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Liquidity stress testing for the EU financial system

Tool inventory and desktop illustrations

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Abstract

This paper reviews system-wide liquidity stress-testing (SLST) frameworks in the European Union and illustrates the impact of a common aggregate liquidity shock on the EU financial system using a range of modelling approaches. Motivated by recent episodes of market turmoil, including the COVID-19 crisis, the 2022 energy shock and the 2023 banking stress, the analysis focuses on the propagation of liquidity stress across financial sectors and institutions. The paper combines a survey of SLST practices among EU authorities, a mapping of cross-sectoral financial interconnections in the euro area, and stress-testing simulations based on jurisdiction-specific models, an ESRB cross-sectoral balance sheet tool and the ECB's system-wide stress-testing framework. The results suggest that the financial system remains broadly resilient to a severe aggregate liquidity shock over a 30-day horizon, with net outflows ranging from 0.5% to 0.7% of total financial assets. However, second-round effects, including fire sales, mark-to-market losses and behavioural responses, can significantly amplify the initial shock. The findings highlight the importance of financial interconnections, the role of non-bank financial intermediaries in shock transmission and the stabilising effect of central bank interventions. This paper also provides a stocktake of existing SLST practices and discusses priorities for the further development of SLST in Europe.

Keywords: system-wide liquidity stress testing; systemic liquidity risk; financial stability; stress testing; liquidity stress testing; financial interconnectedness; fire sales; contagion; macroprudential policy; non-bank financial intermediaries.

JEL codes: C63, G01, G21, G23, G28, E58

Executive summary

Liquidity has become a key vulnerability of modern financial systems. Recent episodes of financial stress, including the COVID-19 market turmoil in 2020, the energy-market disruptions in 2022 and the banking turmoil in 2023, demonstrated how liquidity pressures can emerge rapidly and propagate across sectors, markets and jurisdictions. These events highlighted the need for analytical frameworks capable of assessing liquidity risk from a system-wide perspective rather than solely at the level of individual institutions.

This paper contributes to the growing body of work on system-wide liquidity stress testing (SLST) by providing a stocktake of available tools and practices across the European Union and by illustrating the impact of a common aggregate liquidity shock using a range of modelling approaches. The objective is not to assess a single stress-testing framework, but rather to assess how different methodologies can contribute to a more comprehensive understanding of systemic liquidity vulnerabilities.

The analysis is based on three complementary building blocks.

First, a survey of EU authorities shows that SLST is already widely used. Among respondents, 87% report having an SLST framework in place, primarily for supervisory purposes and macroprudential monitoring. Most frameworks focus on the banking sector, while only a minority explicitly incorporate contagion effects, behavioural responses or interactions between liquidity and solvency risks.

Second, the paper develops a comprehensive dataset of financial interconnections covering approximately €83 trillion of financial assets in the euro area. This dataset maps direct and indirect linkages among banks, investment funds, insurers, households, governments and the rest of the world. The analysis confirms the central role of banks in euro area financial intermediation while also highlighting the importance of investment funds as a source of both funding and potential contagion through overlapping portfolios and common exposures.

Third, a common adverse liquidity scenario is applied across three complementary modelling approaches:

- jurisdiction-specific liquidity stress-testing frameworks developed by national and European authorities;
- the ESRB balance sheet tool, a cross-sectoral and area-wide framework inspired by the International Monetary Fund (IMF) SLST approach;
- the ECB Interconnected System-wide stress test Analytics (ISA) model, a granular entity-level framework that incorporates contagion mechanisms, behavioural responses and feedback effects.

The scenario combines market and funding liquidity shocks calibrated using evidence from recent episodes of stress. It incorporates asset price declines, deposit withdrawals, investment fund redemptions and insurance policy surrenders, which all reflect a broad-based deterioration in funding and market liquidity conditions.

Despite substantial methodological differences across the models, the main conclusions are broadly consistent. Over a 30-day stress horizon, aggregate net outflows range between 0.5% and 0.7% of total financial assets. Banks account for the majority of these outflows, reflecting their role as the main providers of liquidity transformation within the financial system. While banks generally remain resilient over the short-term stress horizon, some institutions could face significant liquidity shortfalls under a prolonged stress scenario in the absence of management actions, supervisory intervention or central bank support.

The analysis also shows that second-round effects can materially amplify the initial shock. Liquidity needs may force institutions to sell assets, generating fire sale externalities and additional price declines. Depending on assumptions regarding liquidation strategies, fire sales can vary significantly and result in meaningful market impacts, particularly in equity markets. These dynamics generate additional mark-to-market losses and create transmission channels across sectors through overlapping portfolios and financial interconnections.

Investment funds emerge as a particularly important channel of shock transmission. Their sensitivity to redemptions and their significant holdings of marketable securities can amplify adverse market developments and contribute to broader system-wide losses. At the same time, the results underline the stabilising role of central bank interventions. Access to central bank funding and asset purchase programmes can materially reduce forced asset sales and mitigate the market impact of liquidity stress.

Overall, the paper finds that the EU financial system appears resilient to a severe aggregate liquidity shock in the short term, but remains vulnerable to amplification mechanisms arising from interconnections, fire sales and behavioural responses. The exercise highlights the value of combining multiple modelling approaches, as no single framework can fully capture the complexity of system-wide liquidity risk.

Looking ahead, further work should focus on improving the integration of banks and non-bank financial intermediaries, enhancing the modelling of behavioural responses, expanding the coverage of cross-sectoral interconnections and developing scenarios that jointly capture liquidity, market and credit risk. Such developments would strengthen the analytical toolkit available for macroprudential surveillance and contribute to a more comprehensive assessment of systemic risk in the European financial system.

1 Introduction

Over the last few years, a series of widespread financial turmoil events have clearly demonstrated how liquidity represents a major fragility of modern financial systems. The COVID-19 lockdowns in March 2020, the Russian invasion of Ukraine in early 2022 and the collapse of Silicon Valley Bank (SVB) and Credit Suisse (CS) in spring 2023 all triggered serious tensions in a variety of financial markets. These events repeatedly brought one of the critical weaknesses of modern financial systems to the surface: the rapid and systemic need for liquidity during periods of stress. In a financial environment shaped by digitalisation, complex and global interconnections and quickly evolving financial infrastructures, market confidence swiftly evaporated, funding pressures escalated and contagion intensified, including beyond banks. In each case, central bank interventions proved key to mitigate the impact of the shocks on the financial system and to prevent it from collapsing.

These crises showed in particular that a sudden and unexpected demand for system-wide liquidity is not necessarily triggered by banks. The economic disruption from the COVID-19 pandemic triggered a global dash for cash by investors, while the high volatility of energy markets following the Russian invasion of Ukraine led to substantial margin calls and a considerable need for highly liquid collateral beyond banks. In the banking sector, the speed of recent deposit runs was significantly higher than generally thought likely (FSB, 2024). Although the build-up of depositor (bank) runs is usually the result of slow-moving fundamental factors, the run itself tends to materialise relatively suddenly (Jamilov et al., 2024). This was the experience of SVB. Unviable banking business models and funding structures (Jiang et al., 2023), poor risk management practices and a new amplifying factor, namely social media communication (Cookson et al., 2026), resulted in massive deposit withdrawals, raising liquidity concerns for the whole sector.

The close interconnection of financial markets and participants together with the amplification and spillover of shocks across the financial system can transform local liquidity stress into a system-wide issue. Liquidity is inherently procyclical and closely tied to the leverage of financial intermediaries (Adrian and Shin, 2010). During periods of financial stress, initial liquidity shocks can trigger feedback loops that intensify market instability. At the same time, asset price falls lead to mark-to-market losses and higher funding costs, weakening the solvency of asset holders. This erosion of equity heightens risk perception and undermines investor confidence, prompting further withdrawals and liquidity outflows. These second-round effects deepen the crisis by transforming liquidity stress into additional market and funding risks. As a result, market participants face growing liquidity needs, reinforcing the cycle of instability. The race for cash (or highly liquid assets) further worsens the liquidity position of affected players, while the subsequent fire sales depress market valuations, spreading losses and uncertainty across the system. The spiral persists as deteriorated solvency and risk perceptions lead to more expensive or restrictive funding conditions, prompting further asset sales, withdrawals and losses throughout the system.

In light of such events, understanding the system-wide implications of liquidity shocks became a top priority for macroprudential oversight. In September 2022 the ESRB issued a general warning highlighting the risk of a sharp fall in asset prices, which could trigger large mark-to-market losses and lead to an amplification of market volatility and hence to liquidity tensions in the financial system (ESRB, 2022). In June 2023 the Bank of England launched a system-wide exploratory scenario to better understand the behaviours of market participants during stressed financial market conditions and how those behaviours could amplify shocks in UK financial markets. In December 2024 a high-level group recommended that the ESRB develop and implement a framework for the holistic assessment of systemic risk in the EU, including system-wide stress testing (ESRB, 2024).

System-wide liquidity stress testing (SLST) is a way to assess the resilience of the financial system under adverse liquidity scenarios. Unlike single entity stress tests, the system-wide approach evaluates how aggregate liquidity shocks (e.g. sudden deposit withdrawals and redemptions, market freezes or funding disruptions) can propagate across markets (e.g. bonds, derivatives or the interbank market) and participants (e.g. banks and non-banks). The goal of system-wide stress-testing tools is to help identify systemic vulnerabilities, provide indicative impact quantifications, enhance crisis management preparedness and inform prudential authorities. While central banks and international organisations have been using system-wide stress testing for monitoring purposes, impact assessments and to guide regulatory and policy decisions, their focus to date has mostly been on solvency (Baudino et al., 2018).

The aim of this paper is to illustrate the system-wide impact of an aggregated liquidity shock similar to recent turmoil events in the EU financial system using a range of available models. To this end, the analysis adopts a top-down approach and employs a range of stress-testing models developed by macroprudential and microprudential authorities across the EU as well as by the ECB and ESRB. While these models differ in terms of coverage, methodological design and analytical scope, they are all subjected to a common adverse scenario and harmonised set of assumptions. Following the findings of a survey conducted at EU level, the analysis carries out simulations for each jurisdiction in isolation by employing systemic liquidity stress-testing models from those jurisdictions. The aim is to quantify the aggregate liquidity shortfall generated under an adverse scenario. Such liquidity needs also provided a useful proxy for the potential market impact associated with asset sales and fire sale externalities. In addition, using available data, we also developed a simple stress-testing desktop tool – inspired by the International Monetary Fund (IMF) SLST framework (IMF, 2022) – which allows simulations to be conducted jointly for several countries and across financial sectors (called the ESRB balance sheet tool). Finally, we also report results from a fully-fledged system-wide stress-testing model developed by ECB staff (Sydow et al., 2024). Taken together, these complementary approaches provide a comprehensive assessment of liquidity vulnerabilities from different modelling perspectives. Overall, this paper provides a stocktake of available SLST models across the EU, also illustrating how various models respond to a common EU-wide scenario. The objective was not to compare the performance of individual models, but rather to quantify the impact of an aggregate liquidity shock on the EU financial system using a range of methodologies and provide a robust understanding of potential vulnerabilities and transmission channels.

SLST is widely used in the EU. To get a stocktake of tools and practices at the jurisdictional level, we surveyed the use of SLST frameworks among competent authorities and central banks in the EU. Of the 22 central banks (including the ECB) and competent authorities that completed the survey, 87% reported having an SLST framework in place. In addition, it appears that SLST is mostly developed for supervisory purposes. In some cases, results are used for macroprudential monitoring and hence featured in financial stability reports. Most SLST frameworks focus on banks, although some also cover insurance corporations, pension funds, non-financial corporations or investment funds. Amplification and second-round analyses are conducted by around one-third of surveyed institutions.

The aggregate liquidity shock in our paper consists of a combination of market risk and funding liquidity shocks. The narrative of the underlying adverse scenario considered similar liquidity tensions to those experienced in recent years (i.e. the 2020 dash for cash, the 2022 energy crisis and the 2023 banking turmoil). The scenario was calibrated in two separate layers (i.e. price market shocks and volume shocks) using the financial adverse scenario prepared for the European Insurance and Occupational Pensions Authority (EIOPA) insurance sector stress-testing exercise as a starting point for asset prices (ESRB, 2024). Volume shocks are derived from the market price shocks based on literature estimates for the various financial sectors considered. The combination of market and funding liquidity shocks echoes Brunnermeier and Pedersen (2009), as also emphasised in the ESRB's monitoring report on systemic liquidity risk (2024).

The results at the jurisdictional level show that the liquidity impact of the same adverse scenario may differ across the EU, reflecting differences in financial structures. Under the common adverse scenario, both banks and investment funds face net outflows while insurers maintain positive net inflows over a 30-day stress horizon. Overall, the stock of liquid assets decreases by 7 percentage points over this stress horizon. However, in the absence of mitigating actions (such as management decisions, supervisory interventions and central bank support), many banks would face liquidity shortfalls from the fourth month onwards. Moreover, the sell-off of assets triggered by the liquidity need arising from the adverse shock affects the price of financial assets to differing extents, with a contained decline in bond prices but much higher volatility in equity markets, also depending on the model used to relate quantities sold and price declines.

The ESRB balance sheet tool, using a cross-jurisdictional and cross-sectoral approach, shows – under the adverse scenario – a substantial reduction of the overall stock of liquid assets and a sizeable mark-to-market loss over a 30-day stress horizon. After the liquidity shock and haircuts, the stock of liquid assets declines from 34% to 24% of total financial assets. This reduction considers on the one hand central bank funding in periods of market distress, which can mitigate banks' liquidity needs and help reduce forced asset sales, and on the other hand deleveraging by affected agents, whose management responses differ across financial sectors, thereby leading to differing deleveraging needs. In terms of mark-to-market losses, first-round and second-round losses for banks, investment funds and insurance corporations (after accounting for hedging, accounting principles and loss absorption capacity) amounted to 1.4% of total financial assets, with investment funds bearing most of the losses. For comparison, the immediate market risk losses by banks for positions valued at fair value in the 2025 European Banking Authority (EBA) EU-wide stress-testing exercise amounted to €183 billion (EBA, 2025), which represents 0.4% of banks' financial assets. Finally, the gross price impact of forced asset sales, following liquidity needs over the 30-day stress horizon, can also be partly offset by central bank interventions such as asset purchase programmes.

Using the ECB system-wide stress-testing model, the results show that banks experience the highest scenario-conditional net outflows in absolute terms, while investment funds face the largest market losses relative to their total assets. Market losses from liquidity stress are concentrated in equities, with second-round fire sales amplifying price declines, while bond holdings remain relatively stable. Over a 30-day stress horizon, liquidity shocks erode liquid asset stocks by 3 percentage points, primarily due to initial volume shocks, with additional losses from second-round effects. Similarly to the cross-jurisdictional approach, it is worth highlighting that the funding impact on banks is not only driven by scenario-based run-off rates, which are calibrated consistently with the adverse asset price shocks, but also by conservative assumptions applied to other funding flows, aligned with supervisory practices.

The remainder of the paper is structured as follows. After a literature survey on SLST, we recall the findings of our inventory of corresponding EU tools and practices. Then, data on EU interconnections across sectors are identified and commented upon, focusing on the main possible channels of transmission across sectors within the area. We then provide details on the scenario, covering its narrative, methodology and calibration both for (asset) prices and (outflow) quantities. We then recall and briefly document the suite of models with which simulations were carried out, both for a single sector or country and considering the area-wide system. We further explain the main cross-sectoral models used: the ESRB balance sheet tool and the ECB Interconnected System-wide stress test Analytics (ISA) model. Aggregated results of the conducted simulations are then presented, distinguishing between first-round and second-round effects and further introducing possible central bank reactions as well as entities' management decisions in the experimental setup. Finally, tentative conclusions are provided.

2 Literature review

In the aftermath of the global financial crisis, the monitoring of systemic liquidity risk has gained prominence among academics and policy practitioners. This heightened focus encompasses the quantification of risk, identification of structural vulnerabilities and analysis of transmission mechanisms and agent behaviour. Stress testing has emerged as a central tool in this context, shifting the analytical lens from individual institutions to a broader, system-wide perspective.

The systemic perspective on liquidity stress has substantially developed over time, progressively incorporating interactions among agents relating to credit, market or funding risks as well as behavioural responses. A seminal piece on how liquidity shocks to a given bank can spread to other banks remains Eisenberg and Noe (2001), whereby an initial bank failure triggers a “cascade of defaults”. The latter reflects the interbank network structure, as a given bank’s default on interbank claims can cause corresponding counterparties to also fail, thereby affecting further connected players. In practice though, rather than cross-bank defaults, systemic failure may arise from “fire sales”, as introduced by Cifuentes, Ferrucci and Shin (2005). If a bank starts selling assets, even at depressed prices, to promptly get cash, market prices and thereby other banks’ valuations are further depressed. In any case, lower asset prices also affect collateral, reducing banks’ borrowing capacity – as flagged by Brunnermeier and Pedersen (2009). More generally, bidirectional links exist between solvency and liquidity (Cont et al., 2020), so that respective stresses reinforce each other. Entities’ specific portfolio decisions under stress can also aggravate the overall systemic impact. Battiston et al. (2011) found that risk diversification can paradoxically increase systemic risk when financial robustness is heterogeneous across agents (see also Amini and Feinstein, 2023, for the effect of institution-specific portfolio decisions). Overall, while such second-round effects can then operate via numerous channels, Glasserman and Young (2017), using metrics such as leverage and connectivity, showed that contagion typically remained weak unless triggered by large, interconnected institutions.

There have been institutional attempts to construct frameworks that extensively capture the externalities rendering liquidity stress systemic. At the IMF, Schmieder et al. (2012) proposed a top-down bank liquidity stress framework incorporating cash flow analysis, maturity mismatch assessment and liquidity-solvency linkages. Similarly, Hałaj and Henry (2017) advocated for a systemic liquidity stress-testing framework, emphasising the need for liquidity-specific scenarios, behavioural rules, comprehensive network topology and the interplay between liquidity and solvency. In such setups, collateral availability and valuation, fire sales, cash hoarding, funding costs in relation to solvency and herding behaviour can play a bigger overall role than normal. The IMF (2022) developed an approach to assess and quantify system-wide liquidity by bringing liquidity and interconnectedness across agents together and considering both domestic and cross-border networks. For instance, Mikropoulou and Vouldis (2023) developed a contagion model based on liquidity interconnections using euro area supervisory data, revealing that indirect contagion, driven by behavioural responses and procyclical haircuts, often outweighs direct contagion. Krüger et al. (2024) introduced a theoretical framework analysing strategic interactions under funding stress, proposing new liquidity metrics such as the systemic liquidity buffer and systemic liquidity shortfall accounting for the aggregate impact of asset sales and liquidity needs.

Central bank measures, while shown to be crucial in system-wide stress episodes, are barely considered in the academic literature. During periods of extreme financial distress, central banks have extended liquidity provisions and stabilised markets in line with monetary policy objectives. Van den End (2010) incorporated central bank measures such as extended refinancing operations and asset purchases into a macro liquidity stress-testing model, finding that these interventions significantly reduce second-round effects, with asset purchases proving more effective than refinancing operations. Using linkages in interbank markets, Georg and Poschmann (2010) developed an agent-based model with central bank intervention to demonstrate that common shocks pose greater systemic risk than contagion alone, and that central bank liquidity provision enhances stability. Bindseil and Jabłecki (2013) examined the implications of central bank liquidity provision on central bank risk-taking and economic efficiency, using a comprehensive system of financial accounts to assess the broader impact.

The interconnection between banks and other financial sectors has also been investigated. After the global financial crisis, mostly focusing on solvency via cross-sectoral asset holdings, Castrén and Kavonius (2009) constructed sector-level balance sheet networks using euro area financial accounts to trace shock transmission across sectors based on a flow-of-funds approach. The model was subsequently extended to capture both domestic and cross-border exposures (Castrén and Rancan, 2013). A similar approach can be found in Grodzicki and Silva (2017), where bank losses from a standard macro-financial stress scenario transmit to other sectors via equity cross-holding valuations.

More recently, institutional attention has shifted towards the whole financial system's liquidity and the related interactions within it. Ding, Laliotis and Taffano (2024) introduced the IMF's system-wide liquidity framework, which aggregates agent-level balance sheet data to simulate liquidity impacts under various stress scenarios. At the ECB, Sydow et al. (2024) integrated the insurance sector in a system-wide stress-testing framework, previously considering only banks and investment funds (Sydow et al., 2021), by modelling the liability side of insurers and their unique "loss-absorbing capacity of technical provisions". They show that while interconnectedness can amplify losses across the financial system in case of liquidity and solvency shocks, insurers' ability to transfer losses to policyholders plays a crucial role in mitigating system-wide contagion. This model was recently run to analyse contagion risk based on the market risk scenario developed for the 2025 EU-wide stress-testing exercise (Grassi et al., 2025).

Overall, there are only a few comprehensive tools available to respond to the developing interest in financial SLST, calling for further investigation.

Assessing the extent to which ESRB member authorities are in a position to conduct such exercises appeared warranted, requiring a check of which tools and data are potentially available for this purpose, as well as whether such tests are operationally feasible and can produce illustrative experimental results. This is addressed in the following sections.

3 Inventory of existing tools and practice

In September 2022 the ESRB warned of the increased risk of liquidity disruptions in the financial markets (ESRB, 2022). One of the severe risks to financial stability highlighted in the warning was a sharp and broad-based asset price correction, which could amplify market volatility and cause liquidity tensions across financial markets. Following this warning, the ESRB acknowledged that a system-wide assessment of the allocation of liquidity risks across all sectors of the financial system was missing. Therefore, the ESRB launched a mapping and identification initiative on key cross-sectoral and cross-asset exposures as well as a cross-sectoral sensitivity analysis to further understand interconnectedness aspects within the EU financial sector.

The first step taken was to launch a survey on SLST frameworks in the EU built on three conceptual pillars. The survey aimed to take stock of SLST frameworks across EU authorities[1] and pursued three operational objectives: (i) provide an overview of approaches available to ESRB member authorities, (ii) identify frameworks relevant for the ESRB cross-sectoral sensitivity analyses or illustrations, and (iii) facilitate the discussion on SLST within the ESRB membership.[2] The survey was structured around three pillars: concept, implementation and results.[3] Each pillar comprised sections covering specific components of a stress-testing framework. The "concept" pillar included questions on the objective, scope and coverage of the SLST framework in place. The "implementation" pillar included questions on data (including data gaps), scenarios (including types of shocks) and models (and underlying assumptions). Finally, the "results" pillar included questions on the use of the results, risk metrics and any further analysis.

The survey provided definitions of systemic liquidity risk and a systemic liquidity stress test but did not specify what an SLST framework should look like. A systemic liquidity risk was defined as the risk that multiple institutions may face simultaneous difficulties in rolling over their short-term debts or in obtaining new short-term funding through widespread dislocations of money and capital markets (IMF, 2011). A systemic liquidity stress test was defined as a liquidity stress test implemented on a group of entities representing a part or the whole of the financial system. At the same time, stress tests that are implemented system-wide may not be systemic in the literature sense of the term, namely they may not consider externalities and interactions within the entities forming the system under review.

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1 The survey was completed by 21 national central banks and national competent authorities as well as by the European Central Bank. Of those 22 authorities, 18 indicated that they have an SLST framework in place, representing 82% of total answers.

2 The survey in this paper is about frameworks developed by EU authorities. At bank level, a survey was conducted in 2008 with the aim of providing a typology of EU banks' liquidity stress-testing techniques (ECB, 2008).

3 The structure was inspired by the survey of practices for solvency stress testing for banks by Baudino et al. (2018), which identified three building blocks in the setup of any stress test: governance (responsibilities and coverage), implementation (technical requirements and design) and outcomes (results and communication). Baudino et al. (2024) have extended this approach to liquidity stress testing, stressing the need for considering jointly banks and non-banks.

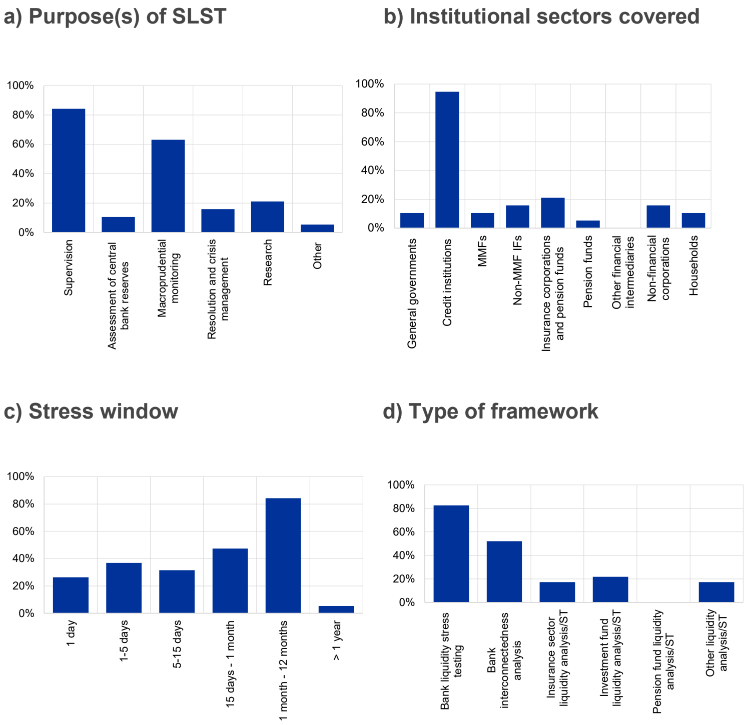
3.1 Objective, scope and coverage of SLST frameworks

SLST frameworks are mainly used for supervision purposes and macroprudential monitoring, with a predominant focus on banks. 83% and 63% of survey answers indicated that supervision and macroprudential monitoring respectively are the purposes of SLST frameworks (Chart 1, panel a). For half of the authorities with an established framework, the framework serves multiple purposes. In terms of sectoral coverage, almost all SLST frameworks focus on credit institutions. In some cases, insurance corporations, pension funds, non-financial corporations and investment funds are also covered (Chart 1, panel b). Regarding the stress horizon, the most common window used in SLST frameworks is between one and 12 months, although some frameworks can consider shorter stress horizons (Chart 1, panel c). Within system-wide liquidity risk analysis, authorities perform mostly bank liquidity stress testing and interconnectedness analysis in 83% and 52% of the cases respectively (Chart 1, panel d).

Chart 1

Objective, scope and coverage of SLST frameworks

(percentages of responses)



Sources: ESRB survey and own calculations.
Note: Percentages of all responses indicating an SLST framework in place.

3.2 Implementation of SLST frameworks

The primary data source for SLST is regular reporting by surveyed entities. 89% of survey answers mentioned entity-level reporting as the main source of information. This was followed by aggregated information (both public and private) and ad hoc data collections, mentioned in 26% and 11% of cases respectively (Chart 2, panel a). A slight majority of authorities use data at the consolidated level, although data at the individual level also play an important role. Regarding the type of reporting, supervisory common reporting (COREP) data (particularly the liquidity coverage ratio (LCR) and maturity ladder templates) emerge as one of the most commonly used sources. Other data sources mentioned by authorities include securities holdings statistics, the Centralised Securities Database and TARGET2 payment system data. Finally, the majority of authorities with an SLST framework in place do not believe they face data gaps. Any new information or data can be collected in an ad hoc manner if needed. From the few authorities mentioning data gaps, banks' behaviour information, accurate investment funds holding data, information from branches of foreign financial firms and forex swaps for funding purposes were highlighted as gaps.

Most SLST frameworks operate with multiple scenarios, frequently incorporating the ECB's liquidity stress-testing scenarios[4] and, in certain cases, adaptations of the ESRB adverse scenarios. The survey results indicate that 74% of authorities employ multiple scenarios, compared with 26% using only a single scenario (Chart 2, panel c). One authority mentioned using multiple scenarios internally, but only disclosed results from one scenario. A commonality in the design and calibration of systemic liquidity stress scenarios is the reliance on historical stress events, expert judgement (including supervisory experience) and benchmark exercises. Idiosyncratic shocks feature prominently in the design of liquidity stress-testing scenarios, mentioned in 84% of answers (Chart 2, panel b). Other important shocks include market freezes and general bank runs (almost 70% of responses).

Top-down stress tests and sensitivity analyses are the most common tools in SLST frameworks, while agent behaviour, contagion effects or feedback mechanisms, and links to solvency stress tests are less prominent. Top-down stress tests are the most common tools, mentioned in 63% of answers, followed closely by sensitivity analysis, mentioned in 58% of answers (Chart 2, panel d). Interestingly, three authorities reported using bottom-up liquidity stress tests, with results typically validated through comparisons with expected outcomes, peer benchmarking and dialogue with the relevant entities. Most SLST frameworks assume static balance sheets and do not incorporate agents' behaviour; however, among those that do, approaches vary. Some have embedded behavioural reactions directly into their stress-testing models, while others apply assumptions on agents' reaction to stress, such as reverting to pre-shock levels. In one case, entities report stress test results before and after accounting for management reactions. Contagion effects and feedback loops are considered in 35% of the frameworks, while 17% of the frameworks include links to solvency stress testing. For those that do, contagion

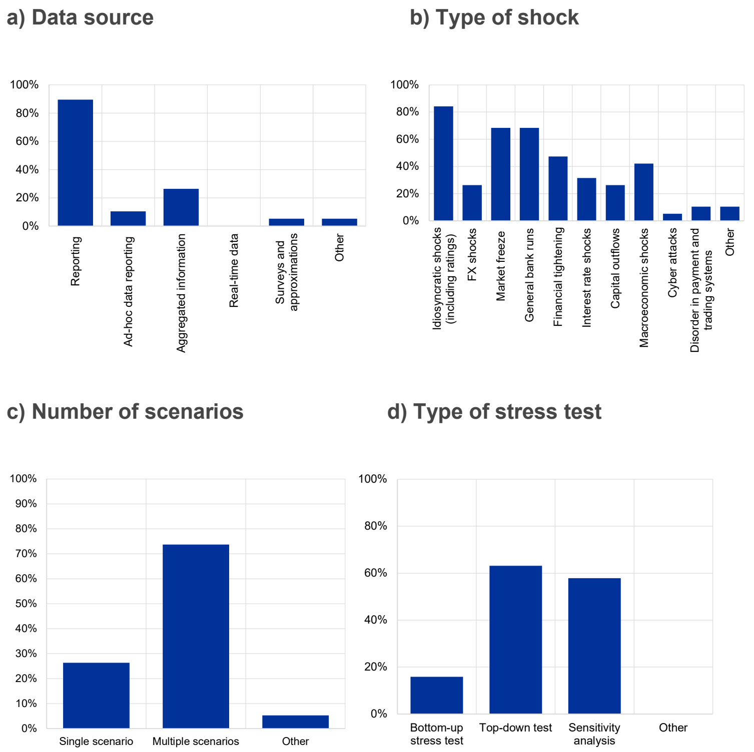
4 See, for example, ECB (2019), "Sensitivity Analysis of Liquidity Risk – Stress Test 2019 – Final results", October.

effects and/or feedback loops are either modelled within and across sectors or through assessments of common exposures. Overall, the integration of liquidity and solvency stress testing remains at an early stage of development.

Chart 2

Data, scenarios and models of SLST frameworks

(percentages of responses)



Sources: ESRB survey and own calculations.
Note: Percentages of all responses indicating an SLST framework in place.

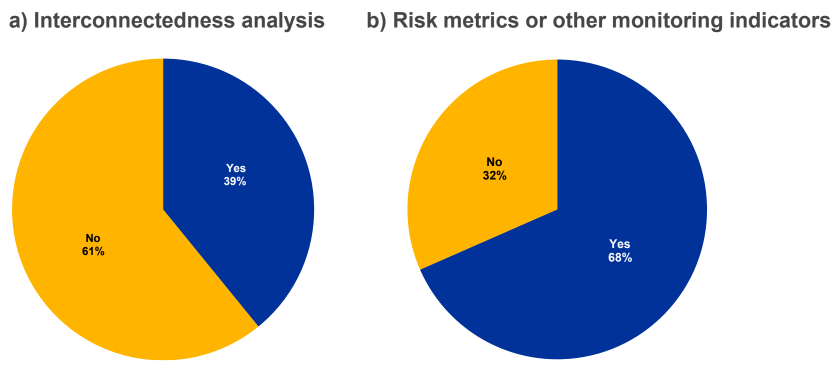
3.3 Use of SLST frameworks

Results are primarily used in supervisory activities, in particular for Supervisory Review and Evaluation Process purposes, while interconnection analyses remain limited in application. Other uses of SLST frameworks are macroprudential monitoring and financial stability assessments. One authority also mentioned the IMF Financial Sector Assessment Program (FSAP) exercise as usage. Risk metrics are often built from the results of systemic liquidity stress tests. The output of SLST frameworks were in 68% of cases used in risk liquidity metrics and other monitoring indicators (Chart 3, panel b). In 39% of cases, interconnectedness analysis complemented SLST frameworks (Chart 3, panel a). Nonetheless, in those few cases, authorities performed a wide range of analyses, such as single name analysis, common inter-exposure evaluations, network analyses, stress of bank-investment funds linkages and interbank interconnections.

Chart 3

Risk metrics, analysis and use of SLST frameworks

(percentages of responses)



Sources: ESRB survey and own calculations.
Note: Percentages of all responses indicating an SLST framework in place.

4 Intersectoral connections in the euro area

A key component of system-wide frameworks is data. Incorporating multiple data sources and varying levels of granularity is crucial to accurately capturing the complex dynamics of financial systems and the transmission and propagation of risk. In this section, we briefly describe the construction of a financial dataset for the purpose of illustrating the key direct and indirect financial exposures in the euro area (financial linkages) and informing the SLST toolkit. Finally, the dataset used in the ECB ISA model is briefly presented.

4.1 Construction of a financial dataset

A comprehensive financial dataset was built to illustrate key financial exposures and stress-testing components. The comprehensive dataset combines multiple data sources available to the ESRB and consists of cross-holdings of financial assets (specifically loans, deposits, debt instruments, fund shares and equities) across the different institutional sectors in the euro area and the rest of the world. The dataset allows matrices (e.g. holder versus issuer) to be constructed at the instrument level and both at the euro area and country level. Pooling different data sources into a single set facilitates the illustration of key financial exposures between sectors and countries and hence helps understand how shocks at the sectoral and instrument level can propagate within a country and/or across countries. Despite this advantage, the dataset is based on statistical information and its level of aggregation does not show single linkages between individual entities or provide information in real time. Furthermore, this level of aggregation does not capture the heterogeneity within specific sectors. Therefore, the dataset cannot provide an accurate and complete assessment of the transmission and impact of shocks stemming from one or a group of entities to the rest of the financial system (see Annex 10.1 for further details on the comprehensive dataset).

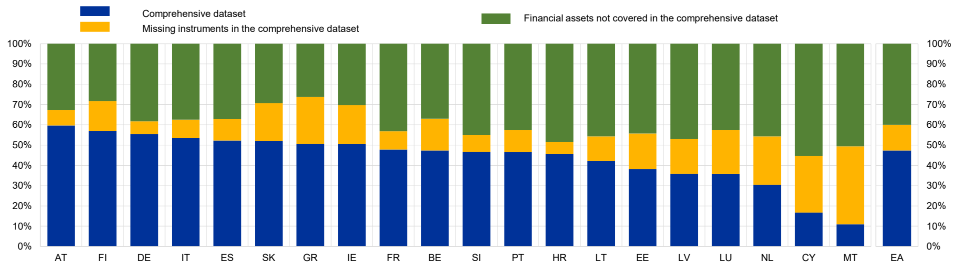
The comprehensive financial dataset covered €83 trillion in financial assets in the euro area as of the fourth quarter of 2023. All the instruments are measured at market value except loans and deposits, which are measured at nominal value. In terms of coverage, the dataset captures almost 80% of similar financial assets in the euro area financial accounts, representing €83 trillion in the fourth quarter of 2023 (Chart 4). The coverage varies across countries, with the share of missing instruments ranging from 6% of total financial assets (Croatia and Germany) to 38% (Malta). The dataset does not include other financial assets such as unlisted shares, financial derivatives and insurance, pension and standardised guarantee schemes (see Annex 10.1 for more details), which on aggregate represent 40% of total financial assets in the euro area.

Chart 4

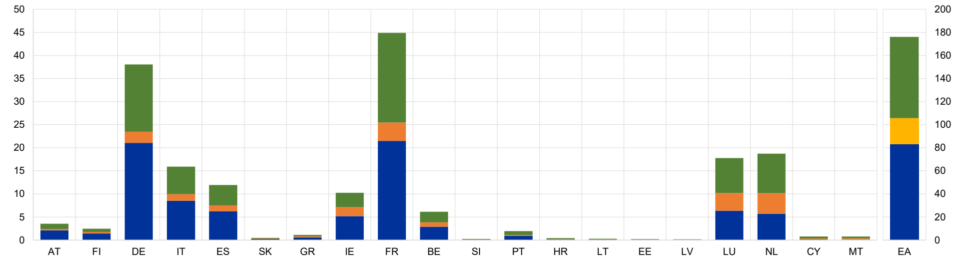
Total financial instruments covered, missing and not covered in the comprehensive dataset

As of the fourth quarter of 2023

(percentages, common instruments and all instruments)



(EUR trillions)



Sources: Quarterly sector accounts, comprehensive dataset and own calculations.
Notes: All institutional sectors are included. "Euro area" (EA) is the sum across euro area countries (unconsolidated). The liability item of deposits from monetary financial institutions other than central banks in the quarterly sector accounts is transformed into an asset item for the respective counterparty (sector and country).

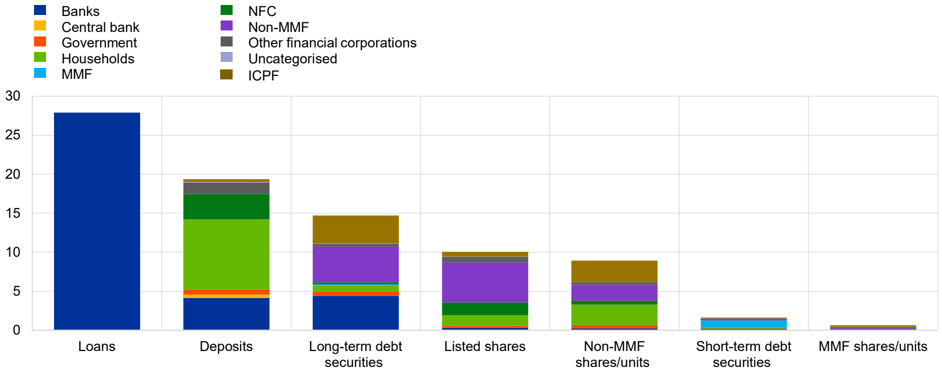
The comprehensive dataset includes the main asset classes in the euro area. The financial assets of financial corporations mainly comprise loans, equity and investment fund shares, and debt securities (Eurostat, 2024). Across instruments in the euro area, loans and deposits represent almost one-third of the comprehensive dataset each: €28 trillion for loans and almost €20 trillion for deposits at the end of 2023 (Chart 5). The next largest asset classes are long-term debt instruments and listed shares, amounting to €15 trillion and €10 trillion respectively. Among holders of financial assets in the comprehensive dataset, banks are the largest sector (measured by the size of the instruments held), holding around €37 trillion in those assets where loans are the major asset. The next largest holding sectors are households and non-money market fund (MMF) investment funds, with around €14 trillion and €12 trillion respectively by the end of 2023.

Chart 5

Composition of the comprehensive dataset by holder and instrument

As of the fourth quarter of 2023

(EUR trillions)



Source: Comprehensive dataset.
Notes: “Households” includes non-profit institutions serving households, “ICPFs” stands for insurance corporations and pension funds, “MMFs” stands for money market funds, “NFCs” stands for non-financial corporations, and “non-MMFs” stands for non-MMF investment funds. Holdings from the Eurosystem are not available and hence the numbers for “central banks” are not representative. “Deposits” are liabilities from monetary financial institutions other than central banks transformed into assets for the respective reported counterparty.

4.2 Direct and indirect exposures

The comprehensive financial dataset enables the mapping of major financial linkages between sectors and countries. From this mapping, we first examine direct exposures, which refer to bilateral financial obligations (e.g. listed shares, loans, securities holdings) between institutional sectors. These obligations can have a financial impact on the holder if the issuer defaults. These financial obligations are illustrated in a bilateral network. Second, we analyse indirect exposures, which transmit vulnerabilities without direct financial ties. Indirect exposures primarily arise from common exposures to similar assets (e.g. overlapping portfolios), shared funding markets (e.g. reliance on similar funding sources) or exposures to third parties.

The bilateral network of the financial system shows that banks are the most interconnected institutions in the euro area. Chart 6 shows bilateral networks of financial linkages across sectors in the euro area. Not surprisingly, the financial system in the euro area as a whole relies heavily on bank intermediation (Chart 6, panel a). At the end of 2023 banks were mainly interconnected with themselves, households and non-financial corporations but also connected with the rest of the world[5]. Non-MMF investment funds are significantly connected with insurance corporations, pension funds, households in the euro area and with sectors outside the euro area (i.e. the rest of the world). Monetary financial institutions in France as well as the Irish and Luxembourgish non-MMF investment fund sectors have important connections with the rest of the world (Chart 6, panel b). Without considering linkages outside the euro area, the main linkages are between Italian

[5] The rest of the world refers to countries outside the euro area.

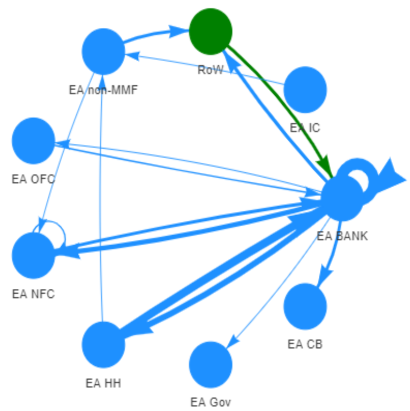
and German households, Italian insurance corporations and Luxembourgish non-MMF investment funds, and Luxembourgish banks and German and French banks (Chart 6, panel c). Finally, the rest of the world has significant claims (deposits) in German, Dutch, Belgian and Luxembourgish banks (Chart 6, panel d).

Chart 6

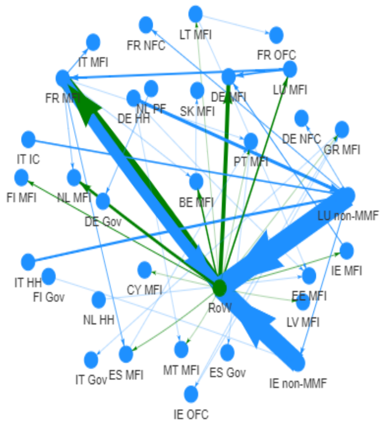
Bilateral network of main financial linkages in the euro area

As of the fourth quarter of 2023

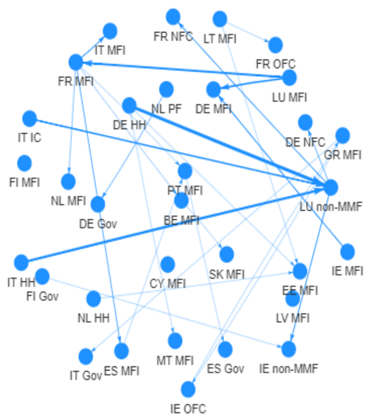
a) All aggregate exposures



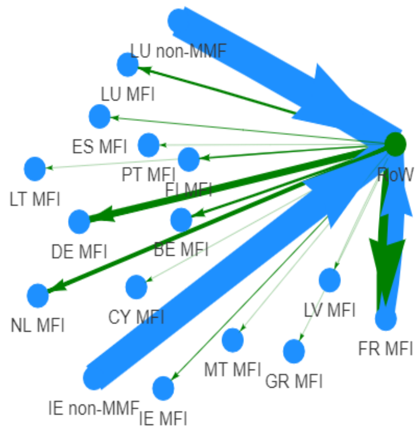
b) All country-sector exposures



c) Only country-sector exposures within the euro area



d) Only country-sector exposures to the rest of the world



Sources: Comprehensive dataset and own calculations.
Notes: Holdings of the European System of Central Banks are not available and hence the key exposures of central banks (CBs) are not representative. Deposits of non-EU sectors placed in euro area banks are not part of the chart. “NFCs” stands for non-financial corporations. “HHs” stands for households and non-profit institutions serving households. “ICs” stands for insurance corporations. “PFs” stands for pension funds. “Non-MMFs” stands for investment funds other than money market funds. “Gov” stands for government. “OFCs” stands for other financial corporations. “CBs” stands for central banks. “RoW” stands for rest of the world. Not all financial linkages are shown, as a (subjective) materiality threshold of 10% of total claims is used to keep the most significant linkages. The nodes are of uniform size. All EU sector nodes are in blue. The rest of the world node is green. The edges between nodes, representing the claims of one holder sector towards another, are divided by a scaling factor which depends on sum of the total market value of the claims.

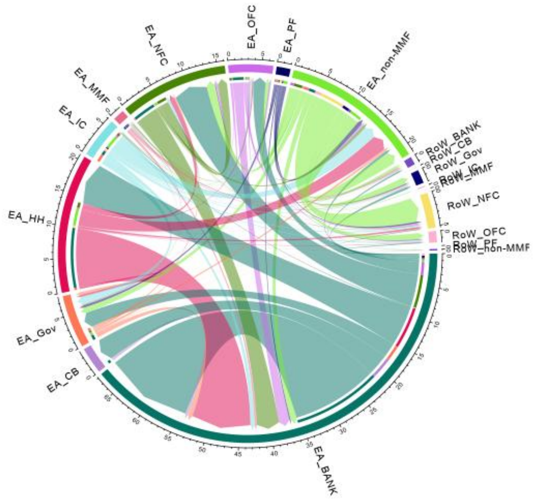
The cross-linkages between sectors in the euro area illustrate the major funding dependencies in the financial system. In the financial networks, institutional sectors act either as funding providers or funding receivers (Chart 7).

Banks are both the main funding providers and main funding receivers. Non-MMF investment funds are important fund providers to entities in the rest of the world. Interestingly, securities from issuers outside the euro area (rest of the world) accounted for 51% of non-MMF investment funds’ aggregate portfolio, while the rest (49% of the aggregated portfolio) were securities issued in the euro area. This is also valid for MMFs. This important link is also shown in the previous chart.

Chart 7

Cross-sectoral interlinkages in the euro area

As of the fourth quarter of 2023



Sources: Comprehensive dataset and own calculations.
Notes: The direction of an arrow shows exposures from a fund provider to a receiver. Figures are not scaled. Country-specific cross-sectoral networks are shown in the annex. Holdings of the European System of Central Banks are not available and hence the key exposures of central banks (CBs) are not representative.

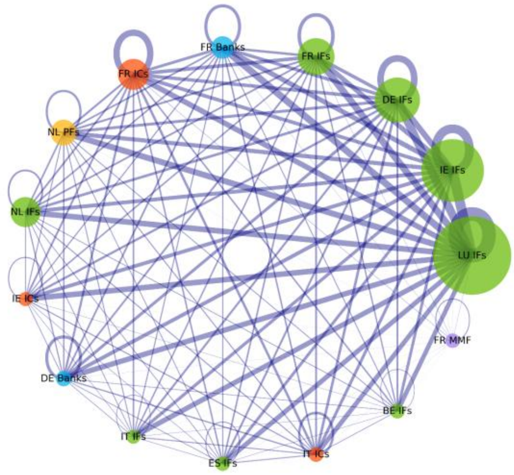
Indirect exposures can transmit shocks across the financial system and lead to financial contagion. According to Clerc et al. (2016), indirect contagion occurs when firms’ actions generate externalities which affect other firms through non-contractual channels: market price and information channels. Holdings of the exact same asset can transmit liquidity shocks across institutional (sub)sectors, even though those sectors are not directly linked to each other. Therefore, portfolio overlaps in the same assets could outweigh direct contagion effects as the primary source of systemic risk (Elsinger, Lehar and Summer, 2006, and Poledna et al., 2021). Chart 8 shows the common cross-sectoral exposures (overlapping portfolios) of debt instruments, listed shares and investment fund shares between euro area countries and sectors.

Investment funds in the euro area have portfolio overlaps with themselves but also with other institutional subsectors. These common portfolios are particularly relevant among Luxembourgish, Irish and German investment funds, which are also the major investment fund jurisdictions in the euro area. This relationship also takes into consideration the size of instrument holdings by these entities compared with the total amount of holdings in the euro area.

Chart 8

Common cross-sectoral exposures to debt securities, listed shares, MMF shares and non-MMF shares in the euro area

As of the fourth quarter of 2023



Sources: Comprehensive dataset and own calculations.
Notes: Portfolio overlap charts encompass only debt instruments, listed shares, MMF shares and non-MMF investment fund shares. The nodes (circles) represent the total holding amount of the financial instruments considered for a holder area and holder sector (e.g. IE banks). The node size is proportional to the total holding amount in the EU. The edges between the nodes connect two holders (e.g. IE banks and LU IFs) when having the same security. The thickness of the edges is the sum of the holding amount of the same security between the two holders proportional to the sum of the holding amount of all securities of the two holders. To improve graph readability, nodes and edges are multiplied by a constant and divided by the value of the lowest node in the chart. Only the top 15 nodes for total holdings and the corresponding edges are displayed in the chart. Overlapping portfolio charts by financial instrument are shown in the annex.

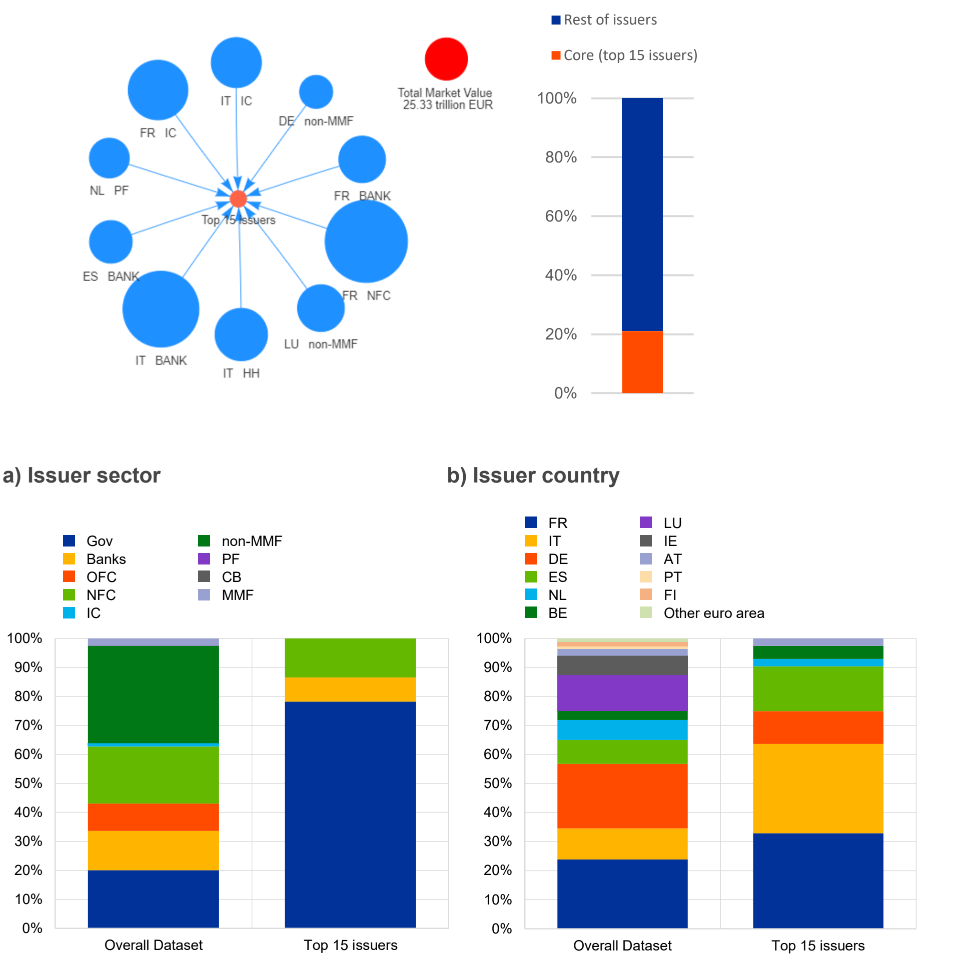
The concentration of holdings among certain issuers or of individual instruments is also a measure of indirect interconnection. This form of concentration can exacerbate the transmission of credit and liquidity shocks that a default of the counterparty or an asset/instrument price movement could trigger. Chart 9 shows the concentration of holdings by issuer in the euro area – also called sun charts. The red node in the middle of the sun represents the relative market value of the holdings in the euro area issued by the top 15 issuers as of the fourth quarter of 2023. The blue nodes represent the major country-sector holders of assets issued by those top issuers. In the euro area, 21% of the total holdings of debt securities, listed shares, MMF shares and non-MMF investment fund shares are issued by the top 15 issuers. These are held by sectors in specific countries, mainly France, Italy and Spain. The sectoral and country distribution of the top 15 issuers is less diversified than the sectoral distribution of issuers for all holdings. Governments are the main issuer sector among the top 15 issuers, representing almost 80% of the holdings issued by the top 15 (Chart 9, panel a). Similarly, France, Italy and Germany are the main issuer countries among the top 15 (Chart 9, panel b). Concentration is also valid at the individual instrument level. On the other hand, Chart 10 below shows the concentration of holdings by individual debt securities in the euro area. The red core in the middle of the sun represents the relative market value of the holdings of the largest International Securities Identification Number (ISIN) debt securities in the euro area. The largest ISIN securities are defined as the top 1% of all ISIN debt securities held in the euro area. At the ISIN level, 72% of the market value of holdings of debt securities are placed on the top 1% of all ISINs from debt securities held by sectors in the euro area. Similar to the concentration by issuer, the largest ISIN securities are issued by governments, followed by banks (Chart 10, panel a), which is again a different composition compared with the overall dataset.

Chart 9

Concentration by holders of debt securities, listed shares, MMF shares and non-MMF shares issued by the top 15 issuers in the euro area

As of the fourth quarter of 2023

(EUR trillions)



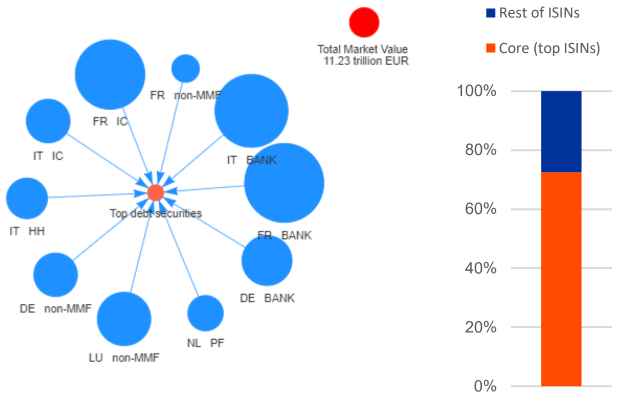
Sources: Comprehensive dataset and own calculations.
Notes: The blue nodes represent the significant holders, i.e. the holders which hold more than 2.5% of the core (i.e. the red node in the middle). The core represents the market value of the holdings in the euro area issued by the top 15 issuers. The size of the core is proportional to the total market value of all holdings in the euro area, which is represented by the red node in the top right of the chart. Observations with an unrecognisable legal entity identifier (LEI) code (issuer) are deleted. The blue nodes have the same scale. The core and the red node in the top right of the chart are scaled down by 100. One node is not shown in the chart due to confidentiality checks. The total number of issuers (identified by their LEI code) in the database is 46,416.

Chart 10

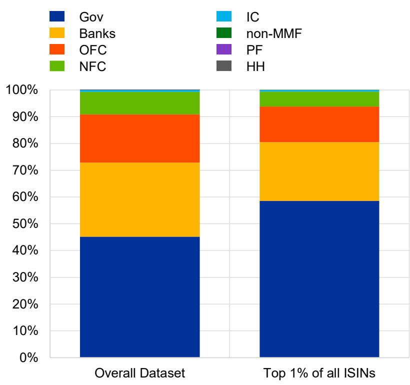
Concentration by holder of largest debt securities by ISIN in the euro area

As of the fourth quarter of 2023

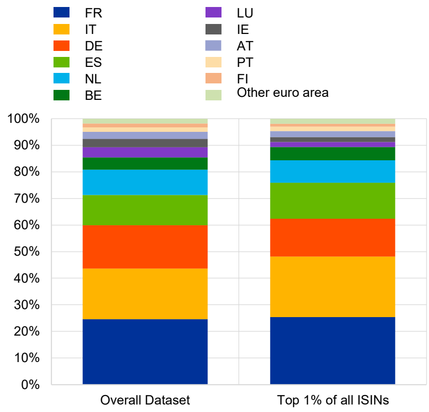
(EUR trillions)



a) Issuer sector



b) Issuer country



Sources: Comprehensive dataset and own calculations.
Notes: The blue nodes represent the significant holders, i.e. the holders which hold more than 1% of the core (i.e. the red node in the middle). The core represents the market value of the largest ISIN debt securities held in the euro area. The largest ISIN securities are defined as the top 1% of all ISIN debt securities held in the euro area. The size of the core is proportional to the total market value of all holdings of debt securities in the euro area, which is represented by the red node in the top right of the chart. Observations with an unrecognisable LEI code (issuer) are deleted. The blue nodes have the same scale. The core and the red node in the top right of the chart are scaled down by 100. Four nodes are not shown in the chart due to confidentiality checks. The total number of debt securities (identified by their ISIN code) in the database is 506,551

4.3 ECB ISA dataset

The ECB ISA model runs on a very granular dataset that combines entity-level and instrument-level information to provide a comprehensive view of the financial system. It is built based on a dedicated data assembly process, taking information from a range of regulatory data sources and commercial data providers. For the banking sector, the relevant information is retrieved from AnaCredit, supervisory reporting (i.e. financial reporting (FINREP) and COREP) and securities holdings statistics by group (SHSG). The insurance data stem from EIOPA Solvency II reporting templates combined with securities holdings statistics by sector (SHSS).

Commercial data from Refinitiv Lipper IM are used for investment funds. Specifically, the banking sector comprises 287 large, consolidated banking groups within the euro area, while the insurance sector consists of 20 country-level sector aggregates. The investment fund sector includes 22,406 open-end investment fund groups domiciled in the EU and other major jurisdictions, mostly in the United States. Portfolio information is available for 12,413 of them, the rest being only present on their liability side (held by other institutions), as their assets are not available in the Lipper IM dataset. The results primarily cover the 7,367 fund groups domiciled in the euro area (2,386 with portfolio information). It is important to note that the funds domiciled outside the euro area are active entities of the network and contribute to the propagation of the shock, thereby having an influence on the results reported for European funds. The data collected for this exercise is from the end of December 2023.

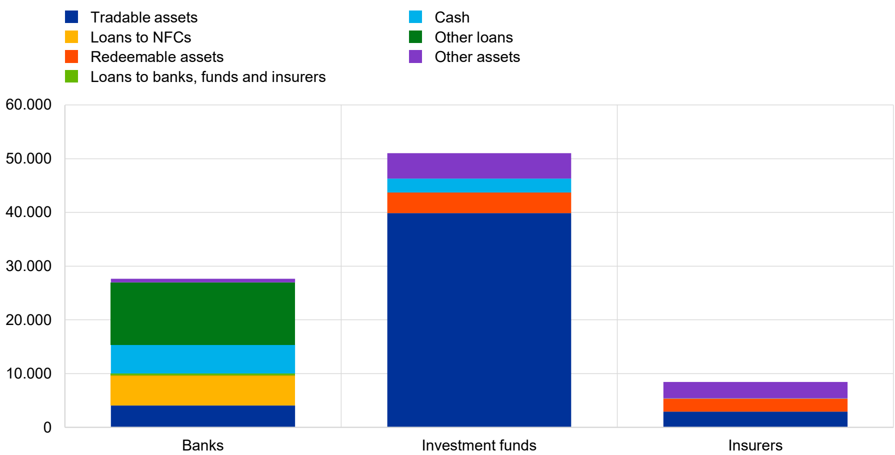
The comparison of the asset-side balance sheet composition across the different sectors resembles the asset coverage outlined in the previous sections. Chart 11 shows that market exposures cover the largest share of financial institutions' total assets. However, there are sizeable differences across sectors: the market portfolio (bond and equity holdings) accounts for only 15% of banks' total assets, while it comprises 35% of insurers' assets and 78% of investment funds' assets. By contrast, loan portfolios cover 63% of banks' total assets, representing the most relevant balance sheet item for the banking sector.

Chart 11

Decomposition of the asset-side balance sheet for the sectors included in the ISA model

As of the fourth quarter of 2023

(EUR millions, asset valuation)



Source: ECB.
Note: Redeemable assets refer to the shares issued by open-end investment funds, which can be redeemed on demand.

5 Aggregate liquidity shock scenario

Stress scenarios are a fundamental tool for assessing the impact of liquidity shocks across the financial system. System-wide liquidity stress arises from aggregate liquidity shocks, defined as changes in net liquidity within a given country or region (Oura, 2022). To realistically capture the dynamics of financial crises, adverse liquidity scenarios must incorporate both market shocks (e.g. asset price declines, interest rate volatility, spread widening) and funding liquidity shocks (e.g. deposit runs, investment fund redemptions, surrenders) simultaneously. This dual-shock approach reflects the empirical observation that market and funding stresses are often correlated. However, designing such scenarios presents significant challenges, particularly in modelling the interaction between market conditions and behavioural responses while preventing shocks from being calibrated under unrealistic assumptions.

In this paper, the adverse liquidity scenario quantifies both market risk (via asset price shocks) and funding risk (via volume outflows) under a hypothetical stress narrative. Importantly, the scenario is not a forecast of the most likely adverse developments, but rather a plausible stress configuration. Asset price shocks are calibrated using the ECB's Financial Shock Simulator (ESRB, 2019), applied as instantaneous deviations from end-2023 levels. To ensure internal consistency, volume shocks are derived using estimated elasticities from the literature, linking asset price changes to scenario-conditional outflows. These outflows are computed for banks (deposit run-off rates), investment funds (redemption rates) and insurance corporations (surrender rates). While the overall stress horizon is one year, volume shocks are rescaled to a 30-day horizon to reflect the short-term liquidity pressures relevant for stress testing.

5.1 Narrative and methodology

For banks, the calibration of deposit run-off rates is critical, as deposits represent their primary funding source. These rates are estimated using elasticities that link deposit flows to bank-specific risk shocks, drawing on studies such as Egan, Hortaçsu and Matvos (2017), which was later expanded by Albertazzi et al. (2022) and Artavanis et al. (2022). The bank risk shock is proxied by changes in credit default swap (CDS) spreads, calibrated over a one-year horizon to reflect gradual risk deterioration, while allowing for frontloaded outflows consistent with the concept of "slow-motion runs" (He and Manela, 2014). CDS shocks are applied by rating bucket, resulting in heterogeneous run-off rates across banks, and take into account the correlation over time of CDS spreads across such buckets, capturing the role of common risk factors that affect banks' solvency. This approach captures the potential for deposit migration across banks while preserving the system-wide nature of the scenario. Additionally, deposit run-off rates are differentiated between insured and uninsured deposits to reflect varying withdrawal incentives.

For investment funds, redemptions can be a source of liquidity stress, especially if they hold illiquid assets. Redemption shocks in investment funds are therefore calibrated using flow-performance relationships, where weaker fund performance leads to higher outflows (Aikman et al., 2019; Baranova, Douglas and Silvestri, 2019). Monthly outflows or redemption rates $r_{I,t}$ are computed using the formula:

$$r_{i,t} = \rho \cdot (p_{i,t} - p_{i,t-1}) * (1 + \beta)$$

where $p_{I,t}$ is the price of the fund i at time t, ρ is the flow-performance coefficient and β is an add-on by asset class capturing the possible steepening in the relationship between asset price shocks and redemption rates under stressed liquidity conditions. The add-on is calibrated using observed redemption behaviour during the March 2020 market turmoil (β=0.6). Portfolio duration is also considered where relevant. Although the shock horizon is 30 days, the calibration is derived from a one-year horizon using the square-root-of-time rule.

For insurance corporations, surrender rates represent the proportion of policyholders who voluntarily terminate their life insurance contracts before maturity. These rates are modelled as a function of changes in long-term government bond yields, following Grochola, Gründl and Kubitza (2023):

$$s_{i,t} = \kappa \cdot \Delta Y_{c(i),t}$$

where the country-specific ten-year government bond yield change, $\Delta Y_{c,t}$, is multiplied by an estimated coefficient κ to produce the surrender rate.

The adverse liquidity scenario is anchored to a narrative similar to that used in the EIOPA 2023 insurance sector stress test (ESRB, 2024). The scenario envisions a deterioration in geopolitical conditions and global supply chains, triggering heightened market uncertainty and a flight to quality. Rising commodity prices and widespread asset sell-offs increase volatility and margin calls, intensifying liquidity pressures. Tighter financial conditions and rising interest rate expectations lead to a dash-for-cash dynamic, affecting financial institutions unevenly. Liquidity outflows are partially reallocated to safer institutions or foreign assets, resulting in milder shocks for entities with stronger risk profiles. This heterogeneity is consistent with differentiated tightening in sovereign financing conditions and the typical behaviour observed during flight-to-safety episodes.

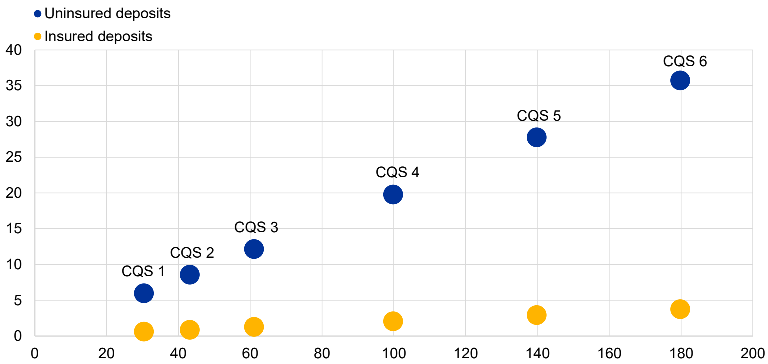
5.2 Link between price and volume scenarios

The credit quality of banks is a key factor in maintaining market confidence. A decline in a bank's credit quality can raise concerns about its solvency, particularly during periods of financial stress. Such uncertainty may prompt deposit withdrawals, especially among uninsured depositors who are more sensitive to the bank's solvency risk. Additionally, deposit run-offs can become self-reinforcing, as increased liquidity pressures further weaken the bank's financial position. In financial markets, the CDS spread reflects investors' risk perceptions and can signal distress to both depositors and counterparties. These considerations are the basis behind the methodology described above, which estimates volume shocks for banks (deposit run-off rates) by using changes in banks' CDS spreads. Chart 12 shows this estimation. For example, a larger increase in a bank's CDS spread over a 30-day period corresponds to a higher deposit run-off rate. Between types of deposits, the run-off rate is also significantly higher for uninsured than insured deposits.

Chart 12

Monthly deposit run-off rates by credit quality step

(x-axis: basis points, y-axis: percentage)



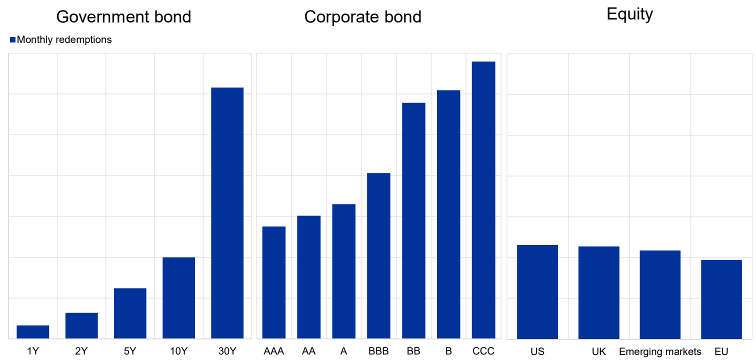
Source: Own calculations.
Notes: The chart shows the monthly run-off rates of banks associated with different CDS shocks per credit quality step bucket, defined according to the banks' rating, by type of deposit. Given a shock to CDS spreads (x-axis) associated with a certain credit quality step, two different shocks per deposit type are derived, in the same column in the chart, according to Egan, Hortaçsu and Matvos (2017). Yellow dots refer to insured deposits, while blue dots refer to uninsured deposits. The classification of credit quality steps depends on the rating, according to the External Credit Assessment Institutions mapping.

Redemption rates in investment funds are closely linked to market indicators reflecting credit risk and investor sentiment. Widening corporate bond spreads typically signal deteriorating credit conditions, which can prompt redemptions from funds holding corporate debt. Similarly, rising government bond spreads may indicate increased sovereign risk, leading investors to withdraw from government bond funds. Significant declines in stock indices also serve as indicators of market distress, often resulting in higher redemption rates from equity funds. Chart 13 shows the impact of these market indicators on the redemption rates of investment funds, taking into account the flow-performance relationship of such funds. For corporate bond funds, redemption rates tend to rise as the credit quality of the underlying portfolio declines. In the case of government bond funds, redemption rates increase in line with the maturity profile of the underlying bonds. In line with the methodology outlined above, these rates include an add-on.

Chart 13

Monthly redemption rates by fund type exposure

(y-axis: percentages)



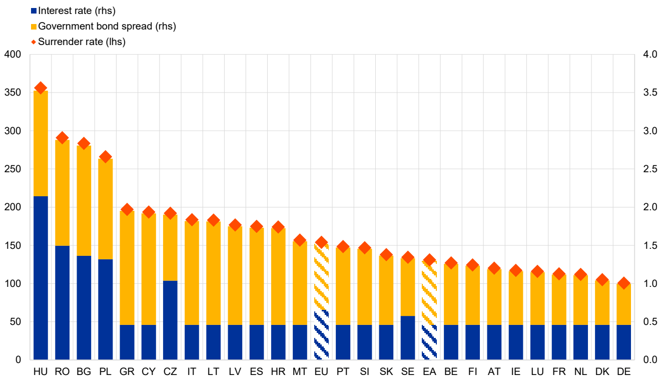
Source: Own calculations.
Notes: The chart shows the estimated redemption rates, per each fund type, in relation to their relevant exposures (x-axis). The relationships between the shock to a certain asset class/fund type and the corresponding redemption rate is derived according to Baranova et al. (2017) and Aikman et al. (2019). The left panel refers to government bond funds, the middle panel to corporate bond funds, and the rightmost panel to equity funds. The one-month-ahead redemption rates shown are reported shocked asset classes on the x-axis and represent the redemption rate affecting a fund if its portfolio was fully exposed to that asset class.

Movements in government bond yields can significantly influence the behaviour of insurance policyholders. They are a trade-off between the cost of forfeiting insurance coverage against the potential for higher investment returns elsewhere. As government bond yields rise, the incentive to surrender insurance policies increases, as policyholders seek better returns. Chart 14 shows the estimated surrender rates by EU country, based on changes in the shocked ten-year government bond spread and taking into account the risk-free rate.

Chart 14

Yearly surrender rates associated with shocks to ten-year government bond yields

(y-axis (left): basis points; y-axis (right): percentages)



Source: Own calculations.
Notes: The chart shows one-year-ahead shocks to ten-year interest rates (swap rates) and government bond spreads (y-axis, left) and the associated surrender rates (y-axis, right), by country (x-axis). The surrender rates (red diamonds) are estimated according to Grochola, Gründl and Kubitza (2023). The sum of the shocks to risk-free rates (blue bars) and spreads (yellow bars) results in a total shock to ten-year government bond yields.

6 Modelling approaches

A stress-testing framework for system-wide liquidity has different layers of complexity. SLST is a hypothetical exercise in which net liquidity is removed from the whole financial system – also framed as an aggregate liquidity shock (Oura, 2022). While standard supervisory liquidity stress tests are conducted on an entity-by-entity basis, SLST requires externalities of various kinds to be accounted for, although it does not fully cover all the entities in the system. These externalities are meant to capture direct or indirect spillovers across entities as well as amplification mechanisms within the system. As a result, modelling contagion channels (through direct and indirect linkages) and feedback loops are key elements for conducting such stress tests. Overall, the systemic element lies in the occurrence of simultaneous liquidity difficulties at multiple financial entities affecting key asset markets, as well as the creation of bidirectional interactions between funding and market liquidity conditions (ESRB, 2025).

The impact of an aggregate liquidity shock is assessed in this paper via a dual-desktop liquidity stress-testing approach and a fully fledged system-wide stress-testing model. The first approach is a jurisdiction desktop exercise that relied on making use of existing sectoral liquidity stress-testing desktop models developed by national and EU supervisory authorities (e.g. national competent authorities, EIOPA, the European Securities and Markets Authority (ESMA) and ECB Banking Supervision). The second approach is an area-wide and cross-sectoral desktop exercise which required the development of a simple stress-testing tool inspired by an original IMF SLST tool (Oura, 2022). This is called the ESRB balance sheet tool and covers all sectors in the euro area at aggregate level, which is also in line with the IMF recommendation to further develop system-wide stress testing in the euro area building on the FSAP approach (IMF, 2025). The fully fledged model is the ECB ISA model, which is a top-down model that works at the entity-level covering the whole euro area.

The results from the exercise only provide a range of outcomes derived from a given common single adverse scenario. These results are not projections and not all of them consider feedback loops, except for the results achieved through the ECB ISA model. On the one hand, the jurisdiction-specific desktop models generate results at the entity level for a given sector and jurisdiction.[6] These results are then aggregated across jurisdictions to get the overall liquidity impact. However, since the liquidity impact comes from individual and jurisdiction-specific models, no cross-sectoral interactions and second-round effects at the EU level are applied or captured. Despite this, the results can still illustrate differences across countries in terms of liquidity needs and structures. On the other hand, the area-wide and cross-sectoral models consider contagion mechanisms. The ESRB balance sheet tool computes results at the sectoral level within the euro area, including banks, insurance corporations and investment funds. Based on simple assumptions, the

6 A jurisdiction can cover one or multiple countries depending on the authority.

model considers contagion channels and agent behaviour without running several rounds until asset prices and entities' financial conditions are stabilised. Those stabilisation dynamics are instead considered in the ECB ISA model, which runs at the entity level.

The exercise builds upon common methodological guidance. This guidance involved a minimum set of instructions and assumptions to ensure consistency across models and comparability of results. The assumptions were expected to be considered on a best-effort basis. Additional assumptions were also allowed under the condition that they were aligned with the common methodology and with the adverse liquidity scenario.

The main assumptions in the common guidance were on haircuts, liquidation strategy (also called pecking order) and liquidity flows. For all sectors, the haircuts by asset class stem from the LCR regulation and were applied to the market value of the stock of liquid assets before stress. In addition, a pro rata liquidation was assumed per default, meaning that sectors liquidate assets proportionally to the structure of their liquid assets before stress. Alternative liquidation strategies were also considered, such as the waterfall approach (i.e. sectors exhaust cash holdings before selling liquid assets from the highest quality to the lowest) and the upstream approach (i.e. financial entities sell liquid assets from the lowest quality to the highest).

Additional assumptions on liquidity inflows and outflows beyond the scenario-driven run-off rates were mainly applicable to banks. Contractual deposits followed the deposit outflow rates, while overnight deposits were assumed to progressively flow out within a period of six months. Inflow rates from loans and advances from retail customers and non-financial customers were calibrated using the shares of stage 2 and stage 3 loans estimated at the EU level under the adverse scenario. For investment funds, a passive approach by fund managers was assumed with no additional assumptions, including no management actions. For insurance corporations, surrender penalties – both contractual and fiscal – were considered to classify lapses, with higher penalties indicating a lower likelihood of lapse.

The models run at the highest level of consolidation and based on year-end 2023 figures. The shocks included in the liquidity adverse scenario were meant to be applied to the stocks of liquid assets as of 31 December 2023. The exercise was conducted at the highest level of consolidation at the jurisdictional level. Moreover, participant authorities from the euro area countries provided a set of results also for less significant credit institutions to complement the results obtained from the ECB Banking Supervision model. This paper only presents the main results from the jurisdiction-specific models at an aggregate level.

6.1 Jurisdiction-specific approach

The jurisdiction-specific stress-testing desktop approach is an exercise built upon existing EU sectoral and national liquidity stress-testing frameworks. In terms of coverage, the exercise covered a substantial share of the main financial sectors in the EU: 90% of total assets for banks, 75% of total assets for insurance corporations and 84% of total assets for investment funds (Chart 15). The models used were designed and calibrated independently. This mirrors the typical jurisdiction-specific exercises, where financial entities rely on their own models, data and general assumptions. For this reason, the minimum guidance played a crucial role in ensuring consistency across the exercise.

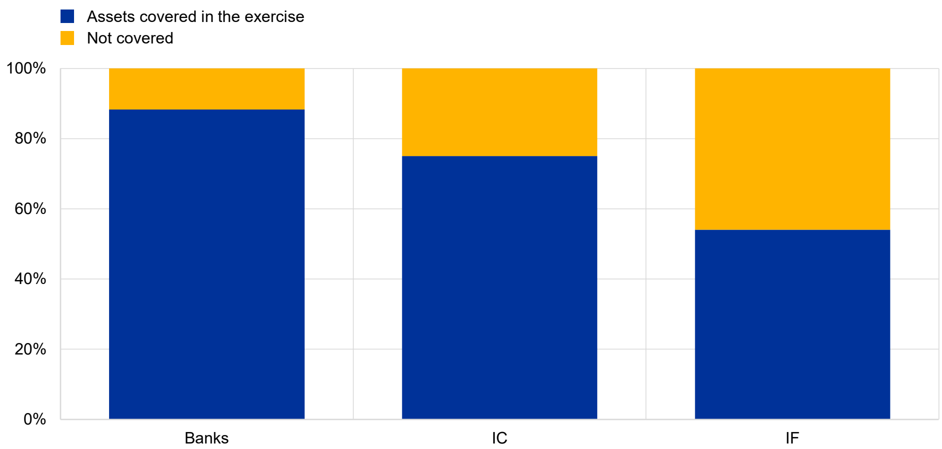
Participation by authorities was voluntary and conducted on a best-effort basis. ECB Banking Supervision participated with its own euro area liquidity stress-testing model, delivering to a greater extent country-specific results, while ESMA participated with its STRESI framework (ESMA, 2019). EIOPA provided data from the 2024 EU-wide insurance sector stress-testing exercise, given that its adverse market risk scenario is aligned with the common adverse liquidity scenario (see Annex 10.2 for a list of participant authorities).

Chart 15

Coverage of the jurisdiction-specific exercise

As of the fourth quarter of 2023

(percentages of total assets in the respective sector)



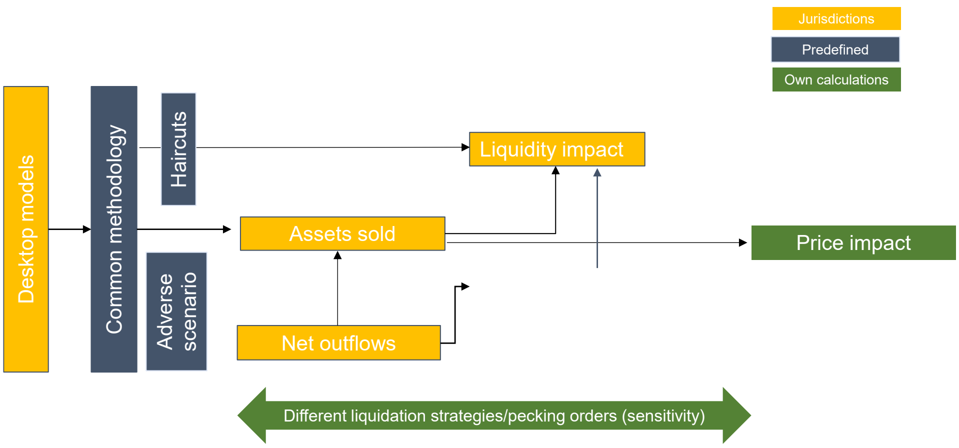
Sources: ECB, ESMA, EIOPA, EBA and own calculations.
Notes: “ICs” stands for insurance corporations. “IFs” stands for investment funds. The coverage of investment funds is based on total assets held by undertakings for collective investment in transferable securities (UCITS) bond funds and mixed funds in the euro area.

The exercise aims to quantify the impact of the adverse scenario on the financial system under common assumptions for different time horizons. The exercise assumes a constant balance sheet beyond the outflow and inflow assumptions and liquidation strategy prescribed in the minimum guidance. For banks, flows were estimated at different stress horizons: five days, 30 days, six months and one year. For investment funds, flows were calculated for a stress horizon of 30 days. For insurance corporations, the flows were reported for a 90-day stress horizon, but for comparability purposes, they were rescaled to five days, 30 days, six months and one year stress horizons (see Annex 10.6 for further details). Contrary to solvency stress tests, stress windows for liquidity stress testing longer than 90 days are less likely to materialise because of management actions, supervisory intervention, central bank support and market dynamics.[7] At the same time, gathering counterfactual information on what may happen well beyond the LCR horizon helps identify critical moments and funding sources. Net stable funding ratio (NSFR) calibration and IMF FSAP exercises also consider much longer horizons than the LCR.

The results from the jurisdiction-specific exercise focused on the first-round effects of the assumed liquidity shocks. Participant authorities computed results using a common methodology and adverse scenario. These results were on the net outflows, on the amount of assets sold and/or cash reserves used and on the impact of entities' liquidity positions (Chart 16). For the jurisdiction-specific exercise management actions, supervisory interventions, central bank support and price impacts triggered from the sell-off of assets under the adverse scenario were not directly considered, even if the adverse scenario implicitly embeds cross-sectoral spillovers and amplification mechanisms, as the shocks are consistent with tail moments of their distribution. Nonetheless, the aggregated results from the jurisdiction-specific desktop exercise were used to assess potential second-round effects using additional and separate models linking asset prices to sales.

Chart 16

Conceptual design of the jurisdiction-specific exercise



Notes: The dark blue boxes show the contribution from the minimum guidance. The yellow boxes show the contribution form the jurisdiction-specific models. The green boxes show the additional calculations by the authors.

[7] The six-month stress window was also considered in, for example, the SSM liquidity stress-testing exercises. The one-year stress window is kept to reflect the supervisory reporting of banks' counterbalancing capacity and the adverse scenario time span. The NSFR also considers an attrition rate up to that maturity.

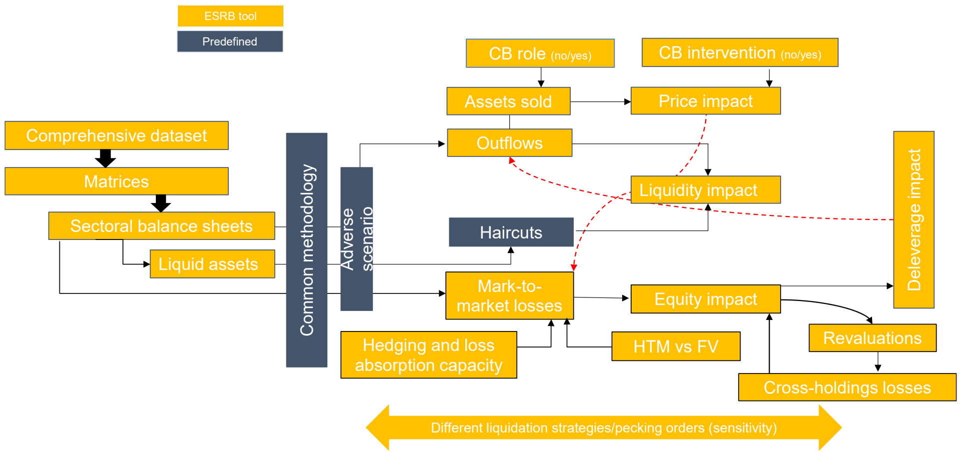
6.2 Cross-sectoral and area-wide approaches

6.2.1 ESRB balance sheet tool

A cross-sectoral and area-wide liquidity stress-testing model was developed inspired by the conceptual framework suggested by the IMF. The IMF conceptual framework consists of four steps. The first step is to understand the key sectors and financial linkages and to identify relevant adverse liquidity stress scenarios. The second step is to model a (cash)flow liquidity stress test at the sectoral level. The third step is to include to the extent possible contagion channels from one sector to another under a variety of behavioural assumptions. The fourth step is to consider the impact of central banks' liquidity policy options. Following those steps, the conceptual design of the ESRB balance sheet model started from the comprehensive dataset as described in Section 4, which was instrumental in developing a simple liquidity flow stress-testing model (Chart 17). The tool using the adverse scenario generated the liquidity and equity impact of aggregated liquidity shocks. The tool was complemented with second-round effects, behavioural assumptions and central bank interventions (e.g. access to central bank funding and the impact of non-conventional monetary policy).

Chart 17

Conceptual design of the ESRB balance sheet tool



Notes: The yellow boxes show the contribution form the ESRB balance sheet tool. "HTM" stands for held to maturity. The dark blue boxes show the contribution from the minimum guidance. "FV" stands for fair value. "CB role" refers to access to central bank funding. "CB intervention" refers to non-conventional monetary policy.

The ESRB balance sheet tool consists of interlinked modules and is Excel-based. The modular approach enhances usability by separating key functions into dedicated modules.

(a) The first module serves as the input layer, incorporating the comprehensive dataset along with ECB collateral aggregated at the country level.

(b) The second module structures the input data into asset and liability items (instruments) by holder sector, counterparty sector, maturity, credit rating, type[8] and geographical region.[9]

(c) The third module simulates volume shocks from the adverse scenario, affecting banks' deposits, investment fund shares and insurance contracts. These shocks generate outflows from the respective sectors to the holders of these instruments, enabling the calculation of net outflows by sector. It is important to note that the tool currently focuses only on volume-driven flows and does not yet incorporate cash flows from other assets and liabilities.

(d) The fourth module quantifies the impact of net outflows on the liquid assets held by each sector. Central bank role and intervention can be activated in this module.

(e) The fifth module estimates the price impact of the assets sold following the impact of net outflows. Central bank role and intervention can be activated in this module.

(f) The sixth module evaluates the impact on equity capital across sectors, accounting for mark-to-market losses from price shocks, the price impact of assets sold, the devaluation of securities due to cross-holdings and deleveraging triggered by potential management actions.

The ESRB balance sheet tool includes behavioural assumptions to simulate potential reactions from agents that are difficult to model but important to consider in a system-wide context. The tool has five behavioural assumptions calibrated based on judgement and/or historical observations and applied in a mechanical way.

- **Type of haircut**: Haircuts are applied to the market value of liquid assets to account for riskiness, volatility and liquidity, which reflects how easily an asset can be sold without significant loss of value. The ESRB balance sheet tool allows for a choice of haircuts between those aligned with the LCR regulation and those estimated from the first-round effects of the adverse market risk scenario, which account for the size of the security, the country of residence of the issuer, credit rating and instrument characteristics (see Annex 10.4 further details on the calculation of scenario-derived haircuts). The tool does not consider further haircuts that can be estimated from the subsequent deterioration of market liquidity (e.g. second-round effects).

- **Direction of outflows**: A key feature in SLST is whether liquidity remains in or flees the domestic financial system. Therefore, the ESRB balance sheet tool

8 Including type of investment fund (see Annex 10.8 for mapping between investment fund shares and investment fund types).

9 Some of the items are further decomposed by maturity or rating.

allows for an exogenous choice between outflows relocating within the system (jurisdiction) and those moving out of the system (i.e. rest of the world).[10]

- **Placement of inflows**: The volume outflows from one sector correspond to the volume inflows of the sector holding the claim. Given that cash cannot be placed in sectors other than banks and central banks, the ESRB balance sheet tool allows for a choice of whether cash inflows to non-bank sectors can be further channelled to banks and central banks, as deposits or holdings of government bonds.
- **Liquidation strategy (pecking order)**: Liquidation is a major channel of amplification in a stress situation. Nonetheless, the selling and buying behaviour of agents can vary as it depends on both idiosyncratic and market factors. Therefore, to cover a liquidity funding gap, an entity could either use cash, sell assets borrow from the market or combine all of these actions. The ESRB balance sheet tool considers the first two actions (i.e. cash and selling of assets), allowing sectors to choose among different liquidation strategies: pro rata (using/selling assets proportional to the holdings of liquid instruments), waterfall (using/selling liquid assets first), waterfall without cash (not using cash but selling liquid assets first) and upstream (using/selling less liquid assets first).
- **Central bank actions**: During market disruptions, central banks may provide funding (e.g. through refinancing operations) and/or buy assets (through asset purchase programmes) to support monetary policy transmission and ensure price stability. This means that banks can access cash through central bank market operations by using eligible (liquid and unencumbered) assets as collateral. The ESRB balance sheet tool allows for this exchange considering the amount of marketable assets (eligible at the euro area level) and the amount used. Central banks can also buy assets, with their intervention then designed to mitigate extreme price changes experienced during these times of stress. The tool allows for the mitigation of the price impact of forced sales depending on the size of the central bank asset purchase using elasticities from Breckenfelder and De Falco (2024).
- **Management actions**: The mark-to-market losses derived from the adverse scenario and the price impact from the forced sales following volume outflows lead to a degradation of equity capital for all agents holding financial instruments. In the spirit of Greenwood, Landier and Thesmar (2015), agents may react and adjust to restore original equity (in terms of equity capital to total financial assets) or liquidity ratios (in terms of liquid assets to total financial assets) following an adverse shock. The ESRB balance sheet tool quantifies the additional deleverage (and hence additional assets sold) in order to return to the original pre-shock solvency and liquidity ratios.

The ESRB balance sheet tool also considers the market risk impact on equity capital. This is driven by the revaluation of assets at fair value following the adverse scenario (first round) and the mark-to-market losses that are triggered by the sell-off

[10] For example, substantial capital outflows towards safer heavens were experienced during the COVID-19 pandemic and the euro area debt crisis.

of assets in the liquidity impact (second round).[11,12] It also considers the partial impact of hedging on market losses in banks and the loss absorption capacity of technical provisions in insurance corporations. The final devaluation of equity capital by sector is considered as an additional valuation drop in the cross-holding of equity, debt securities and MMF and non-MMF investment fund shares issued by those sectors.

6.2.2 ECB ISA model

The ECB ISA model complements the results from the jurisdiction-specific exercise and the ESRB balance sheet tool by including more granular contagion dynamics and the direct propagation of liquidity stress between sectors, such as endogenous redemptions of fund shares and deposit withdrawals. The ISA model was designed by ECB staff to analyse the effects of interconnectedness within the financial system, drawing on entity-level data. It is a dynamic, microstructural model for system-wide stress testing, covering several financial sectors and capturing both first-round and second-round effects. The model features liquidity and solvency interactions, a dynamic balance sheet, the integration of regulatory constraints and endogenous market price formation.[13] However, the model does not embed some scenario dimensions of the banking sector due to a focus on system-wide dynamics.[14] Similarly, it is designed for short-term time horizons, in that it uses solely a stress horizon of 30 days. An overview of the model is provided in Chart 18.

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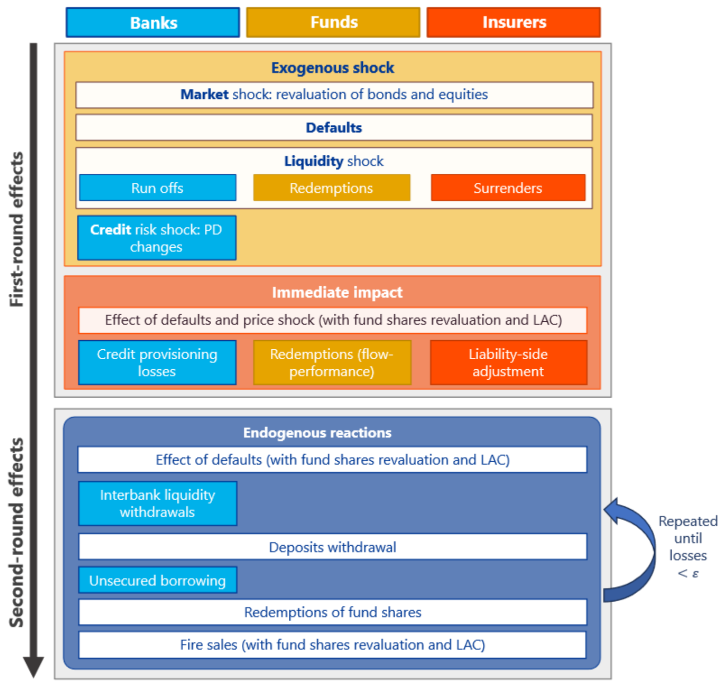
[11] This round also includes the cash inflows from those discounted sell-offs.

[12] The tool does not account for the impact on equity capital driven by higher funding costs under an adverse liquidity scenario (see, for example, Schmitz, Sigmund and Valderrama, 2019, for a study of the nexus between capital and funding costs).

[13] See, for example, Sydow et al. (2024).

[14] For example, the volume shocks for deposits are averaged between insured and uninsured deposits.

Chart 18
Overview of the steps followed by the ISA model



Note: Credit risk shocks are not used in the context of this exercise.

The results embed both direct shock propagation from the scenario and cross-exposures of financial entities to funds, and indirect loss amplification. First-round losses are triggered by the combination of liquidity and market risk shocks, where the latter trigger direct portfolio depletion due to the revaluation of securities driven by the scenario and fund share losses in line with the corresponding investment funds' net asset value (NAV) reduction in the network. Second-round losses are driven by the intertwined reactions of all the financial institutions in the system following liquidity and solvency constraints, which lead to interbank liquidity withdrawals, redemptions and fire sales (Table 1).[15]

Table 1
Liquidity and solvency constraints

Sector	Liquidity constraints that trigger balance sheet reactions	Solvency constraints that trigger balance sheet reactions
Banks	LCR < 100% or cash at hand below buffer level	Breach of capital buffers[16]
Insurers	Constant cash to liabilities that can be surrendered	Capital below Solvency Capital Requirement
Funds	Constant cash / NAV (at time 0)	

[15] Other liquidity channels, such as obtaining funding in private repo markets, are not captured in the version of the ISA model that was used in the context of this publication.

[16] Balance sheet reactions are triggered when banks' capital falls below the maximum distributable amount (MDA), defined as:

$$MDA = Pillar\ 1 + P2R + CCoB + CCyB + \max\{SyRB, G-SII, O-SII\} + sf\,AT1/T2$$

The model relies on behavioural assumptions to address the management of individual financial institutions' liquidity needs. The first-round losses trigger multiple and intertwined reactions across financial entities.

- **Banks aim to meet their LCR requirements**. When their high-quality liquid assets drop below the stressed outflows of LCR requirements, they get into liquidity distress. Second-round dynamics are then triggered, and banks can withdraw repos from counterparties (i.e. not rolling over the ones where they are cash providers) while borrowing more for themselves. When this is not sufficient, they sell shares of open-end funds that they own or sell bonds and equity from their asset portfolio. The amounts sold are determined to restore a non-distress status.

- **Insurance corporations and investment funds set cash targets internally.** These targets are not provided by a data-driven distress threshold, and insurance corporations and investment funds have fewer mechanisms at their disposal to recover liquidity. More precisely, in the second round, investment funds attempt to maintain the same ratio of cash to the initial fund NAV, and insurance corporations maintain their ratio of cash to the amounts that can be surrendered. An additional feature for investment funds is that some of their holdings of liquid assets are identified as bank deposits, with information about the bank. In these cases, reductions in the holdings of liquid assets to meet redemptions result in withdrawals from banks, which can thus transmit the liquidity stress between sectors.

- **Investment funds are exposed to two additional sources of liquidity stress, on top of the direct scenario liquidity shocks.** First, they face redemptions from external investors (not covered by the ECB ISA model) as prescribed by the scenario, with the simplifying assumption that no liquidity gates or suspensions are modelled for funds. Second, in subsequent dynamics, when a financial institution in the model experiences a liquidity shortfall, they partially alleviate it by redeeming fund shares that they may hold. The indirect contagion from this liquidity stress stems from funds selling some of the equity and bond securities in their portfolio to meet liquidity needs. In turn, these asset (fire) sales have a downward effect on security prices, leading to further losses across the financial system due to the presence of overlapping portfolios across the modelled financial institutions. Subsequently, the direct exposure channel of fund shares assumes that counterparties holding fund shares are affected by the mark-to-market revaluation of the corresponding funds' NAV.

where *Pillar 1* is the minimum capital requirement (4.5%), *P2R* is the bank-specific Pillar 2 requirement, *CCoB* is the capital conservation buffer, *CCyB* is the countercyclical capital buffer, *SyRB* is the systemic risk buffer, *G-SII* and *O-SII* are the additional buffers for global and other systemically important institutions, and *sfAT1/T2* is the shortfall of additional Tier 1 and Tier 2 capital.

6.3 Price impact models

The price impact captures the second-round effects of the aggregate liquidity shock. The impact of the adverse scenario forces entities to sell assets under stress due to liquidity needs and/or regulatory constraints. These sales, if happening at the same time for multiple entities, can depress market prices, amplifying the effect of the initial shock. This decline in asset prices can, in turn, reduce the value of similar holdings across other entities, potentially triggering further sales and amplifying losses. We use two models to incorporate the price impact in the dual SLST exercise.

We use estimated impact parameters derived from a non-linear price model on euro area assets (Fukker et al., 2022). This model uses a quantile regression approach in order to explain tail events in the propagation of losses due to contagion from market price impacts. The price impact function is described as follows:

$$\Psi_{\varphi}(V) = B_{\varphi}\left(1 - e^{\frac{V\lambda_{\varphi}}{B_{\varphi}}}\right)$$

where $V\lambda_{\varphi}$ is the price impact coefficient, B_{φ} is the corresponding impact boundary for a given security φ and V is the daily traded volume. The price impact parameters by asset class induce stable prices for low amounts of assets sold. As the volume of assets sold increases beyond a certain threshold, the price impact begins to rise exponentially, reflecting the market's heightened sensitivity to larger sales volumes in this intermediate range. Once the amount of assets sold surpasses an upper threshold, agents may start buying the assets and exploiting arbitrage opportunities, leading to a stabilisation of the price impact. Such parameters reflect a snapshot of tail historical behaviour, typically capturing a partial equilibrium that may differ from estimates derived from general equilibrium models, where feedback effects and cross-sector adjustments are explicitly incorporated.

These price impact parameters are used in the dual SLST approach. In both the jurisdiction-specific approach and the ESRB balance sheet tool, the price impact parameters from the fifth quantile are used on the volume of assets sold under stress by asset class. However, due to the limited granularity of the comprehensive dataset, simulating disaggregate asset sales by specific equity sectors or market capitalisation was not possible. Similarly, for bond estimations, data on all relevant countries and bond maturities were not available. As a result, average values for parameters were used across these dimensions to compensate for the data limitations. The ECB ISA model's calibration also uses price impact parameters from the same model, employing quantile regressions on returns with traded volumes as the explanatory variable. For stress-testing purposes, the tenth quantile is selected to capture severe scenarios relative to historical benchmarks. This approach emphasises the system's vulnerability to extreme events and provides insights into the role of price impacts in propagating financial contagion.

The other model used was a demand-based asset-pricing framework for the euro area (Heipertz and Piquard, forthcoming). This framework built internally at Banque de France is based on a general equilibrium model considering four channels of price transmission and portfolio rebalancing. The price impacts are concentrated into a first-order impact (i.e. changes in prices that must occur in order to clear the initial sell-off of assets caused by the outflows) and a general equilibrium impact or final round (i.e. full market clearing). From the country and sectoral results in the jurisdiction-specific exercise, the authors estimated the first-order and second-order impacts from an asset sell-off. Using this tool made it possible to consider agents that eventually respond to depressed prices by buying stranded assets.

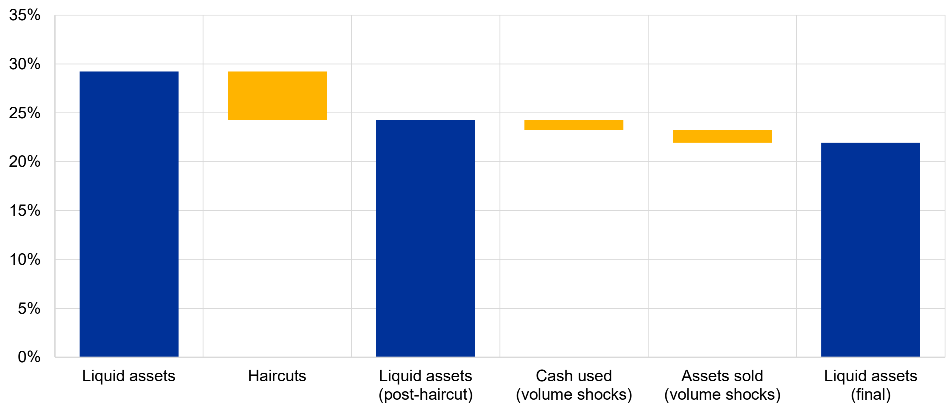
7 Impact of an aggregate liquidity shock

The adverse aggregate liquidity shock leads to a substantial reduction of the stock of liquid assets over a 30-day stress horizon. The reduction of liquid assets is similar in the jurisdiction-specific exercise and the ESRB balance sheet tool, at 7 to 10 percentage points of total financial assets respectively (Chart 19, panels a and b). The reduction in the ECB ISA model is milder, at 3 percentage points. Nonetheless, the aggregated net outflows driven by the adverse scenario are comparable across the stress-testing approaches, ranging from 0.5% to 0.7% of total financial assets (Chart 20). The rest of this section elaborates on the elements behind the liquidity impact on net outflows, second-round effects and behavioural reactions.

Chart 19
Impact on liquid assets

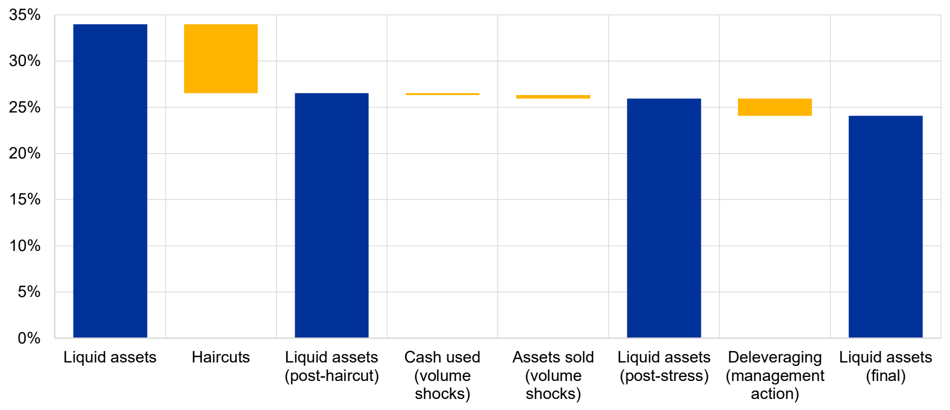
a) Jurisdiction-specific exercise

(percentages of total reported assets)



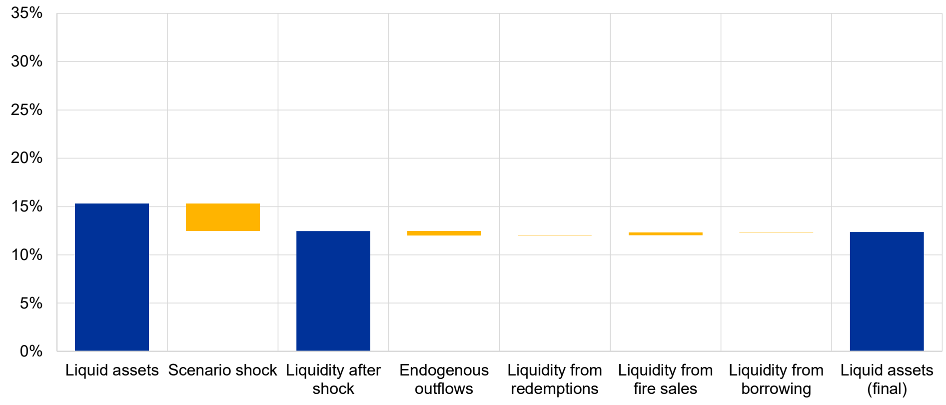
b) ESRB balance sheet tool

(percentages of total financial assets)



c) ECB ISA model

(percentages of total assets)



Sources: Jurisdiction-specific exercise, ESRB balance sheet tool, ECB ISA model and own calculations.
Notes: The jurisdiction-specific exercise covers the EU, and liquid assets are measured as the share of total assets reported by participant authorities. The ESRB balance sheet tool and ECB ISA model cover the euro area, and liquid assets are measured as the share of total financial assets and total assets respectively.

7.1 Net outflows

In an adverse environment, outflows outweigh inflows on aggregate. Net outflows over the 30-day stress window amounted to 0.5% of total financial assets in the jurisdiction-specific exercise, 0.6% in the ESRB balance sheet tool and 0.7% in the ECB ISA model (Chart 20). Across the three main institutional sectors, the jurisdiction-specific exercise produced milder results than the ESRB balance sheet tool and the ECB ISA model. Moreover, banks contributed the largest impact in all of the approaches, at between 80% and 99% of total net outflows. All the models showed almost zero net outflows for insurance corporations, while for investment funds, the ESRB balance sheet tool provided higher net outflows (0.12%) than the jurisdiction-specific approach (0.05%) and the ECB ISA model (0.01%).

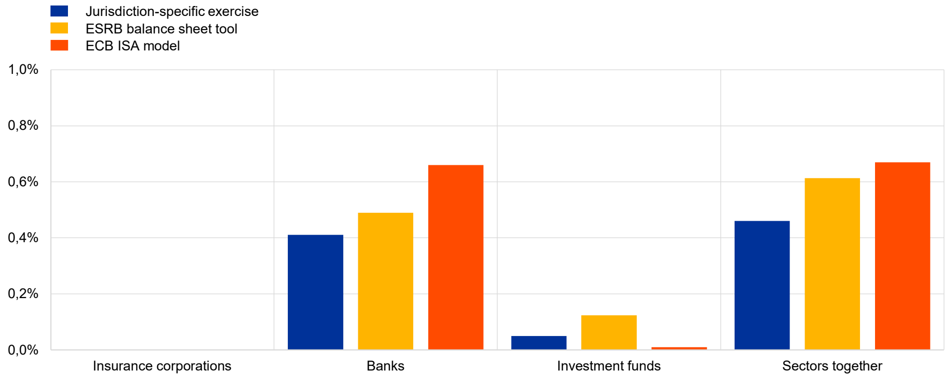
The differences in net outflows are explained by modelling limitations and specific assumptions. The ESRB balance sheet tool is constrained by the limited data granularity and the conservative assumption of no additional cash flows (aside from volume flows) from assets and liabilities. On the other hand, the jurisdiction-specific exercise is constrained by coverage, as only a subsample of the total exposures in the EU is considered. For instance, the results only consider a subsample of non-MMF investment funds and do not consider less significant banks from non-participant jurisdictions (Chart 15). The relatively higher net outflows of banks in the ECB ISA model are explained by the absence of active liquidity refunding by banks that are not in breach of their LCR, the endogenous deposit withdrawals by investment funds and a coarser application of the initial shock to deposits. In this model, the initial outflows for insurance corporations and investment funds are also significant but, following the dynamic liquidity targets by entity, these outflows are almost completely rebalanced through the redemption of fund shares and the sale of tradable securities.

Chart 20

Aggregated net outflows over the 30-day stress horizon by sector

As of the fourth quarter of 2023

(percentages of total financial assets for all sectors)

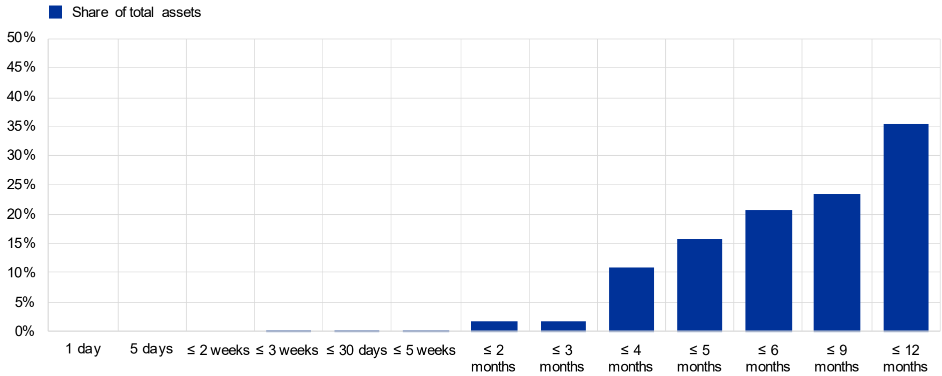


Sources: Jurisdiction-specific exercise, ESRB balance sheet tool, ECB ISA model, quarterly sector accounts and own calculations.
Notes: Investment funds in the ESRB balance sheet tool include both MMF and non-MMF funds. The ECB ISA model and ESRB balance sheet tool cover the euro area, while the jurisdiction-specific exercise covers the EU.

Banks can absorb the aggregated liquidity shock with existing liquidity reserves over the 30-day stress horizon. As banks are the main drivers of aggregate net outflows, the jurisdiction-specific approach estimated the rate of banks not surviving the liquidity shock by exhausting their counterbalance capacity over a period of one year (Chart 21). At the EU level, banks on average started to struggle with their net liquidity position from around the fourth month of the stress horizon, which is longer than the LCR horizon. At the fourth-month mark, banks with a negative net liquidity position (NLP) represented 10% of banks' total assets. This share increased to 35% by the end of the one-year stress horizon. This is naturally an extreme and highly hypothetical situation that does not consider management actions, supervisory intervention and/or central bank support.

Chart 21

Non-survival rate of EU banks



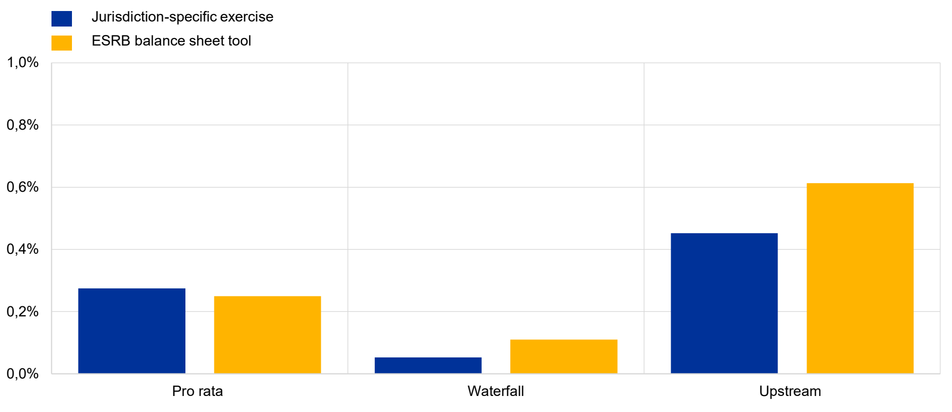
Sources: Jurisdiction-specific exercise and own calculations.
Notes: The non-survival rate is calculated as the amount of bank assets where the accumulated net liquidity position (NLP) is negative. A negative NLP means that the accumulated net funding gap is larger than the stock of liquid assets after haircuts at the entity level. Projections were made where the results were only reported for one stress horizon. Consolidation at the EU level. The results cover banks (significant institutions) in the euro area, banks in NO and DK, and less significant credit institutions in BE, AT, LU and HR.

7.2 Second-round effects

The volume of asset sales (i.e. fire sales) depends on the pecking order strategies adopted by financial entities. Funding and liquidity gaps are covered with the stock of liquid assets. In the jurisdiction-specific exercise and the ESRB balance sheet tool, net outflows originating from the adverse shock are covered with cash, highly liquid assets or a combination of both. This response is assumed to occur simultaneously and in a coordinated manner across all entities. Under this assumption, all entities apply the same liquidation strategy (i.e. default pro rata, waterfall and upstream) at the same time. Chart 22 illustrates the volumes of fire sales under each strategy over a 30-day stress horizon. When the default pro rata liquidation is applied, fire sales amount to 0.25% and 0.28% of total financial assets in the ESRB balance sheet tool and the jurisdiction-specific exercise respectively. Under the waterfall strategy, fire sales are more limited, reaching 0.05% and 0.11% of total financial assets. By contrast, the upstream strategy triggers the largest volume of fire sales, amounting to 0.45% and 0.61% of total financial assets in the jurisdiction-specific exercise and the ESRB balance sheet tool respectively. Assuming that larger volumes of asset sales (fire sales) amplify systemic risk (Duarte and Eisenbach, 2021), the spillover effects of the adverse liquidity shock are significantly greater under the upstream strategy compared with the waterfall strategy.

Chart 22
Assets sold over the 30-day stress horizon by liquidation strategy

(percentages of total reported assets)



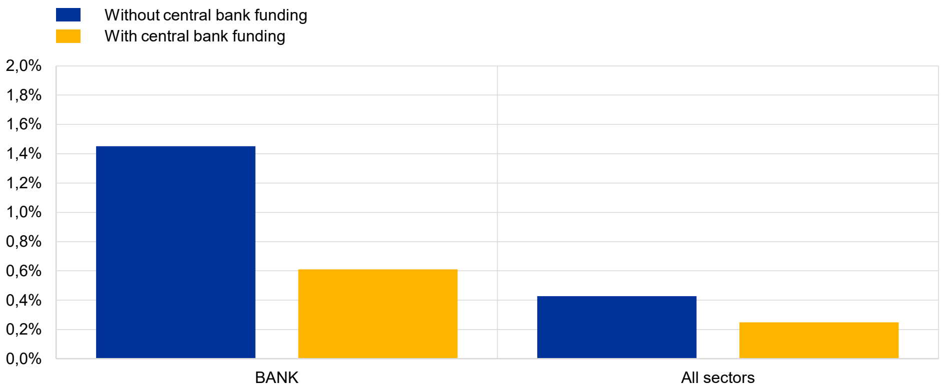
Sources: Jurisdiction-specific exercise, ESRB balance sheet tool, quarterly sector accounts and own calculations.
Notes: As of the fourth quarter of 2023. Investment funds in the ESRB balance sheet tool include both MMF and non-MMF funds. The ESRB balance sheet tool covers the euro area, while the jurisdiction-specific exercise covers the EU.

Resorting to central bank funding reduces by more than half the need for fire sales. During periods of market distress, private repo funding can dry up rapidly, limiting banks' ability to roll over maturing positions and creating significant liquidity pressures. In the ESRB balance sheet tool, banks can therefore resort to central bank funding through refinancing operations. In particular, in the event of a liquidity stress event, banks can use eligible unencumbered assets to enter into a repo transaction with central bank funding (i.e. swapping liquid assets for cash). Repo borrowing by euro area banks with central banks and other counterparties has been shown to mitigate liquidity pressures under different adverse scenarios (IMF, 2025). Chart 23 shows the impact of central bank funding on the amount of assets for sale. This mechanism reduces the amount of assets sold by banks over the 30-day stress horizon from 1.45% to 0.61% of banks' total financial assets. Considering the cross-sectoral picture, the fire sales of the whole system are reduced by 0.18 percentage points when this mechanism is in place. Although central banks can provide the last source of exogenous liquidity and mitigate the impact of liquidity shocks, their actions could also lead to moral hazard issues (ECB Task Force on Systemic Liquidity, 2018).

Chart 23

Assets sold by sector without and with central bank funding

(percentages of total financial assets for each sector)



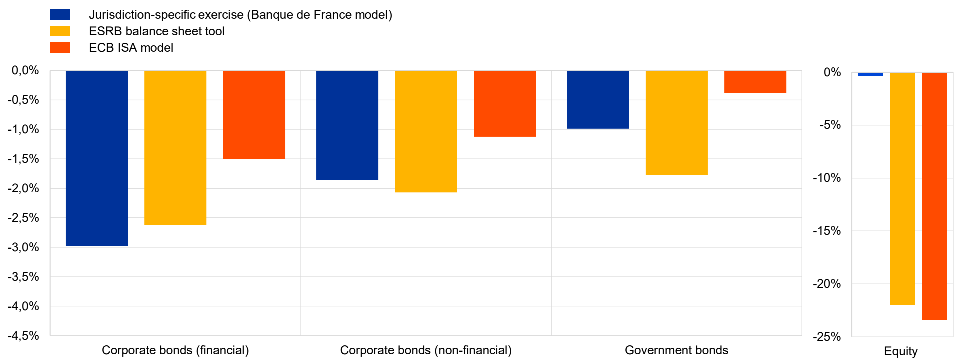
Source: ESRB balance sheet tool.
Note: The y-axis represents the share of total financial assets within each sector.

The amount of assets sold is large enough to affect prices. In a period of limited market liquidity, liquidation leads to sales of assets at lower prices (Shleifer and Vishny, 2011). Using the price impact models described previously, the price impact generated by the fire sales is estimated for all models over the 30-day stress horizon (Chart 24). In particular, the demand-based asset pricing described in the previous section is applied to the country-level results from the jurisdiction-specific exercise. The price impact parameters from the ECB model are used by both the ESRB balance sheet tool and the ECB ISA model, at an aggregate level in the former and at a granular level in the latter. The results show that the price of financial corporate bonds drops by 1.5% to 3%. For non-financial corporate bonds the drop ranges from 1.1% to 2.1%, and for government bonds it ranges from 0.4% to 1.8%. The largest difference in the price impact by financial instrument is on equity shares, where the ESRB balance sheet tool and the ECB ISA model estimate a price drop of 22% to 23.4% respectively, compared with only 0.4% for the bottom-up approach. The latter is driven by the fact that in a demand-based asset-pricing framework, investors' demand for equity shares is very elastic and therefore the amount on sale is more easily absorbed. In all models, outside investors (often the rest of the world) absorb most fire sales. The price impact thus heavily depends on their demand elasticities, which could be lower in a system-wide stress. Overall, the impact of fire sales on prices despite different approximations can in times of distress and high uncertainty still widen these ranges.

Chart 24

Price impact over the 30-day stress horizon by liquidation strategy

(percentage change)

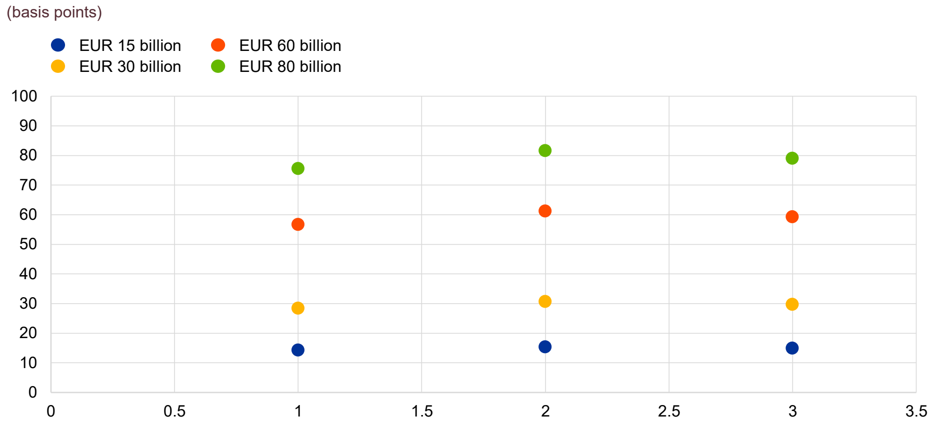


Sources: Jurisdiction-specific exercise, ESRB balance sheet tool and ECB ISA model.
Notes: The Banque de France price model is a general equilibrium model considering price transmission channels and portfolio rebalancing. The ESRB balance sheet tool assumes a selling window of five days. The price impact considers the price mitigation effects from asset purchase programmes. The ECB ISA model uses ECB parameters at the security level. The chart shows the weighted average of those impacts.

Asset purchase programmes (APPs) mitigate the price drops from forced sales. These programmes are a non-conventional monetary policy tool that support monetary policy transmission and ensure price stability. Using the effect on prices of direct demand shocks from ECB purchases (Breckenfelder and De Falco, 2024), the ESRB balance sheet tool estimates the price mitigation effect of different ECB APPs on each asset class (Chart 25). Over the 30-day stress horizon, the intervention of the central bank in those markets reduces the drop in prices following the sell-off of liquid assets by entities by between 10 and 80 basis points under the assumption of monthly asset purchases ranging from €15 billion to €30 billion.

Chart 25

Estimated price mitigation impact through non-conventional monetary policy

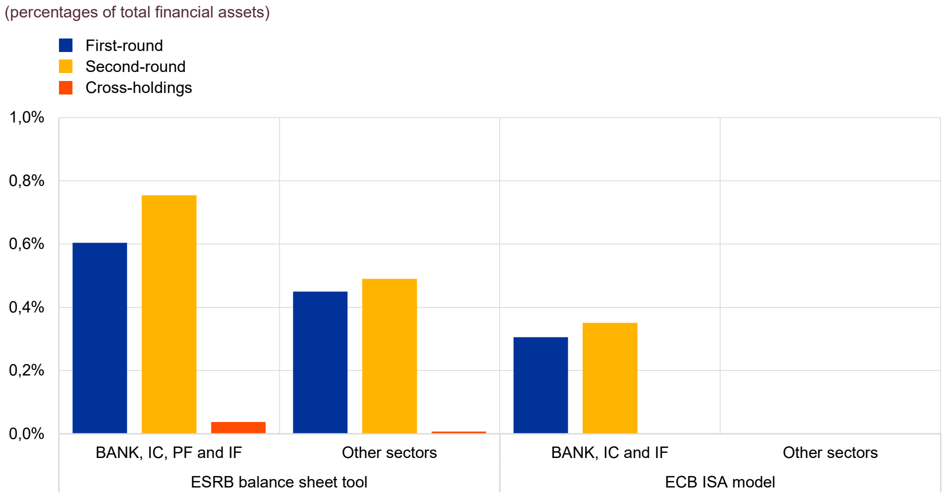


Source: ESRB balance sheet tool.
Notes: The ESRB balance sheet tool assumes by default that the central bank introduces an asset purchase programme of EUR 30 billion monthly. Government bonds are considered in the public sector purchase programme. Corporate bonds (financial) are considered in the covered bond purchase programme and the asset-backed securities purchase programme. Non-financial corporate bonds are considered in the corporate sector purchase programme.

Adverse liquidity shocks can also affect in several ways the solvency of financial entities through mark-to-market losses. In the ESRB balance sheet tool, the mark-to-market losses on the holdings held by sectors are driven not only by the adverse shocks from the scenario but also by the price changes induced by fire sales. Both rounds of mark-to-market losses are absorbed by the sectors' equity capital after considering hedges, fair value accounting principles and loss absorption capacity in the case of insurance corporations (Sydow et al., 2024). Finally, this reduction in equity capital implies a devaluation of instruments issued by the sectors affected (i.e. equity, debt securities and investment funds' shares) and hence an additional value loss from the cross-holdings. Chart 26 shows the mark-to-market losses in both the ESRB balance sheet tool and the ECB ISA model as a share of total financial assets during these stages. The first round of mark-to-market losses for banks, insurance corporations and investment funds represents between 0.3% and 0.6% of total financial assets, whereas the second-round losses for the same sectors range from 0.4% to 0.8%. For comparison, the immediate market risk losses for positions valued at fair value in the 2025 EU-wide stress-testing exercise amounted to €183 billion (EBA, 2025), which as a share of banks' total financial assets represents 0.4%. The impact of cross-holdings estimated in the ESRB balance sheet tool amounted to 0.04% of total financial assets for all sectors on aggregate.

Chart 26

Mark-to-market losses over the 30-day stress horizon



Sources: ESRB balance sheet tool and ECB ISA model.
Note: The ESRB balance sheet tool considers all institutional sectors in the euro area. Other sectors cover non-financial corporations and other financial corporations. The impact of cross-holdings is not calculated for households, governments and central banks. The ECB ISA model covers banks, insurance corporations and investment funds in the euro area.

7.3 Contribution of financial entities' behaviour

The behaviour of financial actors during periods of liquidity stress is a key amplifying mechanism of systemic risk. When financial entities respond to liquidity shortages by engaging in precautionary hoarding, curtailing interbank lending or liquidating assets, they contribute to a deterioration in market functioning and a decline in aggregate liquidity. These actions, which are not coordinated, can trigger adverse feedback loops, where falling asset prices and increasing funding costs further incentivise the initial shock. The ECB ISA model measures the impact of banks' reactions via a set of options, while the ESRB balance sheet tool estimates the deleveraging behaviour at the sectoral level triggered by direct management actions following the impact of the adverse scenario.

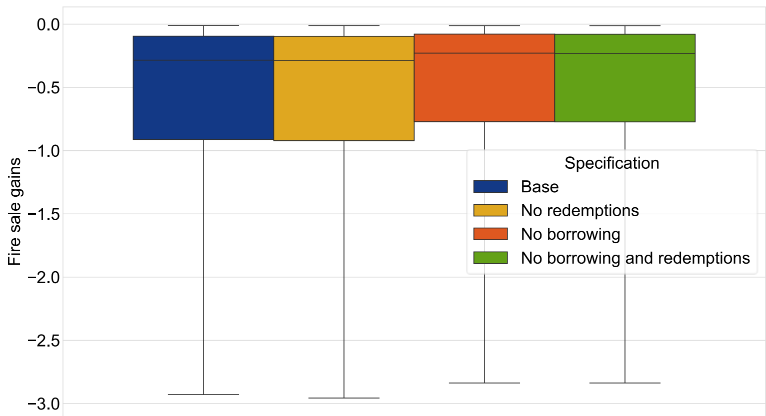
7.3.1 Banks' reactions to adverse liquidity shocks

Banks can react in multiple ways to liquidity shocks via a set of available actions related to their counterbalancing capacity and their activity in the secured and unsecured borrowing market. The ECB ISA model specification allows multiple options to be tested at a time, which banks can use to react to a sudden liquidity shortfall. In this context, the main specification tested considered redemptions of investment funds' shares, unsecured borrowing across banks and, as a last resort, fire sales (Chart 27). Fire sales are considered a last resort due to the additional losses from asset depreciation and the realisation of losses from the liquidation of held-to-maturity bonds. While a broader range of counterbalancing options could result in additional sector-wide losses, unsecured borrowing/lending stands out as a crucial tool for banks in distress (i.e. smaller losses among all reactions). Banks with excess liquidity can lend in the repo market to those solvent but in need of liquidity, thereby boosting their future interest income. Conversely, banks borrowing on the repo market may absorb immediate liquidity gaps, coupled though with higher future interest expenses. If these borrowed funds fail to cover the shortfall, banks may have to resort to fire sales. Such illiquid banks might struggle to survive post-shock, posing systemic risks.

Chart 27

Impact of fire sales on banks' portfolios under different model specifications

(percentage losses relative to exposures)



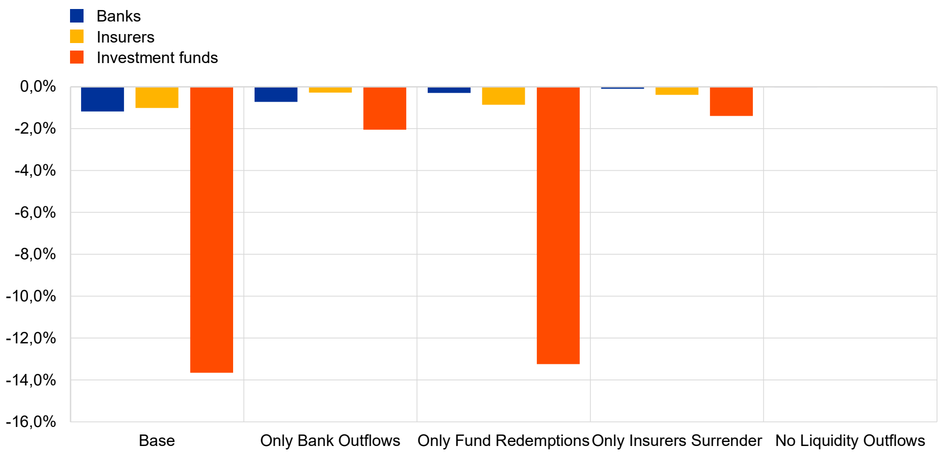
Source: ECB ISA model.
Notes: The boxplots show the results from the 25th to the 75th percentile, with a black line representing the 50th percentile of the distribution and whiskers representing the 10th and 90th percentiles. The blue box refers to the simulation with all available endogenous mechanics for banks included (including unsecured borrowing and redemptions of fund shares' holdings). The yellow box considers a specification without access to fund share redemptions. The red box considers a specification without access to unsecured borrowing. The green box refers to a specification preventing both unsecured borrowing and redemptions of fund share holdings. All the boxplots consider only the impact for banks that do not default in the corresponding simulation.

The impact of an aggregate liquidity shock can have multiple configurations. Although the purpose of the system-wide stress test is to test the resilience of all financial institutions simultaneously and as a whole, the impact of liquidity shocks has been restricted to certain market segments. To disentangle the drivers of the final aggregate impacts, the sectors that are pivotal in fostering the contagion are highlighted. The role of investment funds in the system is central, as their reaction is the leading cause for the generation of system losses (Chart 28). When only funds suffer a liquidity shortfall, their reaction through fire sales has a large impact both on the investment fund sector and on insurance corporations, the latter being largely exposed to the former. On the other hand, if the liquidity shocks were to affect only banks or insurers, losses would be more limited (lower than 2% of total assets for each sector), but it would still be the investment fund sector that reacts most strongly due to its full exposure to an additional drop in securities prices.

Chart 28

Relative impact of fire sales on portfolios under different model specifications for liquidity outflows

(percentage losses relative to portfolio assets)



Source: ECB ISA model.
Notes: The "base" scenario includes all available endogenous mechanics. "Only bank outflows" refers to a scenario where only banks experience deposit runs. "Only fund redemptions" considers a scenario where only investment funds face outflows. "Only insurer surrenders" refers to a scenario where only insurance policyholders make withdrawals. Lastly, "no liquidity outflows" indicates a scenario where neither banks, investment funds nor insurers experience outflows. It should be noted that the losses are those resulting from fire sales, i.e. they do not encompass those from the scenario market shock. The initial market shock is present in all cases, but it does not lead by itself to subsequent fire sales.

7.3.2 Deleveraging at the sectoral level

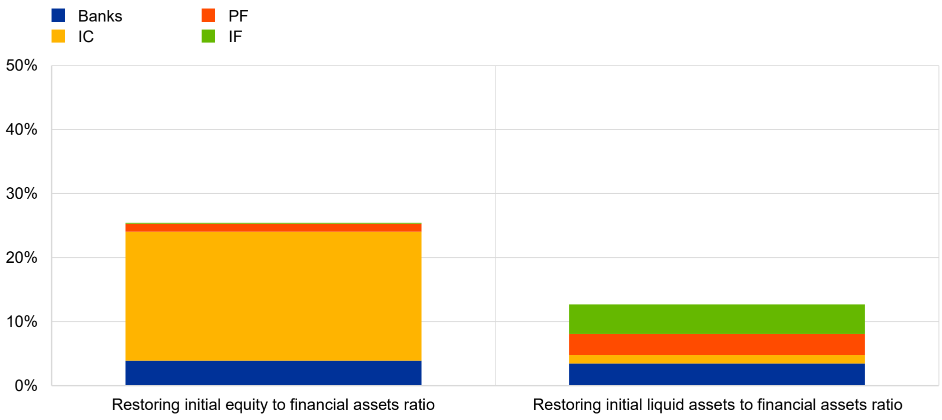
Management actions have different outcomes across sectors and targets. After the impact of the adverse shocks on entities' liquidity and equity positions, financial entities on aggregate aim to restore original prudential ratios by reducing their holdings of financial assets (deleveraging). Depending on the type of ratio that is used, the deleveraging effect is different across sectors (Chart 29). When the initial equity capital to total financial assets ratio is the target, insurance corporations need to deleverage around 20% of their total financial assets. This is driven by a fall in the leverage ratio of 3 percentage points after stress. Under the same conditions, banks need to deleverage around 4% of their total financial assets, while pensions funds and investment funds are less affected with a deleveraging need of 1.3% and 0.1% respectively. When the initial liquid assets to total financial assets ratio is the target, the need for deleveraging is most important for investment funds with an amount equivalent to 5% of their financial assets. Banks and pension funds need to deleverage around 3% of their financial assets, while insurance corporations only need to deleverage 1% of their financial assets. Modelling and/or even assuming management actions at the aggregate level overstate the impact of deleveraging. The level of management actions following market distress depends on a combination of different factors beyond market conditions, including the type of financial entity, the regulations subject to it and its fundamentals.[17]

[17] For example, Da Rocha Lopes et al. (2025) show that management actions on capital are significantly higher for banks that are more capital-constrained at the beginning of a distress period.

Chart 29

Deleveraging size due to management actions in the ESRB balance sheet tool

(percentages of total financial assets for each sector)



Source: ESRB balance sheet tool.
Note: Total financial assets are for the respective sector.

8 Conclusion

SLST tools are increasingly recognised as essential instruments for macroprudential policy analysis and financial stability assessment. These tools enable policymakers to evaluate the resilience introduced by liquidity requirements across financial sectors and assess the potential impact of macroprudential measures under diverse stress scenarios. Their relevance extends to risk monitoring, contingency planning and crisis preparedness, particularly through their capacity to illustrate interlinkages between financial institutions, markets and collateral dynamics. While the ECB ISA model offers the highest degree of granularity and methodological sophistication, which is meant to better capture complex liquidity dynamics, this level of granularity is not always attainable across all sectors or jurisdictions. At the same time, less data-intensive approaches can still generate valuable system-wide insights. Aggregate frameworks, such as the ESRB balance sheet tool or jurisdiction-specific stress-testing models, remain important analytical instruments because they enable cross-sectoral assessments where granular data gaps persist and capture macro-financial mechanisms that do not necessarily require full granularity to be meaningfully identified. Consequently, while greater emphasis on granular models is warranted where feasible, it remains essential to rely on a plurality of methodological perspectives – including sensitivity analyses and reverse stress tests – since no single model can fully capture the multifaceted and complex nature of liquidity dynamics and their propagation under system-wide stress.

Jurisdiction-specific stress-testing models can contribute to the system-wide assessment of liquidity risk. The integration of results from sectoral and jurisdiction-specific stress-testing models under common assumptions and adverse shocks enables a consolidated view of potential systemic liquidity risks. The advantage is that sectoral models tailored to country-specific characteristics enhance the identification of risks at the national level, which are often not necessarily parametrised in global models. The disadvantage is that this consolidation assumes static balance sheets and does not consider contagion or cross-sectoral spillovers. Nonetheless, these results can inform further analysis, such as estimating price impacts from asset sell-offs.

Area-wide cross-sectoral top-down models complement the system-wide risk assessment in the euro area. The ESRB balance sheet tool offers a simple, flexible approach using aggregate euro area data and generalised assumptions to address data gaps. This tool can be further decomposed to incorporate country-level stress test results and by adding granular data to better capture entity-level reactions and transmission channels. Expanding coverage to include pension funds, MMFs and central counterparties, particularly with respect to margin dynamics, would improve the tool's comprehensiveness. A country-level extension, linked to a network of sectors and markets, would allow for the assessment of cross-border contagion and country-specific stress responses. The ECB ISA model captures dynamic interactions between solvency and liquidity at the entity level and includes feedback loops, making it effective for simulating amplification effects following sudden shocks. However, it is less suited for long-term stress scenarios and is best used alongside other models when longer time horizons are analysed.

The exercise shows that the financial system appears resilient in the short term, but remains vulnerable to rapid amplification mechanisms (i.e. fire sales, interconnections and behavioural reactions) that could undermine financial stability if shocks persist or if policy support is insufficient. Across all three modelling frameworks, the adverse liquidity shock generates consistent net outflows (between 0.5% and 0.7% of total financial assets), suggesting that direct liquidity pressures remain broadly manageable over the initial 30-day horizon. However, banks account for the majority of these outflows, reaffirming their central role as both shock absorbers and potential amplifiers in a system-wide liquidity stress. Second-round effects are significant. Even relatively small asset sales create important price pressures in bond and equity markets (at least using empirically estimated price impact parameters), with upstream liquidation strategies producing the strongest fire sale dynamics. Central bank funding can mitigate these pressures substantially, though its use may raise moral hazard concerns. The estimated price impacts, especially for equities, show that market liquidity can deteriorate rapidly under stress, transmitting losses across sectors through mark-to-market valuation effects and cross-holdings. Behavioural reactions, including changes in repo market activity and deleveraging, further reinforce these dynamics. Investment funds emerge as a key transmission channel given their sensitivity to redemptions and their exposure to asset price declines.

System-wide approaches are gaining importance in an evolving and interconnected financial system. Further development should focus on improving scenario design through joint calibration of credit, market and liquidity risks across multiple horizons, with greater emphasis on the non-bank financial intermediation sector and its linkages to banks. Moreover, further understanding of the behavioural responses of financial entities is critical to improve the realism of model-based approaches, as these behaviours significantly influence the transmission and amplification of shocks. For instance, the system-wide exploratory scenario work conducted by the Bank of England is a good example of how these complex behaviours can be identified, with the potential to feed these results into top-down system-wide assessment models.

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10 Annex

10.1 Comprehensive financial dataset

The data sources behind the comprehensive financial dataset are securities holdings statistics (SHS), balance sheet items (BSI), the Centralised Securities Database (CSDB) and quarterly sector accounts (QSA). These data sources strike a pragmatic balance between granularity and simplicity and allow the mapping of interconnections at a semi-aggregated level. For instance, SHS include the holdings of financial instruments (debt instruments, listed shares and investment fund shares) by institutional (sub)sectors at the aggregate and country level with a breakdown by issuer at the individual and country level. This means that the instruments are reported according to their International Securities Identification Number (ISIN). BSI include specific balance sheet items (e.g. loans and deposits) of monetary financial institutions measured at nominal value and available at the aggregated level. Despite this aggregation, they also include breakdowns by counterparty (institutional) sector, maturity, rating and currency. For this, granular information at the instrument level was extracted from the CSDB. QSA provide a comprehensive and comparable overview of the transactions reported in the euro area. The transactions, recorded as closing balance sheet asset positions, are valued at market prices on the date to which the balance sheet relates and are recorded between economic agents grouped by sector. Although this statistical information cannot illustrate the interconnections in the same granularity as SHS and BSI, it serves as a key reference for the size of the financial assets held in the euro area.

The comprehensive dataset covers €83 trillion in financial assets as of the fourth quarter of 2023. All the instruments are measured at market value except loans and deposits, which are measured at nominal value. In terms of coverage, the dataset captures 81% of similar financial assets in the euro area quarterly financial accounts, amounting in total to €104 trillion.

Matrices between holders and issuers of financial instruments can be created from the comprehensive dataset. The matrices reflect the cross-exposures between sectors and countries. Depending on the level of granularity, these matrices can summarise the data along four dimensions:

- country of issuer, which includes the three regions “domestic”, “EU (not including domestic)” and “rest of the world”;
- sector of issuer, broken down according to the European System of Accounts (ESA) 2010 classification;
- country of holder, which includes the two regions “domestic” or “EU”;
- sector of holder, broken down according to the ESA 2010 classification;

- type of instrument, including loans, deposits, debt instruments (i.e. government bonds, financial corporate bonds, non-financial corporate bonds), listed shares and investment fund shares.

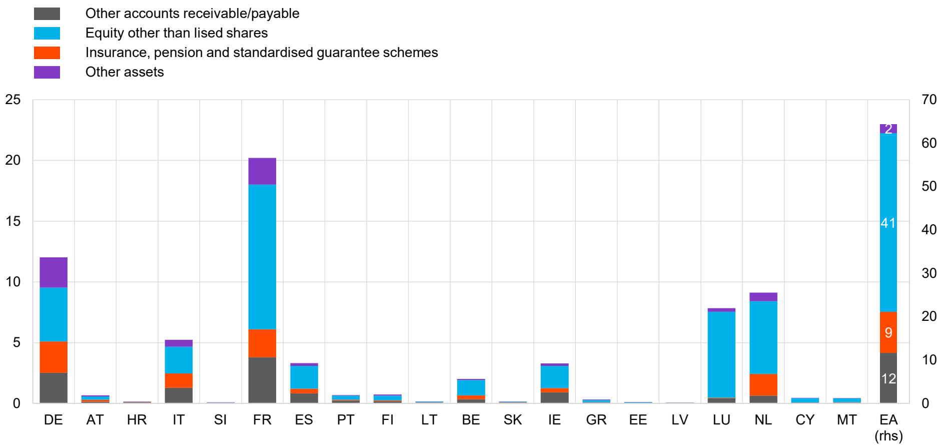
Not all financial assets are covered at the country-sector level in the comprehensive dataset. Due to the lack of granular data, the comprehensive dataset does not include the following instruments at the country-sector level: monetary gold and special drawing rights, currency, unlisted shares, other equity, insurance, pension and standardised guarantee schemes, financial derivatives and employee stock options, and other accounts receivable/payable. The total amount of these assets was to €64 billion as of the fourth quarter of 2023 (Chart A1). Of this amount, unlisted shares are the largest assets not included, accounting for €31 billion in the euro area. In absolute terms, this instrument is relevant in France, Luxembourg, the Netherlands and Germany. Unlisted shares are illiquid assets and hence bring additional risks to the holders of these instruments in times of distress.

Chart A1

Total amount of financial instruments not included in the comprehensive dataset by country

As of the fourth quarter of 2023

(EUR trillions)



Sources: QSA and own calculations.
Notes: Other assets include monetary gold, special drawing rights, currency and financial derivatives and employee stock options. Equity other than listed shares includes unlisted shares.

10.2 Participant authorities and coverage of desktop models

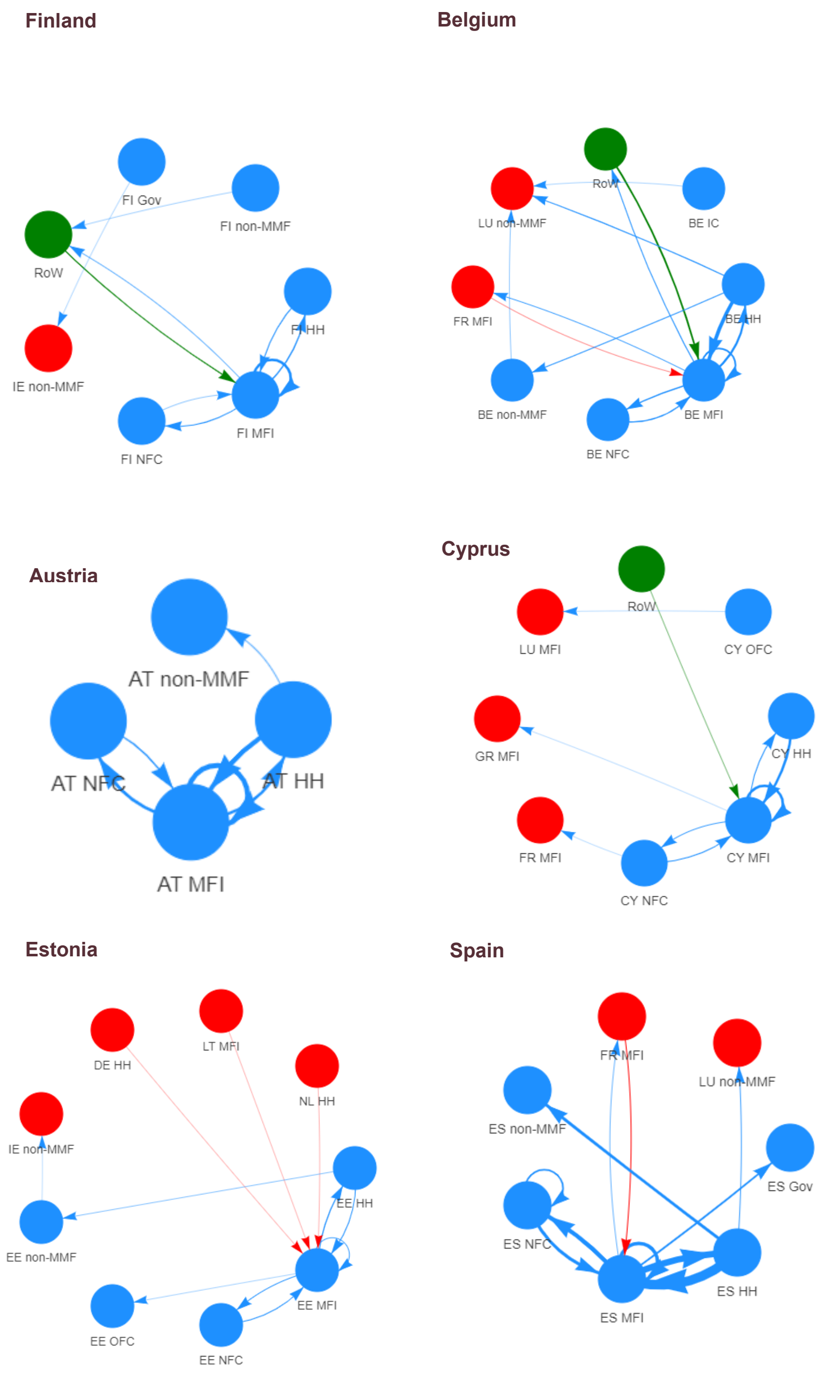
Coverage	Participant authority	Individual sector			Cross-sectoral
		Banks	Insurance corporations	Investment funds	Price impact
Austria	Oesterreichische Nationalbank	✓			
Belgium	Nationale Bank van België/Banque Nationale de Belgique	✓	✓		
Croatia	Hrvatska narodna banka	✓			
Denmark	Finanstilsynet	✓			
EU	European Securities and Markets Authority (ESMA)			✓	
EU	European Insurance and Occupational Pensions Authority (EIOPA)		✓		
France	Banque de France				✓
Hungary	Magyar Nemzeti Bank	✓			
Luxembourg	Commission de Surveillance du Secteur Financier	✓			
Netherlands	De Nederlandsche Bank	✓			
Norway	Norges Bank	✓			
Euro area	Single Supervisory Mechanism	✓			
Sweden	Sveriges Riksbank	✓			

10.3 Country and portfolio charts

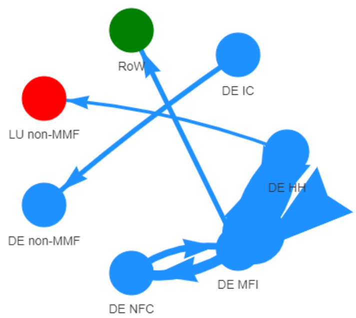
Chart A2

Bilateral cross-country and cross-sectoral networks by euro area country

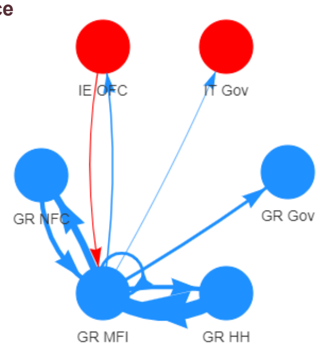
As of the fourth quarter of 2023



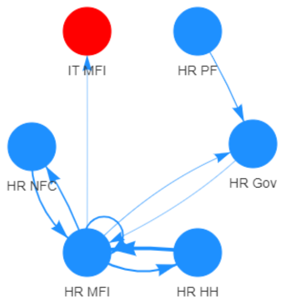
Germany



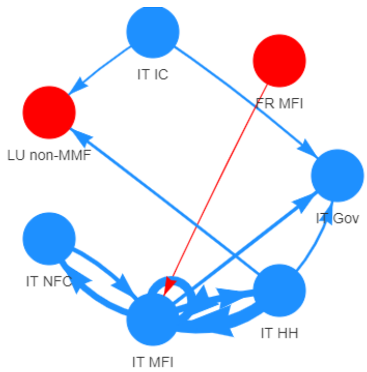
Greece



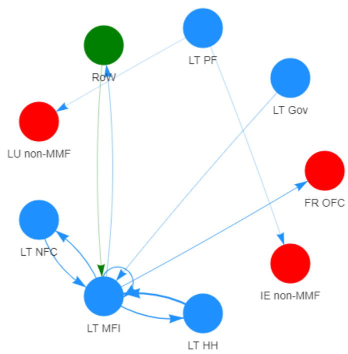
Croatia



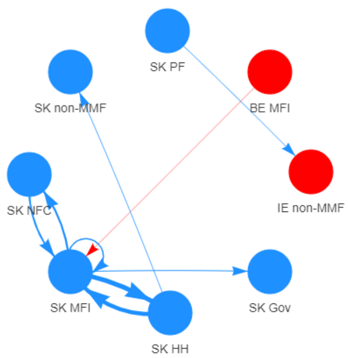
Italy

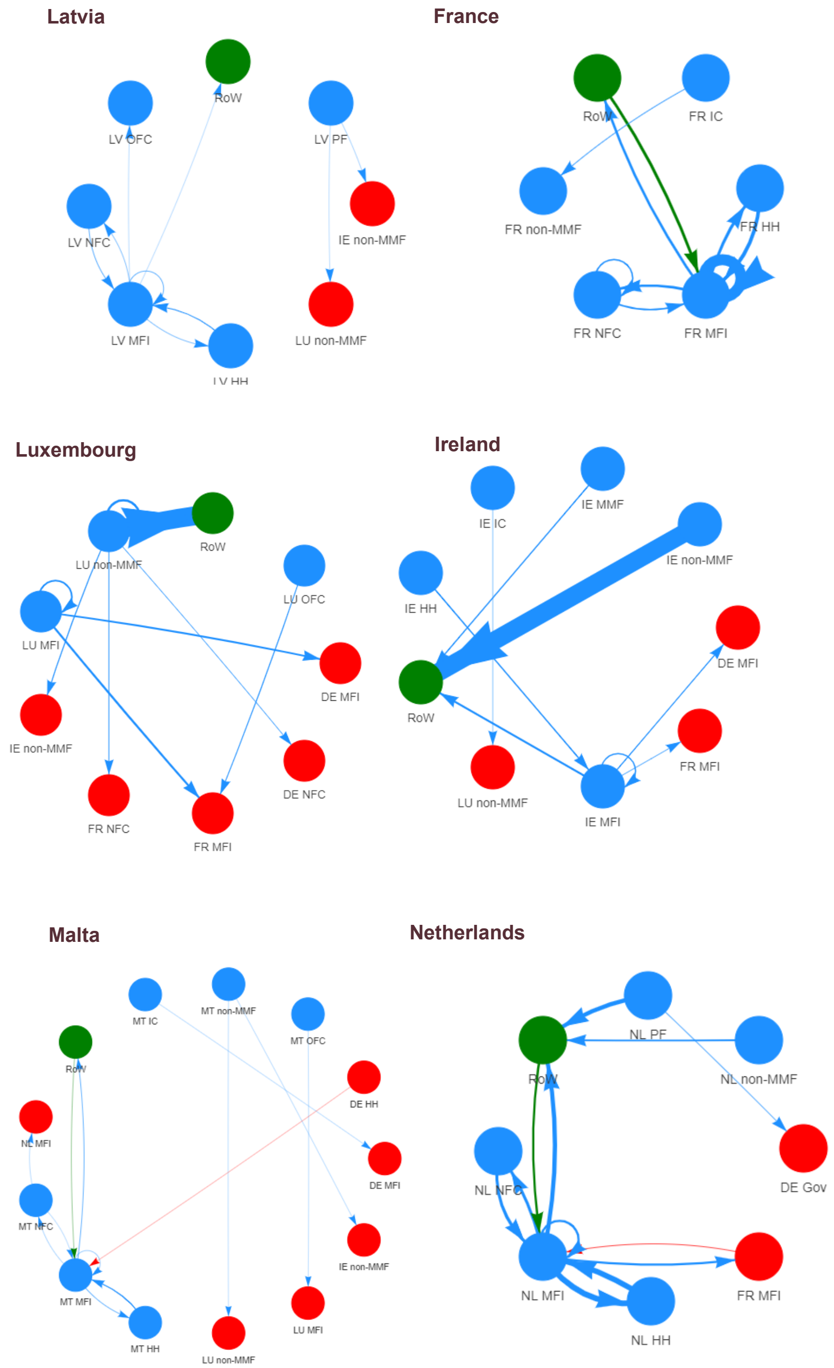


Lithuania



Slovakia




Latvia
RoW
LV OFC
LV PF
LV NFC
IE non-MMF
LV MFI
LU non-MMF
LV HH
France
RoW
FR IC
FR non-MMF
FR HH
FR NFC
FR MFI
Luxembourg
RoW
LU non-MMF
LU OFC
LU MFI
DE MFI
IE non-MMF
DE NFC
FR NFC
FR MFI
Ireland
IE MMF
IE IC
IE non-MMF
IE HH
DE MFI
RoW
FR MFI
LU non-MMF
IE MFI
Malta
MT non-MMF
MT IC
MT OFC
RoW
DE HH
NL MFI
DE MFI
MT NFC
IE non-MMF
MT MFI
LU MFI
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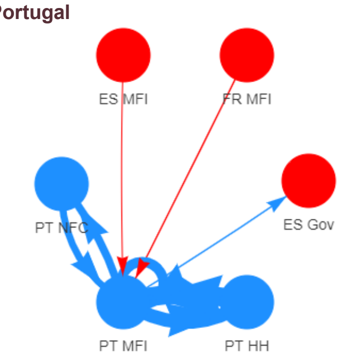
NL PF
RoW
NL non-MMF
NL NFC
DE Gov
NL MFI
FR MFI
NL HH

Portugal



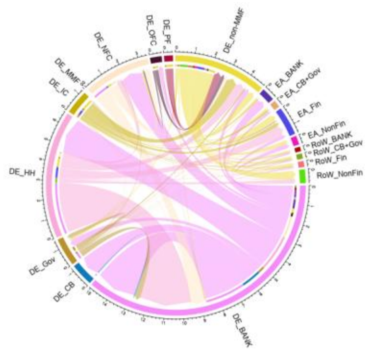
Sources: Comprehensive dataset and own calculations.
Notes: Holdings of the European System of Central Banks are not available and hence the key exposures of central banks (CBs) are not representative. Deposits of non-EU sectors placed in euro area banks are not part of the chart. “NFCs” stands for non-financial corporations. “HHs” stands for households and non-profit institutions serving households. “ICPFs” stands for insurance corporations and pension funds. “Non-MMFs” stands for non-money market funds. “Gov” stands for government. “OFCs” stands for other financial corporations. “CBs” stands for central banks. “RoW” stands for rest of the world. Not all financial linkages are shown, as a (subjective) materiality threshold of 1% of total claims is used to keep the most significant linkages. The nodes are of uniform size. All domestic sector nodes are in blue. The non-domestic euro area sectors are in red. The rest of the world node is green. The edges between nodes, representing the claims of one holder sector towards another, are divided by a scaling factor which depends on sum of the total market value of the claims in the respective country.

Chart A3

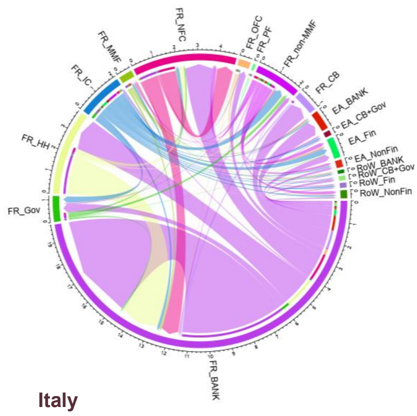
Sectoral fund providers and receivers’ networks by euro area country

As of the fourth quarter of 2023

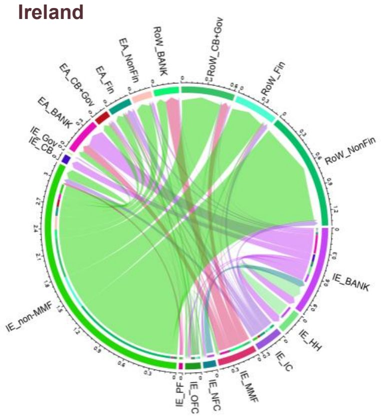
Germany



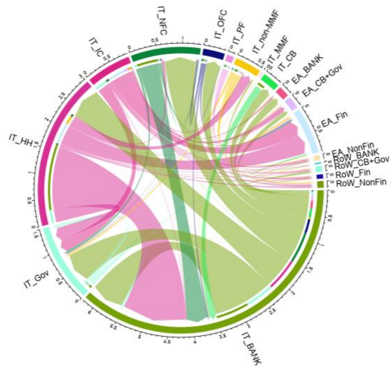
France



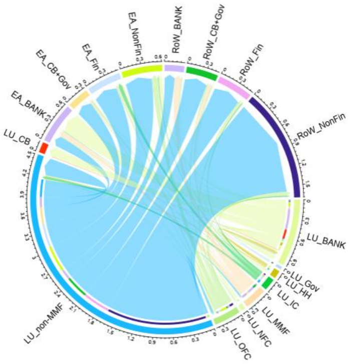
Ireland



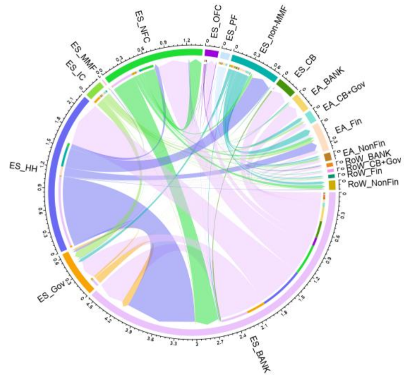
Italy



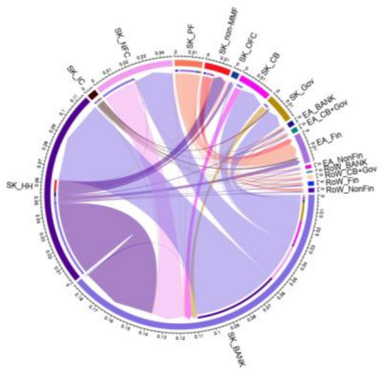
Luxembourg



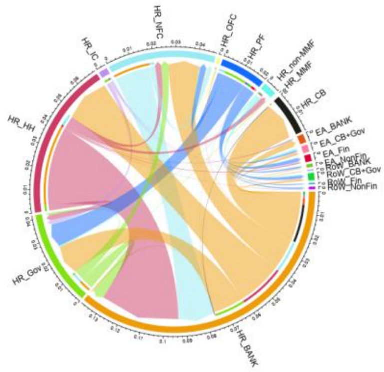
Spain



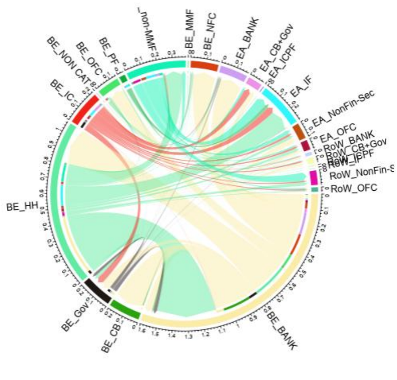
Slovakia



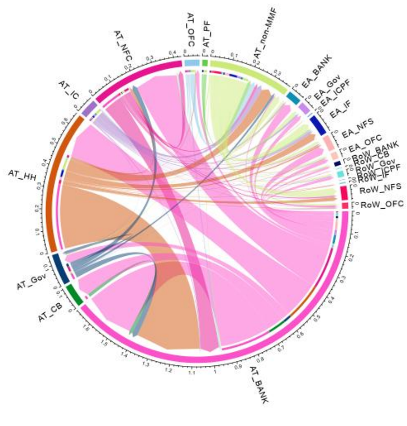
Croatia



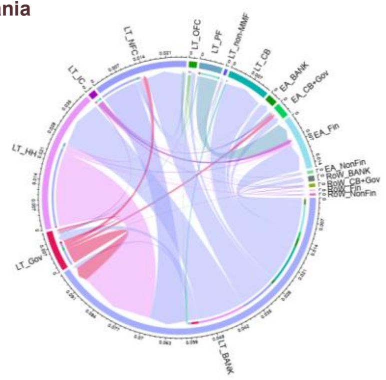
Belgium



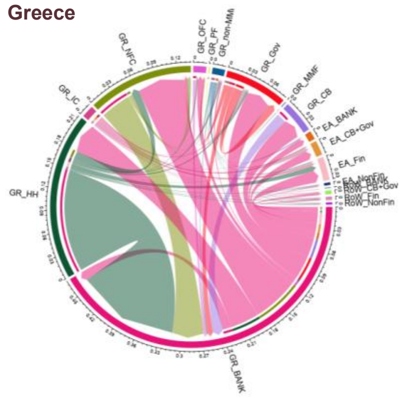
Austria



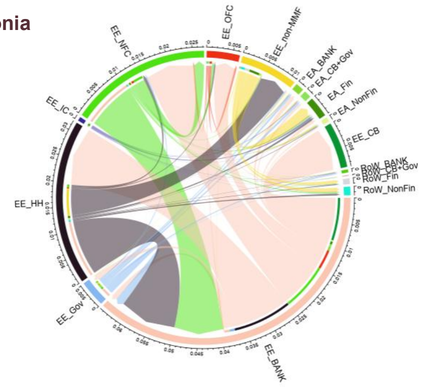
Lithuania



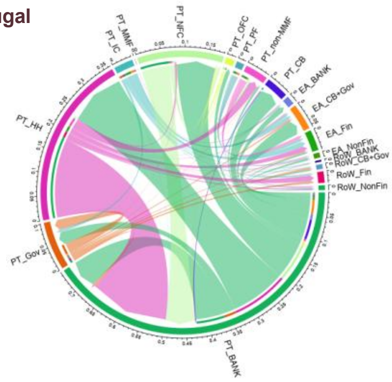
Greece



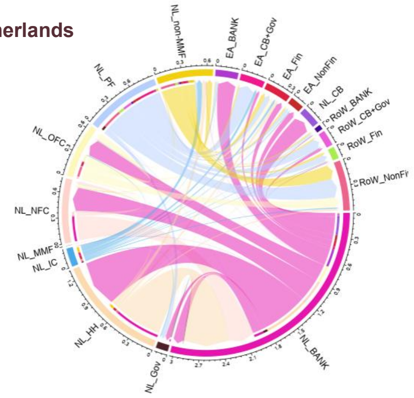
Estonia



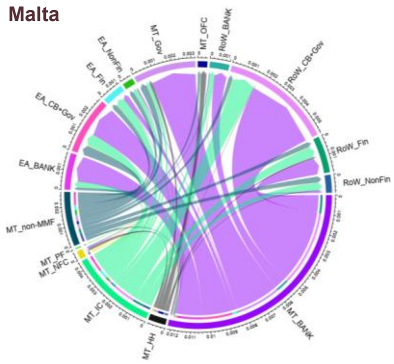
Portugal



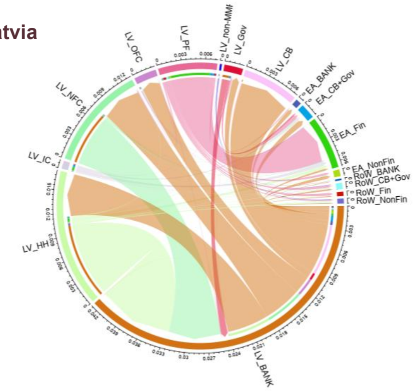
Netherlands



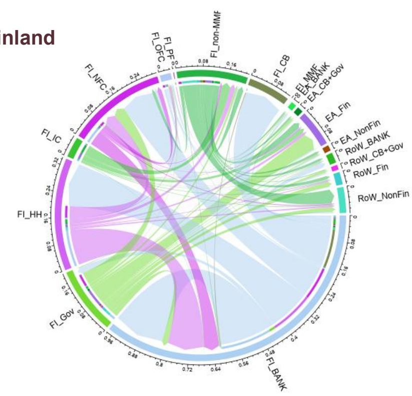
Malta



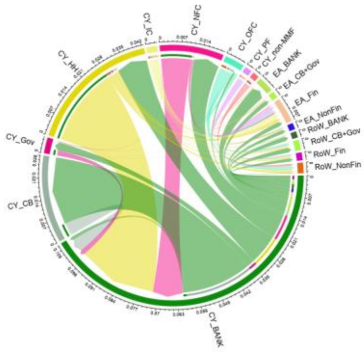
Latvia



Finland



Cyprus

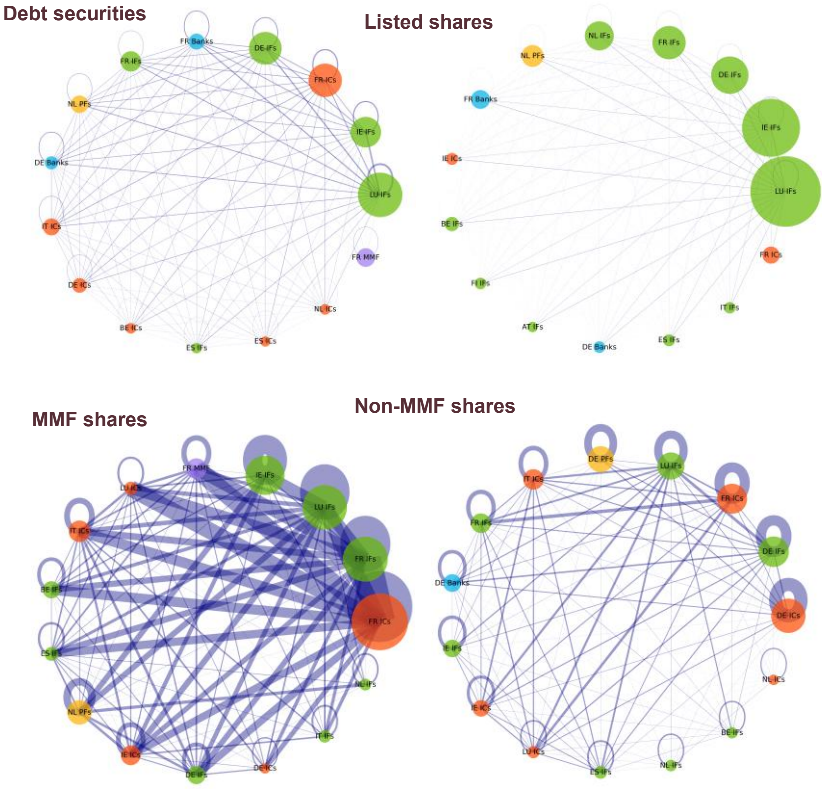


Sources: Comprehensive dataset and own calculations.
Notes: The direction of an arrow shows exposures from a fund provider to a receiver. Figures are not scaled.

Chart A4

Overlap portfolios in the euro area by financial instrument

As of the fourth quarter of 2023



Sources: SHS, BSI and own calculations.
Notes: The nodes (circles) represent the total holding amount of the financial instrument considered for a holder area and holder sector (e.g. IE banks). The node size is proportional to the total holding amount of that instrument in the euro area. The edges between the nodes connect two holders (e.g. IE banks and LU IFs) when having the same security. The thickness of the edges is the sum of the holding amount of the same security between the two holders proportional to the sum of the holding amount of all the specific instrument of the two holders. To improve graph readability, nodes and edges are multiplied by a constant and divided by the value of lowest node in the chart. Only the top 15 nodes for total holdings and the corresponding edges are displayed in the chart.

10.4 Haircuts derived from the adverse liquidity scenario

Haircuts for specific asset classes are also derived from the adverse scenario. The jurisdiction-specific approach and the ESRB tool use by default haircuts aligned with the LCR regulation. Nonetheless, using the market risk shocks from the adverse scenario, haircuts were computed as the difference of the market value before and after the shocks.

For each financial security by ISIN *i* and instrument type *j* in country *c* with rating/maturity bracket r, the market value after the shock is computed using the following three steps:

1. The change in market value is calculated for each security (identified by ISIN), instrument type and country, and based on its rating and maturity bracket. The formula used considers the modified duration of the security, which measures its sensitivity to changes in interest rates. The total shock includes both a spread shock (depending on the instrument type, country, and rating) and a shock to the risk-free rate.[18] These shocks are then multiplied by the market value of the security and scaled down (by 0.0001) to get the change in its value:

$$\Delta \text{mkt value}_{i,j,c} = -\text{ modified duration}_i * (\text{shock to spread}_{j,c,r} + \text{ shock to riskfree}_{j,c,r}) * 0.0001 * \text{mkt value}_{i,}$$

   The market value after shock is calculated by adding the change in market value to its original value. The formula includes a floor at zero to prevent negative market values:

$$\text{mkt value}_{i,j,c,\text{after shock}} = \max\left[\text{mkt value}_{i,j,c} + \Delta \text{mkt value}_{i,j,c}, 0\right]$$

2. The haircut for each ISIN (security) is calculated as the percentage reduction in its market value due to the shock. This is found by taking 1 minus the ratio of the post-shock market value to the original market value:

$$\text{haircut}_i = 1 - \frac{\text{mkt value}_{\text{after shock}_i}}{\text{mkt value}_i}$$

3. Each ISIN is given a weight based on its outstanding amount relative to the total outstanding amount of all securities of the same instrument type, country/region and rating. The weighted haircut is then calculated by multiplying the haircut of each ISIN by its respective weight:

$$\text{weight}_i = \frac{\text{amount oustanding}_i}{\sum_{i=1}^{N} \text{amount oustanding}_{i,j,c,r}}$$

$$\text{weighted haircut}_i = \text{ haircut}_i * \text{weight}_i$$

[18] The shocks to the government spread are by tenors. For other bonds, the shocks to spreads are by rating.

The overall haircut for each instrument type, country/region, and the rating[19] is found by summing up all the weighted haircuts of the securities within that group:

$$\text{haircut}_{j,c,r} = \sum_{i=1}^{N} \text{weighted haircut}_{j,c,r}$$

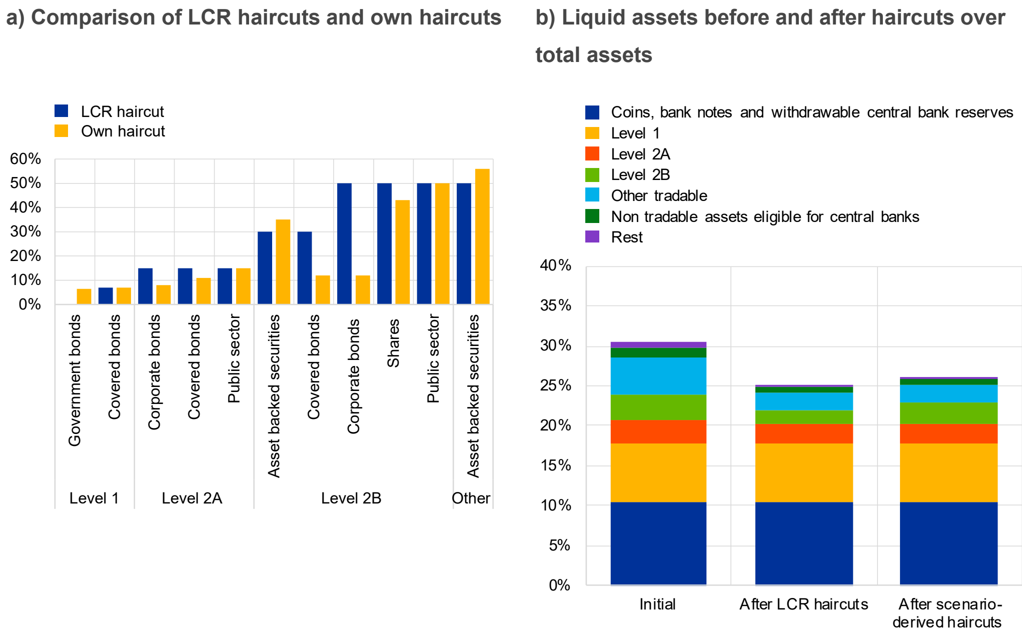
The scenario-derived haircuts are not always the same as the LCR defaults. For some asset classes, scenario-derived haircuts differ from the LCR haircuts. For Level 1 government bonds, the scenario-derived haircut is 5% in contrast to the 0% haircut in the LCR regulation (Chart A5, panel a). For Level 2A liquid assets, the scenario-derived haircuts are smaller than the LCR haircuts for corporate bonds (8% versus 15%) and covered bonds (11% versus 15%). For Level 2B, the difference is more important. The scenario-derived haircut for asset-backed securities is greater than the LCR haircut, while it is smaller for covered bonds, corporate bonds and listed shares. The impact of applying those haircuts is slightly larger using the LCR haircuts than the scenario-derived haircuts (Chart A5, panel b). The ratio of liquid assets to total assets was 31% before haircuts. After haircuts, the ratio fell to 25% using LCR haircuts and 26% using scenario-derived haircuts.

Chart A5

LCR haircuts, scenario-derived haircuts and impact on liquid assets after haircut

As of the fourth quarter of 2023

(EUR trillions)



Sources: SHS, CSDB, SLST desktop exercise and ESRB calculations.
Notes: Approximations/estimations have been made where the results were not fully completed. The results cover banks (significant institutions) in the euro area, banks in HU, NO, SE, DK, less significant institutions in BE, AT, LU, HR, investment funds in the EU and insurance corporations.

[19] The rating is used to classify the haircuts according to the level of the liquid assets.

10.5 Data adjustments in the jurisdiction-specific stress-testing exercise

Some of the information reported by the Single Supervisory Mechanism (SSM) was at the aggregate level. Although the SSM provided country-specific data and results, which were essential for accurately assessing the price impact, some of the liquid assets for Cyprus, Malta, Lithuania and Latvia were reported in aggregated form. To disaggregate these values, the percentage of total assets from the ECB's consolidated banking data (CBD2) was used to proportionally allocate the aggregated liquid asset figures across these countries. Furthermore, the SSM did not provide country-specific data on accumulated contractual flows or outflows, which are critical for calculating asset sales. To address this gap, total contractual asset flows and outflows were extracted from the SSM's desktop exercise submission and allocated across countries using either total assets (from the CBD2 dataset) or liquid assets (from the SSM submission), depending on the variable in question. Once the necessary variables were obtained, haircuts were applied to the liquid assets, including both the LCR haircut and the scenario-derived haircut. Subsequently, the three liquidation strategies as in Section 6 were computed.

In addition, some data corrections, approximations and adjustments were implemented in the jurisdiction-specific results. The purpose was to enhance the comparability and extensibility of the results across jurisdictions. Initially, for countries that reported the outflow data only for the six-month time horizon, the projections for the other time horizons were estimated using the profile of the SSM results. Adjustments were also performed to the amount of assets needed to be sold by asset class to ensure that they did not exceed its initial stock. This was addressed by adding a cap on the asset sold by asset class to avoid surpassing the available stock of a specific asset at each stress horizon. In cases where the stock was fully depleted, any unsold residual was redistributed proportionally across the remaining positive stocks.

10.6 Adjustments to EIOPA stress test data

The results from EIOPA required some adjustments to fit the jurisdiction-specific approach. Despite using a similar adverse scenario, the EIOPA results were reported in accordance with the 2023 EIOPA EU-wide insurance sector stress-testing exercise templates and main assumptions. The following adjustments were made to the results.

- Surrender rate alignment: EIOPA assumed an annual surrender rate of 20%, significantly higher than the 1.3% rate derived from the volume shocks at the EU level (Section 5). The adjustment was a simple rescaling of the reported surrender delta using:

$$\text{Adjusted } \Delta = \text{Reported } \Delta \times \frac{0.013}{0.2}$$

- Time horizon rescaling: EIOPA data reported outflows over a 90-day stress window, while the jurisdiction-specific approach uses different stress windows: five days, 30 days, six months and one year. Rescaling was applied as follows.

  (i) Linearly time-distributed items (for premiums and claims):
  For periods shorter than 90 days, both the baseline and stress delta were proportionally scaled. For longer horizons, only the baseline was scaled up while the delta remained fixed. For example:

  $$30 - \text{day value} = \left(\text{Baseline} \times \frac{30}{90}\right) + \left(\Delta \times \frac{30}{90}\right)$$

  (ii) Non-linear stress items (for investments and reinsurance):
  These were rescaled using the square-root-of-time rule, reflecting that stress impacts may accumulate more gradually:

  $$\text{T} - \text{day value} = \left(\text{Baseline} \times \sqrt{\frac{T}{90}}\right) + \left(\Delta \times \sqrt{\frac{T}{90}}\right)$$

For time horizons beyond 90 days, the full delta was applied without further scaling.

  (iii) Margin calls:
  Reported over a 90-day horizon but assumed to materialise within five days. The same value was applied uniformly across all time stress windows.

  (iv) Surrender outflows:
  These already captured peak stress effects over 90 days. To reflect different timeframes, the delta was redistributed rather than increased. For shorter periods, the delta was scaled down in proportion to the full one-year horizon:

  $$5 - \text{day value} = \left(\text{Baseline} \times \frac{5}{90}\right) + \left(\Delta \times \frac{5}{365}\right)$$

10.7 Qualitative information from the jurisdiction-specific stress test results

Part of the reporting requirements in the jurisdiction-specific approach was a qualitative assessment of the results and assumptions. Participating authorities provided varied interpretations of own stress test results. They generally found that the inclusion of inflows from retail and non-financial corporate customers led to mild stress on banks. In some jurisdictions, it was mentioned that the liquidity positions were satisfactory, but the assumptions affected institutions differently based on their business models. Some participant authorities identified key drivers of the results, such as haircuts and the 100% outflow assumption for overnight deposits, which disproportionately affected smaller, deposit-reliant institutions. Some authorities mentioned that while loan inflows offset some of the stress, assumptions such as the

100% outflow rate for non-operational deposits were deemed excessive, particularly for non-financial corporates. In one case, limited reliance on quantitative easing, longer-term refinancing operations and central bank reserves and therefore cash represented a small fraction of the stock of liquid assets. One participant mentioned that the static nature of the jurisdiction-specific stress-testing exercise overlooks the dynamic nature of financial flows Authorities recommended more dynamic models and sector-specific adjustments for future iterations to better reflect liquidity risks.

Participant authorities had varied perspectives on the liquidation strategy having a worse impact in their own jurisdiction. Some noted that no alternative pecking order would significantly worsen first-round impacts due to the mark-to-market valuation of counterbalancing capacity. However, second-round effects could be more severe if central bank reserves were excluded or if high-haircut assets were prioritised for liquidation. One authority mentioned that selling covered bonds could amplify liquidity problems due to banks' interconnected holdings, leading to sharp price declines and weakened resilience. Conversely, another participant mentioned that liquidity reserves were mostly in cash and central bank reserves and hence alternative liquidation assumptions did not have any significant impact.

10.8 Mapping investment fund shares to investment fund types

The SHS dataset does not include information on the specific type of fund underlying investment fund shares held by financial institutions. To infer the fund type, a classification methodology is applied based on the composition of each fund's asset holdings. This classification is implemented through a multi-step structured query language (SQL) query that processes portfolio-level data to identify the predominant investment focus of each fund. The procedure begins by mapping all individual holdings within each fund to broad asset classes, forming the basis for determining the fund's investment orientation. These asset classes include:

- equity (e.g. shares, real estate investment trusts, rights, warrants);
- corporate bonds (e.g. corporate debt instruments, convertible bonds, deposits);
- government bonds (e.g. sovereign bonds, Treasury bills, supranationals);
- other (residual asset types not falling into the above categories).

The classification of investment fund types is based on a structured analysis of portfolio holdings and issuer-level information. Each security holding is grouped by fund, and the total market value for each asset category is computed. These category-level values are then aggregated to determine the overall size of each fund's portfolio, ensuring that the classification reflects the relative weight of each asset type. To enable linkage between fund classifications and issuers, a distinct set of issuer legal entity identifiers (LEIs) is extracted from a separate dataset. Instruments are retained for mapping only if they meet specific criteria:

issued by financial institutions, valid as of the reference period (fourth quarter of 2023), held within a defined set of EU countries, active and associated with non-null market values. Once both total and per-category values are established, the share of each asset class in the total fund value is calculated. Asset classes are ranked by size for each fund, and if the largest category accounts for more than 50% of the fund's value, the fund is assigned to that category. Otherwise, it is classified as "mixed", indicating a more balanced allocation. The resulting classification is then mapped to the filtered list of issuer LEIs, allowing each issuer to be linked to the dominant investment focus of its corresponding fund. This output supports applications in risk monitoring, supervisory reporting and further analytical work.

10.9 Additional ECB ISA results

The dispersion and relative size of market losses across entities vary between the first-round and second-round impacts. The dispersion and relative size of losses from the holdings of debt securities (i.e. non-financial, financial and government bonds) tend to be larger during the first round than the second round for all financial sectors (Chart A6). For banks, this can be explained by the larger share of bond holdings booked as held-to-maturity assets.[20] For insurance corporations, this dispersion is limited compared with that in other sectors, reflecting a homogenous holding of bonds across insurance undertakings.

As expected, debt securities experience more contained losses, with government bonds facing the lowest losses (within a 5% range) and financial corporate bonds the highest. The dispersion of losses from the holdings of equity is larger in the second round than in the first round, although the relative size of losses (median) is greater in the first round for banks and insurance corporations, while the opposite holds for investment funds. The dispersion and relative size of losses from the holdings of investment fund shares are slightly higher in the second round for all financial sectors. For fund shares, the market losses relative to exposure of the first and second rounds are more similar.

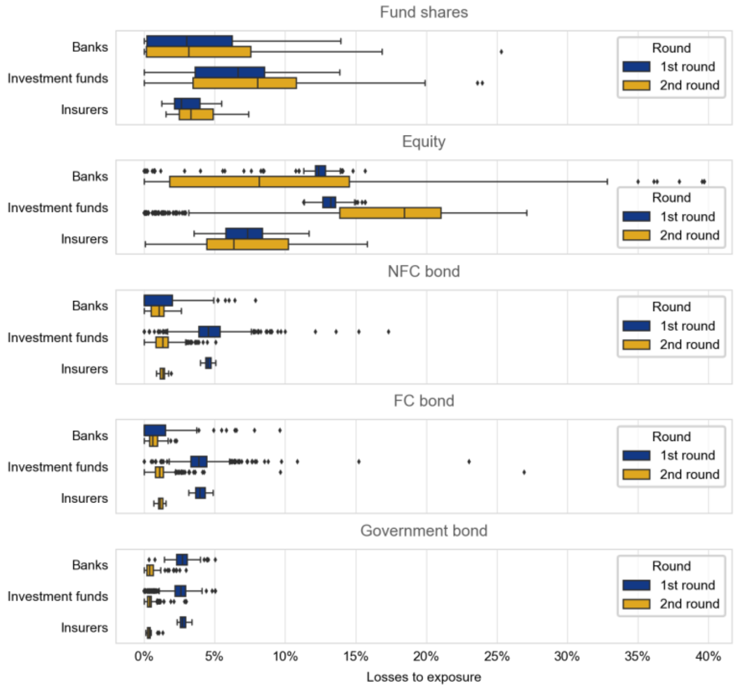
[20] Losses on these securities are not realised according to banking regulation.

Chart A6

Market losses on the holdings of equity, debt securities and funds shares

As of the fourth quarter of 2023

(percentage losses relative to exposure)

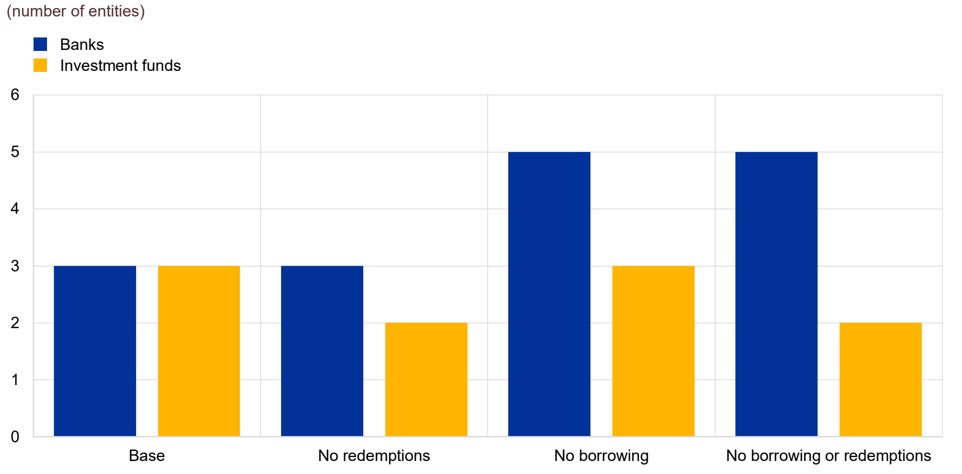


Source: ECB ISA model.
Notes: Exposures are defined as the total known holdings in the given asset category, i.e. fund shares, equity, NFC bonds, FC bonds and government bonds. Data are restricted to euro area-based entities.

Banks with more means to mitigate, but not completely absorb, initial external shocks might exacerbate systemic distress by liquidating large volumes of assets, thus becoming sources of instability. While these banks may temporarily meet the minimum LCR, depositors may panic, leading to withdrawals that necessitate further fire sales, thereby affecting the system again. By contrast, banks resorting to fire sales as their sole option may cause a more significant initial shock, but those unable to recover sufficient liquidity will ultimately exit the network. Simulations indicate that more banks default when limited to fewer liquidity recovery measures (Charts A7 and A8).

Chart A7

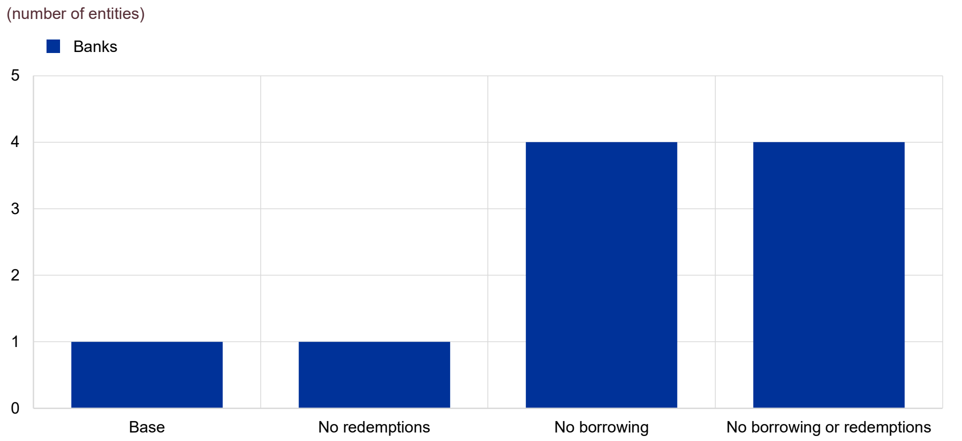
Solvency defaults under different model specifications



Source: ECB ISA model.
Notes: "Base" refers to the simulation with all available endogenous mechanics for banks included (including unsecured borrowing and redemptions of fund share holdings). "No redemptions" considers a specification without access to fund share redemptions. "No borrowing" considers a specification without access to unsecured borrowing. "No borrowing or redemptions" refers to a specification preventing both unsecured borrowing and redemptions of fund share holdings. Insurance corporations' defaults are registered.

Chart A8

Liquidity defaults under different model specifications



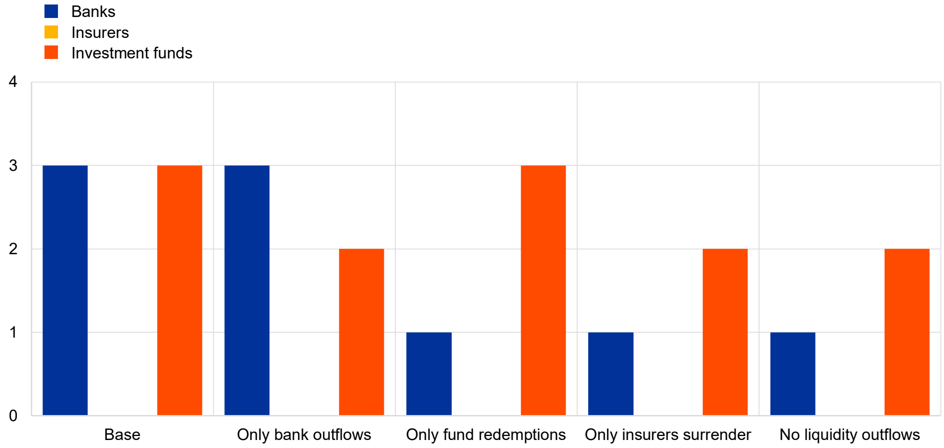
Source: ECB ISA model.
Notes: "Base" refers to the simulation with all available endogenous mechanics for banks included (including unsecured borrowing and redemptions of fund share holdings). "No redemptions" considers a specification without access to fund share redemptions. "No borrowing" considers a specification without access to unsecured borrowing. ""No borrowing or redemptions" refers to a specification preventing both unsecured borrowing and redemptions of fund share holdings.

The single bank liquidity default mentioned above is fully dependent on the scenario outflows, while three solvency defaults out of four are caused by second-round dynamics in response to the liquidity shortfall (Charts A9 and A10). The scenario considering no liquidity outflows shows that one bank and two funds are greatly exposed to market risk and prone to suffering high losses in a severe financial market downturn. Nonetheless, as seen for the liquidity scenarios affecting either only banks or funds, additional entities are vulnerable to fire sales in the second round, eventually resulting in two more banks and one more fund defaulting.

Chart A9

Solvency defaults triggered by market risk shocks and under different model specifications for liquidity outflows

(number of entities)

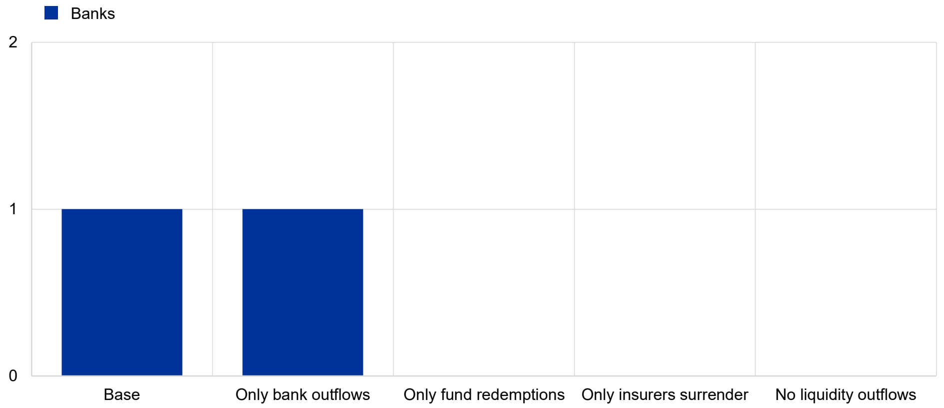


Source: ECB ISA model.
Notes: The “base” scenario includes all available endogenous mechanics. “Only bank outflows” refers to a scenario where only banks experience deposit runs. “Only fund redemptions” considers a scenario where only investment funds face outflows. “Only insurer surrenders” refers to a specification where only insurance policyholders make withdrawals. Lastly, “no liquidity outflows” indicates a scenario where neither banks, investment funds nor insurers experience outflows.

Chart A10

Liquidity defaults under different model specifications

(number of entities)



Source: ECB ISA model.
Notes: The “base” scenario includes all available endogenous mechanics. “Only bank outflows” refers to a scenario where only banks experience deposit runs. “Only fund redemptions” considers a scenario where only investment funds face outflows. “Only insurer surrenders” refers to a specification where only insurance policyholders make withdrawals. Lastly, “no liquidity outflows” indicates a scenario where neither banks, investment funds nor insurers experience outflows.

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For specific terminology please refer to the ESRB glossary (available in English only).

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