogeneous estimation techniques, commonly employed for market impact, might lead to loss estimates that are more than twice as large as losses estimated with heterogeneous price impact parameters. Another new feature in this work is the application of a *price-at-risk* measure instead of the average market price impact to evaluate the tail risk of possible market price movements in scenarios of different severity. Results, presented in more detail in a recent working paper (Fukker et al., 2022), also show that system-level losses at the tail can be three times higher than average losses using the same scenario.

*The views expressed are those of the authors and not necessarily those of the institutions they are affiliated with.

Commonality as a source of risk

When financial institutions invest in common assets they become exposed to indirect contagion risk, that is the risk of marked-to-market loss originating from a decline in value of overlapping portfolios which exposes banks and other financial intermediaries to market risks even vis-a-vis institutions with whom they have no direct exposure or explicit financial relationship. Indirect contagion is therefore a form of systemic risk and represents a major threat to the stability of the financial system, having the potential to generate deleveraging spirals and constituting a vector of loss amplification.

In monitoring the build-up of such risk there exist two main factors to be considered. First, the amount of system-wide overlap in market positions – that is, to which extent financial intermediaries invest in the same assets or asset classes. This has the effect of increasing the interconnectedness of the system across geographical borders, adding to the complexity of the system and the interdependence of its agents. Second, the price impact associated with the sale of such assets, which may either dampen or exacerbate indirect risk sharing depending on the asset classes which constitute the overlaps in investments.

The first factor can be monitored by regulators by computing overlapping portfolios on Security Holding Statistics, which provide prudential and market authorities with ISIN-level information of entity-by-entity portfolio holdings. For what concerns the second factor, historical information on daily traded volumes and prices of the securities held by major participants in the euro area financial markets, can be used to estimate price impacts at the level of individual ISINs.

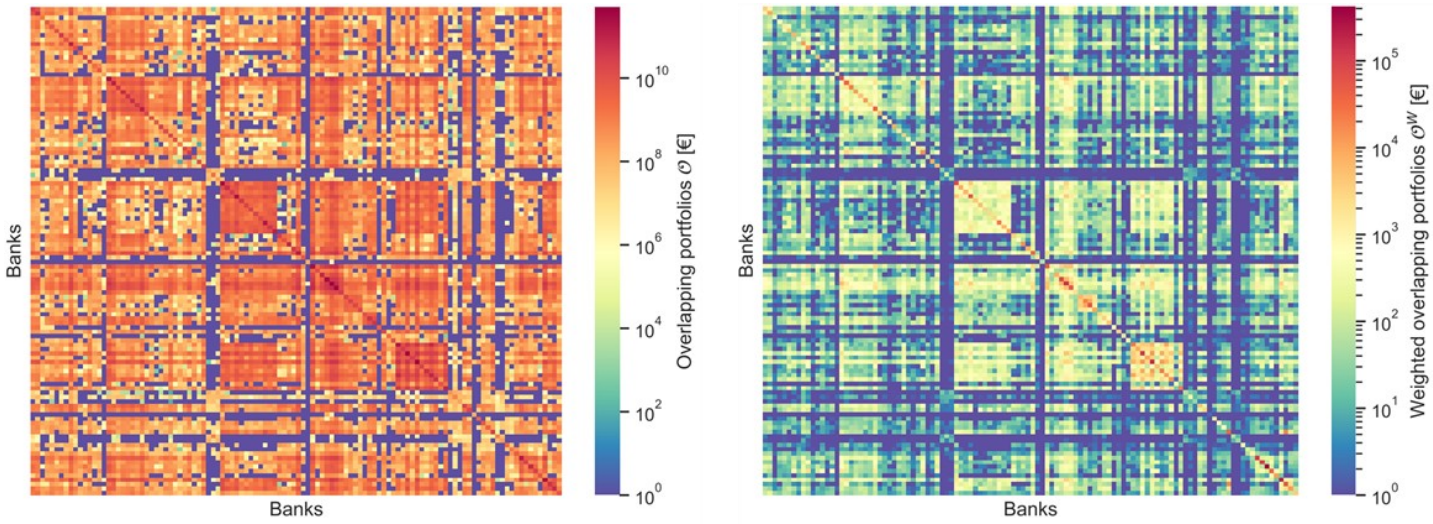
Price-at-Risk

A range of different parameters are estimated corresponding to different specifications for the functional form of the impacts. Analysing the results across different asset classes confirms the intuitive notion that more volatile asset classes may be more sensitive to movements in prices for similar volumes traded. Indeed, equities are found to be generally associated with higher price impacts, with bond prices being instead less impacted ceteris paribus, which broadly contributes to a reduction in indirect risk-sharing when considered in conjunction with the fact that government bonds make up a large fraction of euro area bank portfolios. Moreover, in order to capture different scenarios in which market sentiment and the level of system-wide distress may influence the magnitude of price impacts due to deleveraging, we further introduce a system-level market return as additional factor explaining security level price changes. Then, performing non-linear quantile regressions to estimate different quantiles of the security-level price impacts as a function of volumes sold and system-level returns allows to isolate market sentiment from the role of individual trade volumes, hence also capturing to an extent the correlation of price movements.

One common analytical tool which can be employed to monitor and assess the evolution of the risk of indirect contagion are overlapping portfolio matrices. As shown in Figure 1.a these square matrices present on the two axis a selection of entities of interest (here the 126 largest banking groups in the euro area), with each entry of the matrix representing the euro-amount of securities in which each pair of entities have common investments. Pure overlapping portfolios are however biased insofar price impacts differ across different instruments and asset classes. More specifically, one cannot a-priori attach the same risk to the same euro-amount of overlapping investments, but should rather differentiate between asset classes, or better between instruments.

This is shown in Figure 1.b, where the ISIN level overlapping investments are weighted by the corresponding instrument's price impact parameter. Because most of bank's portfolios are made up of bond instruments (over 70%), to which one can associate lower price impacts on average, the resulting risk profile of the banking system appears more nuanced than could otherwise be inferred by pure overlapping portfolios alone, although still maintaining system-wide correlations. At the same time, one can also observe risk to be more concentrated in fewer pairs of institutions sharing investments in instruments associated with larger price impacts.

Figure 1: Weighting overlapping portfolios by security level price impacts reveals indirect contagion poses less risk on average than could otherwise inferred. Here, impact in (b) refers to quantile q = 0.05. Portfolios are those of the 126 largest euro area banking groups reporting in SHS-G. Banking groups on both axis are clustered by country of residence.



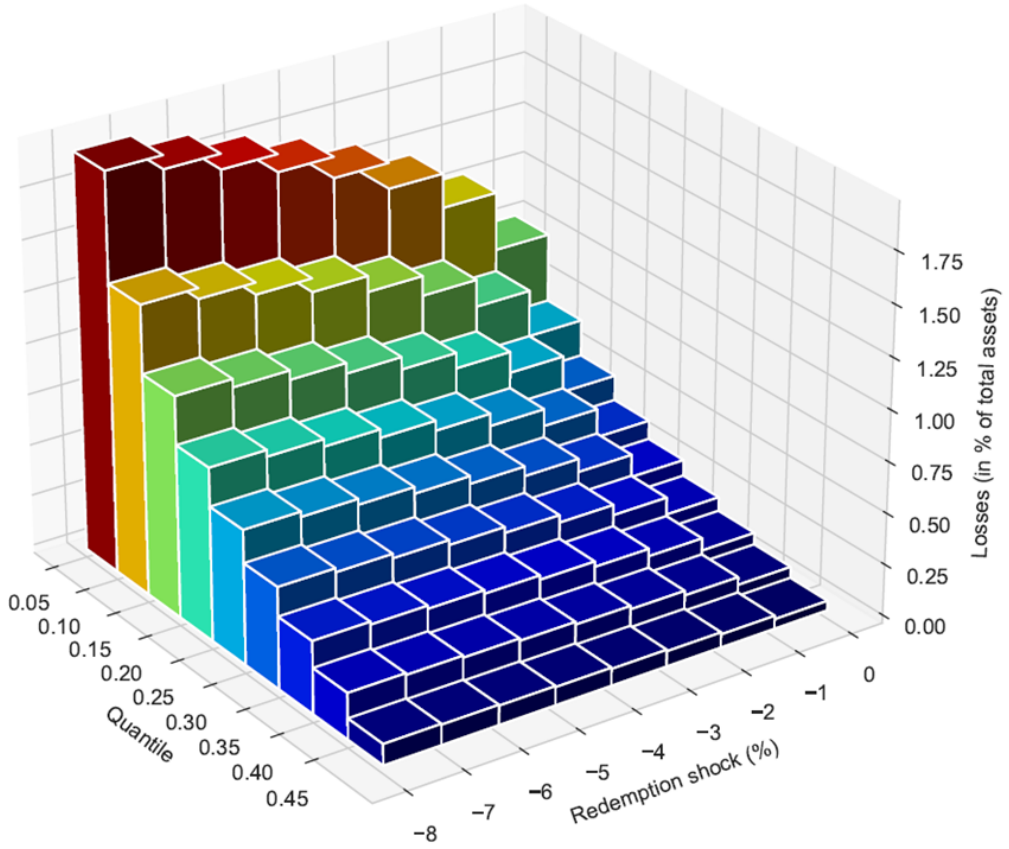
(a) Nominal overlapping portfolios

(b) Impact weighted overlapping portfolios

Source: Fukker et al. (2022).

Models of financial contagion may also feature indirect contagion channels, albeit employing proxies and stylised approximations for the impact on prices due to deleveraging. Considering a model of financial contagion and system wide stress testing endogenously modelling both the banking and funds sectors at an entity-by-entity level, and capturing both direct and indirect channels, one can also observe the significant difference brought about by heterogeneous price impacts. Distress scenarios where funds face redemption shocks of increasing magnitude originate the fire sale dynamics where pro-rata deleveraging allows market participants to cover for their liquidity shortages (see Sydow et al., 2021 for more details). First, homogeneous price impact is shown to overestimate losses and contagion by a factor of two on average. Secondly, the full value of a quantile regression approach to estimate price impacts can be exploited by repeating the impact assessment for different quantiles of the price impact distribution (Figure 2). Results provide numerical evidence of the relevance of tail scenarios in modelling fire sales dynamics where the impact of extreme deleveraging pressures, such as those which the financial system may experience in times of system-wide distress, is assessed across a range of shocks to the system and price impacts.

Figure 2: System-level losses for increasing quantiles and redemption shocks.



Source: Fukker et al. (2022).

Conclusion

In conclusion, the realistic assessment and modelling of indirect contagion risk and price impact relies on the ability to estimate heterogeneous price impact parameters. These impacts may, however, be dependent on the level of distress in the financial system or more broadly, market sentiment. This has been resolved, from a modelling perspective, by introducing a factor to control for systematic returns and estimating price impacts at different quantiles.

Our analysis can be utilized by both banks and other systemically important institutions (such as CCPs), but most importantly by policy makers and regulators to prepare for potential distress events which might threaten the stability of the financial system. Moreover, the potential impact of the introduction of new macroprudential measures, aimed at preventing financial intermediaries from the adverse effects of liquidity stress situations, could also be simulated using what-if analyses.

About the authors

Gábor Fukker *is currently Lead Financial Stability Expert in the Stress Test Modelling Division of the European Central Bank. He graduated in Mathematics from Budapest University of Technology and Economics. After a short period in academia and working as an actuary, he joined the Macroprudential Policy Department of the Magyar Nemzeti Bank (the central bank of Hungary) in 2015 where his main area of focus has been financial interconnectedness besides different kinds of analytical work. In 2018, he started working with the European Central Bank on stress testing, financial contagion and macroprudential policy calibration. Since 2020, he has been involved in a long-term analytical project of the ECB focusing on system-wide stress testing of the financial system.*

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