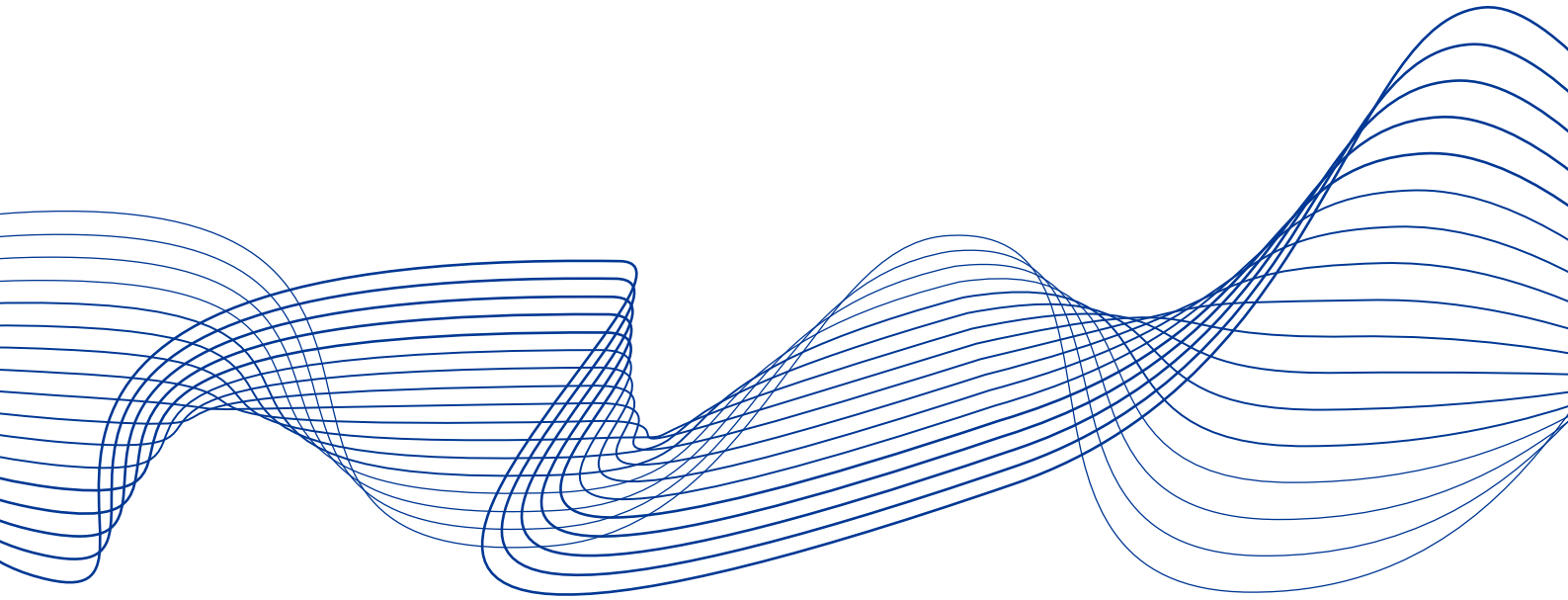
Systemic liquidity risk: a monitoring framework

February 2025



ESRB
European Systemic Risk Board
European System of Financial Supervision

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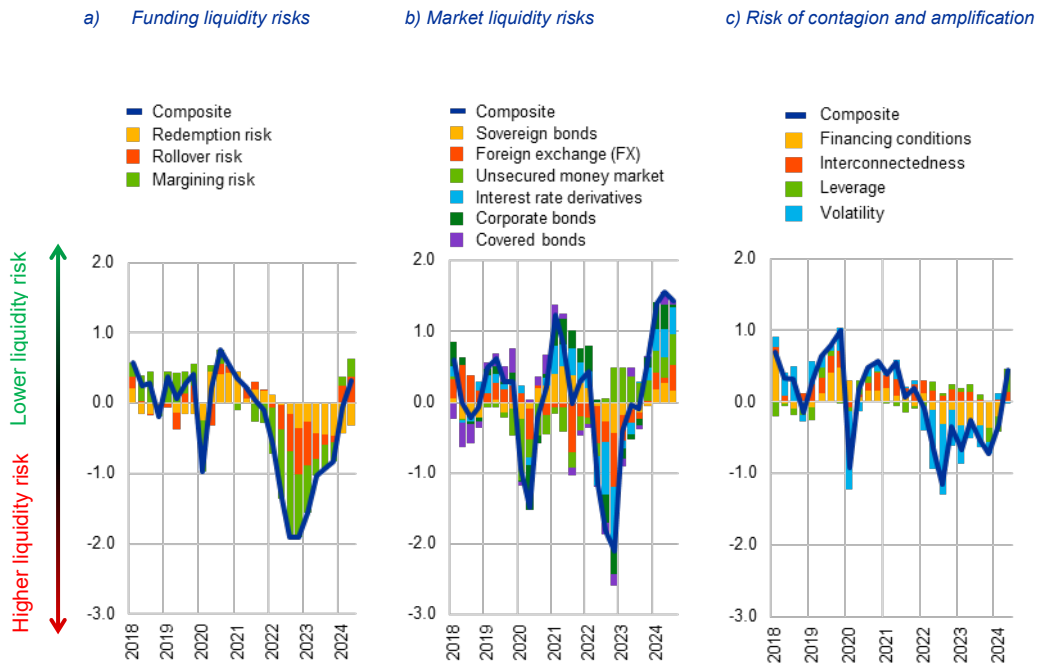
Executive summary

Liquidity can evaporate quickly and trigger system-wide stress. This has been observed in several recent episodes, including the “dash for cash” during the COVID-19 pandemic, the liquidity stress faced by GBP funds following liability-driven investment strategies in September 2022, and the banking stress in the United States and Switzerland in early 2023. In all these instances, liquidity shortages propagated across entities and markets with increasing intensity. In two cases, non-bank financial intermediaries (NBFIs) were at the epicenter of stress. Markets beyond the sovereign bond market also faced dislocations. These experiences suggest that it is only possible to fully understand and measure risks to systemic liquidity by paying due attention to financial system entities beyond banks and key asset classes beyond sovereign bonds. The risk of stress transmission and amplification must also be considered as fundamentally important.

With these observations in mind, this report provides a unified framework for monitoring systemic liquidity risks, expanding on existing frameworks (see ECB, 2018 and 2023b) to cover the elements mentioned above. The report starts with a specific operational definition of systemic liquidity risk and its essential dimensions. It then discusses which entities and markets are key and should therefore be systematically monitored for emerging liquidity risks. Finally, based on the selection of entities and markets, it presents two composite indicators that capture the main dimensions of systemic liquidity risks (funding liquidity risks and market liquidity risks) and an accompanying indicator measuring the risk of contagion and amplification. The three panels in the chart below provide an overview of these three components. The framework can be used to zoom in on specific types of entities and individual markets. It presents detailed heat maps covering all indicators included in the composite indices.

Chart 1

Composite indicators for systemic liquidity risk in the euro area



The application of the framework to the euro area reveals that funding liquidity risks increased markedly in 2022 (see Chart 1, panel a), when the monetary policy stance was tightened to address high inflation. Subsequently, funding liquidity recovered fully and appeared comparable to its historical average in the second quarter of 2024. Market liquidity risks and the risk of contagion and amplification followed a similar dynamic: after a deterioration in the course of 2022, risks gradually dissipated and appeared lower than the historical average in the second quarter of 2024. (see panel b and c in Chart 1).

While the monitoring framework is a useful tool for measuring systemic liquidity risks, there are several potential avenues for further extensions and uses. First, the measurements are contemporaneous (and even delayed for some sub-indicators, as a result of reporting lags) and therefore not as suitable for predicting liquidity stress. They could be usefully complemented by a set of early warning indicators. Second, the surveillance framework could inform a dedicated system-wide liquidity stress test and vice versa: the two could refine and enrich each other systematically over time. Third, this framework focuses largely on domestic and regional developments and could be expanded to cover the global dimension of systemic liquidity risks. Finally, the report presents a general application of the framework to the euro area, along with two examples for individual Member States (the Netherlands and Finland) and a case study focusing on systemic illiquidity during the pandemic. The monitoring framework could in principle be applied to any EU Member State and to the EU as a whole.

In that context, the report features five analytical boxes expanding the analysis of funding and market liquidity issues. Box 1 outlines the preliminary findings of the ongoing work by the European Systemic Risk Board (ESRB) to develop a system-wide liquidity stress test for the EU financial system. Box 2 takes a closer look at Europe's largest covered bond market– the Danish mortgage bond market. Box 3 provides an overview of the structure of sovereign bond markets in Germany and Italy, highlighting common features and important differences. Box 4 outlines the liquidity monitoring framework for undertakings for collective investment in transferable securities (UCITS) in Luxembourg, home of the largest fund industry in the EU. Box 5 discusses the usefulness of the framework for real-time monitoring, using the episode of systemic illiquidity during the pandemic as a case study.

1 Introduction

A long period of ultra-low interest rates and benign financial conditions was followed, in 2022, by a sharp tightening of monetary policy, amid declining central bank liquidity support. The low-for-long era was accompanied by search-for-yield behaviour amid abundant funding liquidity, which also supported market liquidity. As noted by the European Systemic Risk Board (ESRB) (2021b), low interest rates and structural changes have given rise to a financial system that is more sensitive to market shocks. Systemic liquidity risks may have increased during this period due to an endogenous build-up of risk, liquidity illusion and interconnectedness within the financial system. As a result, there is a need for improved liquidity reporting and monitoring, more effective use of existing data and system-wide liquidity stress tests.

Large, unanticipated shifts in liquidity can result in system-wide stress, as two distinct episodes in 2022 and 2023 demonstrate. The liquidity stress faced by GBP funds pursuing liability-driven investment strategies in September 2022 and the banking stress in the United States and Switzerland in early 2023 demonstrated how changes in financial conditions can trigger large contingent liquidity needs. This creates a risk of shocks being propagated and amplified throughout the financial system. The scope and scale of these developments highlight the need for a macroprudential approach to monitoring systemic liquidity, as a complement to ongoing microprudential initiatives to increase resilience at the level of individual entities, markets and activities.

This report proposes an indicator-based monitoring framework for systemic liquidity risks, expanding existing work along the following dimensions: (i) developing the scope in terms of the entities and markets covered, and (ii) measuring the propensity for stress transmission and amplification. The framework in this report expands the scope of existing frameworks for surveillance — which largely focus on banks and sovereign bond markets (see ECB, 2018 and 2023b) — to include financial entities beyond banks and markets other than the sovereign bond market. Localised liquidity shortages can result in system-wide stress due to contagion across entities or markets, with increasing intensity related to adverse feedback loops. The framework therefore accounts for transmission channels and potential amplifiers of illiquidity. In that sense, it has a distinct macroprudential angle.

Further extensions of the framework could be considered in future, but are beyond the scope of this report. The report seeks to provide a monitoring tool that could be applied in all EU jurisdictions and enriched by adding further dimensions in the future. For example, the surveillance framework could be used to design early warning indicators for systemic liquidity risk. Cross-border dimensions beyond the EU might also be considered at a later stage, especially for entities such as investment funds that invest and are held mainly outside the EU.

The monitoring framework could also inform and be refined using the outcome of systemic liquidity stress testing. The ESRB's Task Force on Stress Testing is performing a system-wide liquidity stress test across a number of banks and non-banks (see Box 1 for an overview of this work). The results of this stress test exercise could be very useful in identifying system-wide vulnerabilities and risks that arise from interconnectedness between markets and entities. Similarly,

the systemic liquidity surveillance framework outlined in this report can support system-wide stress testing by identifying risks and helping to calibrate liquidity stress scenarios. The Bank of England has published the conclusions of its system-wide exploratory scenario exercise[1] in November 2024, which has proved to be an effective tool for improving the understanding of system-level vulnerabilities in core UK markets.

The report first defines systemic liquidity risk and then builds on insights from recent empirical literature to develop a surveillance framework. It then discusses how to measure systemic liquidity risk across the dimensions of funding and market liquidity, while also taking into account contagion and amplification factors. Finally, it applies the framework to the euro area and two Member States (the Netherlands and Finland). It includes five topical boxes that cover (i) the ESRB's work to develop a system-wide liquidity stress test for the EU financial system; (ii) an overview of the Danish covered bond market, which is the largest and most liquid in the EU; (iii) details of the microstructure of German and Italian sovereign bond markets; (iv) an analysis of liquidity risks in UCITS domiciled in Luxembourg; and (v) an analysis of systemic illiquidity during the COVID-19 outbreak, evaluating the usefulness of the framework for real-time monitoring.

[1] See Bank of England (2024).

2 Systemic liquidity risk: conceptual considerations

Liquidity risk and its dimensions

Liquidity is a complex concept with multiple dimensions. In general terms, it refers to the ability of solvent economic agents to settle their obligations when due. This typically means they must be able either to refinance (e.g. roll over existing debt or obtain alternative funding) or to sell financial assets (e.g. sell existing liquidity buffers in the form of sovereign bonds) to meet liquidity demands. Two major dimensions of liquidity are therefore **funding liquidity**, or the ability of institutions to obtain funding, and **market liquidity**, or the ability to trade financial assets. Each of them has several important sub-dimensions, which are explained in Figure 1 below.

Figure 1
Major dimensions of liquidity

Source: ECB (2023b).

The key dimensions of funding liquidity risk are rollover, redemption and margin risk (see ECB, 2023b). Rollover risk means that entities may be unable to maintain (or expand) financing, typically in times of stress. **Redemption risk** arises because investors or clients may withdraw money, exposing entities to the risk of large, unforeseen outflows of funding. The nature of redemption risk varies across financial institutions. For banks, it refers to deposit withdrawals, which clients redeem at par. For funds, it relates to redemptions of fund shares, usually at market value (except for money market funds (MMFs) offering a stable net asset value (NAV)). For insurance companies offering life insurance contracts, it refers to surrender, which allows policyholders to terminate a contract before its maturity and receive an ex ante guaranteed redemption value (see Grochola et al., 2023). Finally, **margin risk** refers to liquidity needs that arise from variation margin or initial margin requests in relation to derivative exposures. This risk also covers additional collateral requests on repo positions, since adverse changes in market prices result in liquidity demands for counterparties.

The key dimensions of market liquidity risk – tightness, depth, breadth, immediacy and resilience – reflect the costs and time required to sell assets. A liquid market for financial assets would in principle allow market participants to dispose of large portions of their portfolio quickly, with limited transaction costs and a contained impact on the equilibrium market price. In practice, however, disposal of assets can generate a significant price impact and therefore losses

on assets sold, with potential spillover effects to other investors. This market liquidity dimension is referred to as **tightness**, which measures the possibility of executing trades at low costs.[2] Market participants may also be unable to sell large portions of their portfolio at prevailing market prices, resulting in liquidity issues. This dimension is referred to as **depth**, and it assesses the amount of available liquidity posted around market prices. **Breadth** measures the ability to transact large volumes with a limited impact on prices. Risks related to **immediacy** (or, more precisely, a lack of immediacy) capture the time aspect of market liquidity, or the ability of market participants to sell assets quickly. Finally, the **resilience** of market liquidity measures the ability of liquidity providers to continue to supply liquidity during market turmoil, and is particularly relevant from a financial stability perspective.[3]

Systemic liquidity risk

Liquidity stress can have system-wide repercussions, affecting multiple institutions and markets, with potential spillovers between funding and market liquidity. The International Monetary Fund (IMF) (2011) defines systemic liquidity risk as the "*risk of simultaneous liquidity difficulties at multiple financial institutions*". This definition does not fully consider the fact that liquidity issues are amplified when affected entities are also significant players in key markets, such as banks for government bonds or MMFs for unsecured short-term funding markets. This report therefore defines systemic liquidity risk as the risk of simultaneous liquidity difficulties at multiple financial institutions affecting key markets, expanding the IMF definition to include spillovers from funding to market liquidity and vice versa.

Over the last decade, the nature of systemic liquidity has evolved due to structural changes in the financial system. A tighter regulatory framework and the resulting changes in bank business models have reduced the amount of liquidity transformation performed by banks and their use of leverage (ESRB, 2021a). As a result of the rise of non-banks (Chart 2), including open-ended funds offering daily liquidity to investors, more liquidity transformation is performed outside the banking sector. Non-banks have also gradually increased their role in providing liquidity to financial markets (including proprietary trading firms on electronic markets). The move from bilateral to central clearing and from unsecured to more secured funding has reduced counterparty risk (Chart 3). However, it has reinforced the link between market and liquidity risk by translating price volatility into margin calls and collateral requests.[4] Existing frameworks for surveillance of systemic liquidity risk largely focus on banks and sovereign bond markets (see ECB, 2018 and 2023b). In view of the structural changes mentioned above, there is a need to expand surveillance frameworks to cover NBFIs and key markets beyond sovereign bond markets.

2 For a discussion of the different dimensions of market liquidity, see De Renzis et al. (2018).

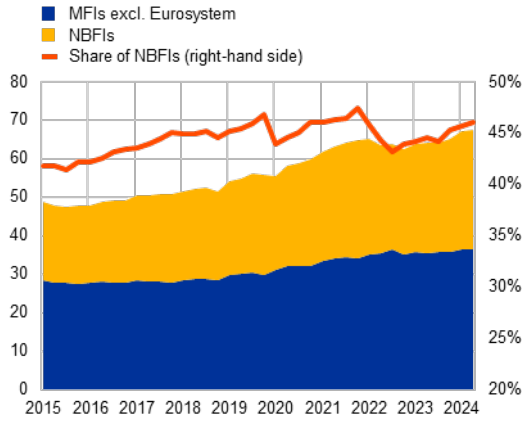
3 When markets freeze, all dimensions of market liquidity deteriorate sharply; investors are unable to dispose of assets quickly, in large amounts or with limited losses.

4 For a list of factors that have altered the nature of liquidity supply and demand, see Berner (2023).

Chart 2

Total financial assets of the euro area financial sector

(left-hand side: EUR billions, right-hand side: share of NBFIs)

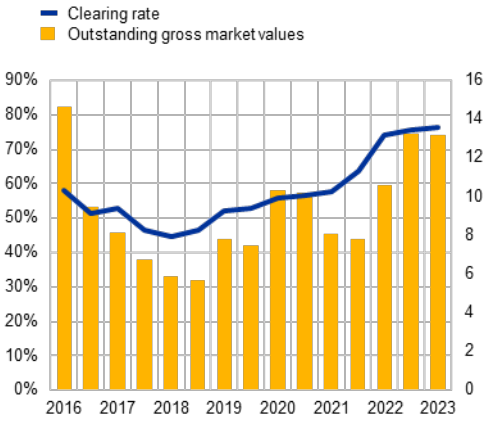


Sources: QSA and BSI.
Notes: NBFI share of the total financial assets of NBFIs and monetary financial institutions (MFIs), excluding Eurosystem. NBFIs comprise insurance corporations, pension funds, investment funds and MMFs.

Chart 3

Clearing rates of global interest rate swap markets

(left-hand side: share of net market value, right-hand side: USD trillions)



Source: Bank for International Settlements.

3 Review of the economic literature and its implications for the surveillance framework

The existing economic literature on systemic liquidity risk provides a useful starting point for our monitoring framework. The economic literature on liquidity risks and liquidity crises is rich and dates back as far as the seminal works by Thornton (1802) and Bagehot (1873). Relevant existing studies discuss the underlying vulnerabilities that give rise to liquidity risk, contagion channels that spread stress across entities and markets, and factors that increase the likelihood of stress intensifying as it propagates through the system.

Liquidity and maturity transformation are at the core of liquidity risks, which means that indicators of these vulnerabilities should be an integral part of the monitoring framework. The classical literature on funding liquidity risks focuses on bank runs. Long-term illiquid assets (i.e. loans) are funded with short-term callable liabilities (i.e. deposits), which expose banks to liquidity risk. Runs on even fundamentally solvent institutions can occur because the costs of inefficient liquidations of assets are born by the remaining depositors. Due to this externality, depositors are better off withdrawing deposits whenever they expect that others will do so, even if they do not need the funds and the bank is fundamentally sound (see Diamond and Dybvig, 1983, among others). Similar mechanisms are at play for NBFIs engaged in liquidity transformation: investors in illiquid open-ended funds have an incentive to redeem ahead of others to avoid costs related to the liquidation of assets (see Chen, Goldstein and Jiang, 2010). These incentives are stronger for funds that invest in less liquid assets while providing daily liquidity to investors. For corporate bond funds, investor flows tend to be more sensitive to weak fund performance, resulting in a concave relationship between flows and returns; sensitivity to weak performance increases when market liquidity is low (see Goldstein, Jiang and Ng, 2017).

Localised liquidity difficulties can propagate through the financial system via three broad transmission channels, ultimately resulting in system-wide stress. The first set of transmission channels operates via **direct exposures**: for example, institutions experiencing runs withdraw short-term funding they have provided to other banks (see Allen and Gale, 2000, on contagion within the banking system). Complex funding chains across banks, non-banks and funding markets are capable of transmitting stress through the entire financial system (see Kashyap, 2020).[5] The second set relies on the **impact of runs on the market value of a common pool of liquidity**: institutions experiencing a run bid up short-term market funding costs, which shrinks the market value of a common pool of liquidity and creates or aggravates liquidity shortages elsewhere in the system (see Diamond and Rajan, 2005). Finally, **confidence effects** can ignite contagion. If there is incomplete information, a run on individual banks can be interpreted as indicating fundamental

[5] For example, drawing on Kashyap (2020), a pension fund might hold MMF shares for cash management purposes, such as meeting margin calls on derivatives positions. The MMF might in turn lend its cash in a reverse repo operation with a bank, receiving short-term bonds as collateral. The bank could then lend the cash to a hedge fund, which would in turn invest in sovereign bonds. This complex funding chain means that if any of the actors involved in the chain faces stress, the shock could be transmitted across entities and markets. For example, during the UK mini-budget stress of September 2022, EU GBP liability-driven investment (LDI) funds faced high liquidity demands (margin calls on interest rate derivatives and collateral calls on repo positions). To raise cash, LDI funds sold gilts but also redeemed their MMF shares, thereby transmitting the liquidity stress to EU GBP MMFs. See the special feature in **ESRB (2023)** for further details.

weakness in other institutions, which creates self-fulfilling expectations of a crisis in other parts of the financial system (see, for example, Temzelides, 1997, and Brown et al., 2014).

Binding balance sheet constraints on financial intermediaries can amplify the severity of liquidity stress as it propagates through the system. These include funding constraints, leverage constraints and value-at-risk (VaR) constraints. The existing literature covers impaired access to the repo market, redemptions that exceed available liquidity buffers, margin calls, leverage and VaR constraints.[6] When current investors are affected, binding balance sheet constraints can result in forced deleveraging and asset price declines. In turn, lower asset prices mechanically increase the leverage of intermediaries that mark their assets to market, inducing further sales in difficult market conditions (see Adrian and Shin, 2010). By contrast, when market-makers or dealers are affected, they are no longer able to quickly expand their balance sheets and absorb excess supply of securities in times of stress (see Breckenfelder and Ivashina, 2021, and Duffie, 2023), which results in lower market liquidity when it is most needed. They are therefore not able to mitigate non-fundamental price movements. Finally, if potential investors or arbitrageurs are affected, they cannot exploit existing discrepancies between market pricing and fundamentals in periods of stress (see Shleifer and Vishny, 1997). In such circumstances, price dislocations can persist for longer.

A second set of amplification effects operates via financial intermediaries' portfolio allocation decisions and liquidation strategies. Portfolio similarity can act as an amplification factor because it creates stronger fire sale externalities for intermediaries with similar portfolios. For instance, in the case of investment funds, redemptions from illiquid funds can force asset sales with large spillovers to the returns and flows of similar funds, leading to further asset sales. The spillover via common holdings is economically large and occurs when market liquidity is low (see Falato et al., 2021). It has been shown that investors with overlapping portfolios are more likely to generate larger price declines during asset liquidations, and measures of portfolio similarity can be used to predict common selling by investors (see Girardi et al., 2021). In a similar vein, the tendency to not deplete but rather to beef up cash holdings to discourage outflows can amplify fire sale externalities on others, as institutions sell more assets than needed in an attempt to boost their liquidity buffers (see Morris, Shim and Shin, 2017).

Amplification effects are more likely when volatility is high, as it can activate all the above-mentioned channels at the same time. A surge in financial market volatility mechanically tightens VaR constraints and can result in deleveraging by investors. It also mechanically results in higher margin calls, which constitute an adverse funding shock for entities that fund themselves in the repo market or have large positions in derivatives. Finally, it can affect market liquidity and therefore increase the impact of any deleveraging on asset prices, because it results in tighter balance sheet constraints for market-makers and dealers, which tend to operate under VaR risk management frameworks. Market-makers have been shown to retrench from their activities when volatility spikes (see Stoll, 1978).

[6] These constraints can interact and result in strong feedback loops. See, for example, Brunnermeier and Pedersen (2009) for an interaction between leverage and funding constraints (the exact funding constraint mentioned being a margin call) that results in a loss and margin spiral.

Overall, the economic literature reviewed here, and the available stylised facts, indicate that the risk of systemic liquidity stress is state-contingent. Elevated systemic liquidity risks emerge when two conditions are fulfilled at the same time. The first condition is met when the financial intermediaries and markets that comprise the financial system are vulnerable. This is typically visible in high maturity and liquidity mismatches and low liquidity buffers relative to liquidity needs under adverse conditions. High leverage and concentrated or overlapping portfolios also constitute vulnerabilities, as they might result in heightened liquidity demands and forced sales in key markets. The second condition occurs when there is high susceptibility to strong transmission and amplification effects, which increases the odds of localised liquidity difficulties morphing into system-wide stress. Liquidity difficulties are more easily transmitted from entity to entity and to associated markets in complex, interconnected financial systems. Amplification is also more likely when (i) volatility is elevated – as it makes VaR constraints more binding; (ii) when monetary and financial conditions are tight – as funding constraints tend to be tighter in such circumstances; and (iii) when asset prices decline, resulting in tighter leverage constraints for institutions that mark their assets to market.

Measurement of systemic liquidity risks needs to capture not only liquidity vulnerabilities at the level of entities or markets but also stress transmission and amplification. The monitoring framework described in the following sections captures the two main dimensions of liquidity risk – funding and market liquidity – but also tracks the risk of adverse second-round effects. The underlying set of indicators comprises different variables.

- Those that measure the degree to which financial system entities engage in maturity and liquidity transformation, as well as the adequacy of their stock of safe and liquid assets to meet contingent liquidity needs.
- Those that measure the multiple dimensions of market liquidity – immediacy, breadth and depth, tightness and resilience.
- Those that measure complexity and interconnectedness within the financial system, including volatility, financial conditions and leverage. We also include information on portfolio similarity across financial intermediaries, which measures the intensity of common exposures and potential fire sale spillovers.

The next section outlines the design of the surveillance framework in more detail.

4 Monitoring framework

There are four main steps to operationalising the surveillance framework.

1. **Identifying the key entities and markets in scope.** The aim is to cover entities or markets that are likely to trigger stress, transmit it or be subject to strong spillovers from stress elsewhere. Bearing in mind the substantial heterogeneity across countries in terms of what constitutes a key entity or market, we first explain their features in principle.[7] This would allow ESRB members to apply the framework domestically, factoring in all relevant country-specific features.

2. **Selecting surveillance indicators for funding and market liquidity risks.** The indicators should cover all relevant dimensions of market and funding liquidity for the key entities and key markets subject to surveillance (as determined in step 1). This step requires an operational definition of the relevant indicators and their calculation based on available data. The focus is therefore on indicators that can be implemented based on existing reporting requirements.[8]

3. **Selecting indicators for contagion and amplification risks and interactions between funding and market liquidity.** Measurement of systemic liquidity risks – as opposed to risks for individual sectors, markets or institutions – needs to account for stress transmission at a potentially higher intensity. Indicators are selected based on the comprehensive literature review included in Section 3 and complement the indicators for funding and market liquidity risks.

4. **Synthetising the information into practical heat maps and a set of composite liquidity risk indices.** This step aims to reduce complexity and provide a useful overall assessment of risks to systemic liquidity. The composite liquidity risk indicators include sub-indices that allow a focus on specific entities or markets, and a breakdown of changes in the evolution of the overall index by the liquidity dimensions it captures. Complementary heat maps provide a visually intuitive indication of the very specific entity types, markets and indices that merit close monitoring.

This report features example applications of the framework. The main text explains how the framework can be applied, using the euro area as a case study. The importance of cross-country differences are then highlighted in two country-specific applications – for the Netherlands and Finland – in Annexes A.1 and A.2 respectively.

7 The features are framed as a set of selection criteria for identifying key entities and markets in the section below.

8 Since the market structure might differ by country (e.g. degree of OTC or on-exchange trading for sovereign bonds), ESRB members might opt for additional indicators on top of the minimum set of metrics.

4.1 Identifying key entities and markets

Key entities

Key entities from a systemic liquidity perspective are either particularly vulnerable to liquidity risks – i.e. potential triggers for system-wide illiquidity – or likely to be at the epicentre of stress transmission and amplification. We use the three criteria below to decide which institutions to include in the monitoring framework for funding liquidity risk. Entities are considered key if one or more of these criteria is fulfilled.[9]

- First, entities that have an inherently large liquidity mismatch and perform liquidity and maturity transformation, potentially coupled with other vulnerabilities such as high leverage. These entities could be a potential trigger of system-wide liquidity stress.
- Second, entities whose liabilities can serve as liquidity buffers and are therefore redeemed or called in periods of stress. These entities are likely to face potentially large outflows and be at the epicentre of stress transmission and amplification.
- Third, entities that have a substantial market footprint in key markets through their security holdings. These entities could transmit stress to the key financial markets in which they invest, adversely affecting market liquidity.

In the euro area, investment funds, banks, insurance corporations and pension funds could be seen as key entities for systemic liquidity (Table 1). Banks and open-ended funds (alternative investment funds (AIFs) and UCITS) engage in a significant amount of liquidity transformation and would therefore be considered key entities based on the first criterion. MMFs – which are used by investors as cash management vehicles (ESRB, 2021a) – are considered key entities based on the second criterion. Insurance corporations have a substantial footprint in several important financial markets, including the sovereign debt market, which is important from a systemic liquidity perspective. They therefore fall under the third criterion (Chart 4, panel a). Pension funds also have significant holdings of long-dated sovereign bonds and are key players in interest rate derivatives, which they use to hedge their structural negative duration gaps. Given the importance of interest rate derivatives from a systemic liquidity perspective (see below), they could also be included as key entities in our monitoring framework under the third criterion.

[9] Alternative and complementary approaches can rely on the G-SIB assessment framework. See Cecchetti and Schoenholtz (2022).

Table 1

Key entity types: selection criteria and relevant dimensions of funding liquidity risk for the euro area

Assessment criteria	Banks	Insurance corporations and pension funds	Open-ended investment funds	MMFs
Liquidity transformation/ mismatch	Yes	No	Yes	Yes
Liabilities serve as liquidity buffers	Yes	No	No	Yes
Substantial market footprint in key markets	Yes	Yes	Yes	Yes

Note: Assessment based on expert judgement.

The relative importance of key funding vulnerabilities varies according to the type of financial institution. For example, rollover risks – which are prominent for banks – are much less significant for NBFIs. Non-banks typically only face rollover risk for a relatively small amount of short-term liabilities that need to be refinanced. Instead, investment funds and MMFs face redemption risks, as funds are typically called in times of heightened liquidity needs, and act as a liquidity buffer for other financial institutions (e.g. MMF shares).[10] For insurance corporations and pension funds, which are providers of liquidity to the financial system in normal times, margining risk is the key driver of liquidity risk. Insurance corporations and pension funds use interest rate derivatives for hedging purposes, and in the event of adverse developments, they could face liquidity risk from margin calls and transmit this risk, as was observed in March 2020 (see Ghio et al., 2023).

[10] Banks can also face significant redemption risks, as the US banking sector stress episode in March 2023 showed.

Chart 4

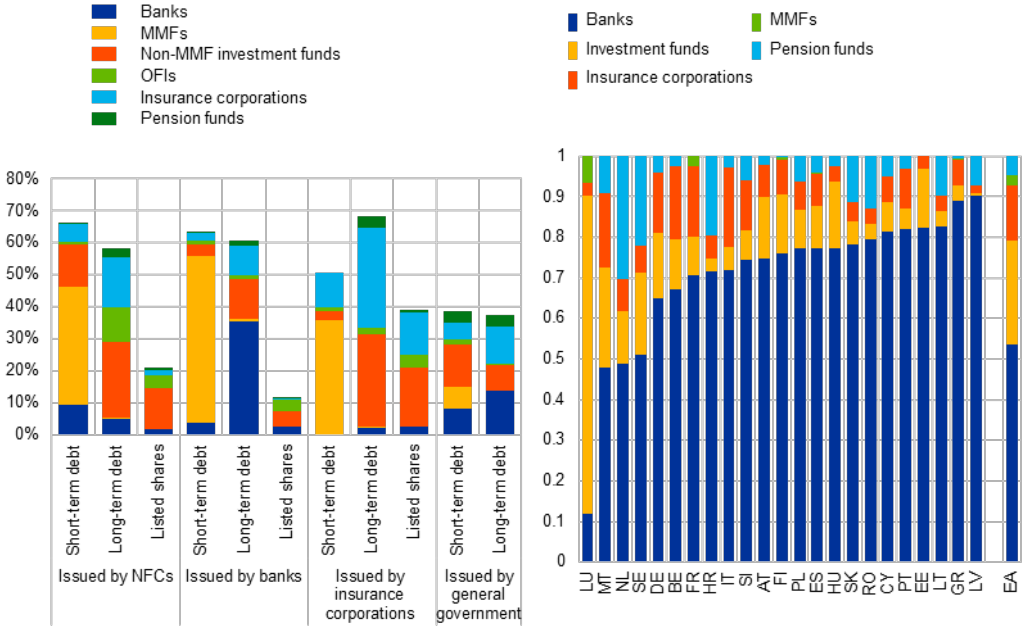
Footprint of euro area institutional investors in euro area financial markets and entity weights

a) Footprint of euro area institutional investors in euro area financial markets

(holdings of securities by issuer sector and investor sector, percentages)

b) Entity weights across selected EU countries

(Q4 2023)



Sources: ESRB NBFI Monitor 2024, BSI, QSA, ECB and ESRB calculations.
Notes: Panel a: data relate to financial instruments issued by euro area entities and held by euro area institutional investors. Data as of Q3 2023.

Key entities vary by country, reflecting specific features of the financial sectors. To assess the relative importance of specific entities at a country level, we look at their share in the total financial assets of a country's financial sector (Chart 4, panel b). This measure is used as a proxy for their footprint in a country's financial system and is complemented by expert judgement. Table 2 shows that, while banks are considered key entities in all jurisdictions, the relative role of NBFIs varies substantially across European countries. For example, pension funds are key in the Netherlands and Sweden, while investment funds account for the most significant share of total financial assets in both Luxembourg and Ireland (reflecting cross-border activities in those two global asset management centres; see Chart 4, panel b). Insurance corporations play an important role in Denmark, Italy and France, among others.

Table 2

Key entities for each jurisdiction

Entity	Key entity in …
Banks	All EU countries
Insurance corporations	BE, DE, DK, FR, IT, MT, NL
Pension funds	DK, HR, LV, NL, SE
Investment funds (including MMFs)	AT, BE, DE, DK, EE, FI, FR, HU, IE, LU, MT, NL, SE

*Notes: Based on expert judgement and the share of the respective sector in each country's total financial system assets. For the latter, a threshold of 10% was used as a starting point.Total financial system assets capture the total assets of the entities in the scope of the report, or more specifically, the entity share in the total of: banks (S122), MMFs (S123), investment funds (S124), insurance corporations (S128) and pension funds (S129), where S*** refers to the sector definition in the QSA.*

Key markets

Key markets are mainly identified based on their role in liquidity provision for the financial system. A financial market is considered key if it is crucial for the overall liquidity of the financial system. This is the case if any of the criteria below are met.

- Markets for securities that serve as liquidity buffers, as these are typically sold when financial intermediaries face unforeseen liquidity needs.
- Markets for financial assets or contracts that serve as pricing benchmarks. Any dislocations in these markets would affect the pricing of all linked financial instruments, rendering the disruption systemic in nature.
- Markets that are essential for providing liquidity, or price discovery in markets that are deemed key based on the first two criteria.
- Markets that are key for entities subject to significant funding liquidity risk. Any disruption in those markets could crystallise liquidity mismatches for relevant entities and shocks could be amplified given the large market footprint of those entities.

Certain markets are key for the EU financial system overall, while others may only be systemic at national level. At EU level, government bond markets meet the first criterion as they are used as liquidity buffers by financial institutions. In Nordic countries, covered bonds are also used as a source of liquidity (including for bank liquidity requirements) and pledged as collateral in repo markets (see Box 2 for further details on the Denmark covered bond market, which is the

largest in the EU).[11] Some derivatives markets are also systemic. For example, interest rate derivatives (e.g. the overnight index swap curve) serve as benchmarks for pricing a wide range of financial contracts (second criterion). Similar considerations apply for foreign exchange derivatives markets, which play a key role as benchmarks and are key for funding liquidity in foreign currencies. Government bond futures are important for price discovery in several sovereign bond markets; this renders them essential for the functioning of the cash market and they are therefore considered key under the third criterion. Repo markets are essential for providing market liquidity, including the financing of market-makers' inventories in sovereign bond markets (see ESRB, 2016; Financial Stability Board, 2022; third criterion).[12] Unsecured short-term funding markets are also a key source of short-term financing for banks, and an essential means of portfolio allocation for MMFs. Finally, corporate bond markets can be considered key under the fourth criterion, since open-ended funds investing in corporate debt typically face high liquidity mismatch risk. Table 3 shows a tentative list of key markets at EU level, and Table 4 provides a list of key markets for selected jurisdictions.

[11] According to the European Banking Authority Risk Dashboard for the third quarter of 2023, extremely high-quality covered bonds account for a substantial share of Nordic countries' high-quality liquid assets (ranging from 12% for Sweden to 40% for Denmark), compared with less than 5% across the EU as a whole. For further details on the role of the covered bond market in Denmark (the largest in the EU), see Danmarks Nationalbank (2015 and 2022).

[12] Repo market indicators are covered in the funding liquidity section.

Table 3

Key markets: selection criteria and relevant dimensions of market liquidity risk

Assessment criteria	Sovereign markets (bonds and futures)	Unsecured short-term funding markets	Covered bond markets	Corporate bond markets	Interest rate derivatives markets	Foreign exchange (FX) derivatives markets	Repo markets
Markets serve as liquidity buffer	Yes	Yes	Yes	No	No	No	No
Pricing benchmark	Yes	Yes	No	No	Yes	Yes	No
Markets key for liquidity provision	Yes	Yes	No	No	No	No	Yes
Markets key for entities with liquidity mismatch	Yes	Yes	No	Yes	Yes	Yes	Yes
Resilience to liquidity stress	High	Low	Medium	Low	Medium	High	Medium

Notes: Assessment based on expert judgement. Resilience refers to the resilience of market liquidity.

The structure of key markets can vary widely across EU countries, making it even more challenging to design risk metrics. For example, EU sovereign bond markets share some common features (e.g. the use of primary dealers[13]), but may also substantially differ in market structures (see Box 3 for an overview of the structure of German and Italian sovereign bond markets). In a few countries such as Italy, most government bond trading takes place on trading platforms using a limit order book[14], and trades are mostly cleared through central counterparties. In many other EU countries, trading takes place over the counter (OTC), rather than on trading platforms. In addition, some sovereign bonds (such as those for Germany, France, Italy and Spain) serve as underlying for liquid futures markets, while derivative activity in some other countries is low or non-existent. As a result, risk metrics for market liquidity can vary based on the structure of sovereign bond markets.

13 For further details by country, see the Association for Financial Markets in Europe (2020).

14 For an overview, see, for example, Bouveret et al. (2022).

Table 4

Key markets for each jurisdiction

	Key market in…
Sovereign bond markets (cash)	All EU countries, EA
Sovereign bond markets (futures)	DE, ES, FR, IT, EA
Sovereign bond markets (repo)	All EU countries, EA
Unsecured short-term funding markets	BE, DE, ES, FI, FR, IE, LU, NL, PT, SE, EA
Corporate bond markets	FR, IE, LU
Covered bond markets	DE, DK, FI, FR, NL, NO, SE
Interest rate derivatives markets	All EU countries, EA
FX derivatives markets	DK, NO, SE, EU

Note: Based on survey of Agile Team members for national authorities.

4.2 Funding liquidity risk indicators

A comprehensive set of indicators is used to measure all relevant dimensions of funding liquidity risk. 45 indicators are included, and these cover risks associated with the refinancing of debt (**rollover risk**), those associated with liquidity outflows (**redemption risk**) and those associated with changes in collateral valuation in the repo market or derivative transactions (**margin risk**). The indicators cover all entities that are key from a systemic liquidity perspective: banks, insurance corporations, pension funds and investment funds. They are collected from harmonised regulatory reporting templates – such as FINREP/COREP, AIFMD, MMSR and Solvency II reporting – to allow for replication of the framework at country level across EU Member States. The technical annex to this report (Annex C) contains the full list of indicators, including short explanations of indicator properties, a detailed manual for computation, and relevant data sources.

Indicators for banks enhance the methodology applied in previous work by the ECB. Similar to ECB (2023b), **rollover risk** is measured by a combination of indicators, including the share of short-term wholesale funding volumes in total funding, repo and unsecured overnight money market borrowing interest rates, average long-term market funding spreads vis-à-vis risk-free rates with a similar maturity, and asset encumbrance. **Redemption risk** is measured by deposit growth rates for households and non-financial corporations (NFCs), the euro short-term rate minus the

agreed overnight deposit interest rate for households and NFCs[15], contingent outflows, the liquidity coverage ratio and the counterbalancing capacity of banks. **Margining risks** are captured by the market funding encumbrance ratio, the leverage ratio, and the ratio of short-term liabilities to short-term assets and long-term liquid assets.

Due to the evolving structure of the financial system in the euro area, an expanded set of indicators is required in order to capture the systemic liquidity risks originating from non-banks. The key liquidity risks for each type of entity are broken down into the dimensions of rollover, redemption and margining risks, measured by a combination of indicators tailored to non-banks. For example, the primary liquidity vulnerability for open-ended investment funds (including MMFs) is **redemption risk**, whereas for pension funds it is **risks from margin calls**. Redemption risks for MMFs are gauged using measures of asset liquidity such as the weighted average maturity and life of portfolio assets, the share of weekly and daily liquid assets, and observed outflows. For other open-ended funds, risks are measured by the liquidity on the assets side (cash-to-assets ratio), the mismatch between portfolio and investor liquidity profiles, realised fund flows and the cross-correlation in fund flows, and conditions in the repo market. For insurance corporations and pension funds, both **margining** and **redemption risks** are relevant for assessing systemic liquidity. Margining risks are measured using indicators such as the cash and derivatives-to-total-assets ratio, asset duration, repo market functioning, and estimates of margin calls. Redemption risks are assessed based on asset concentration, asset liquidity, duration mismatch, changes in liquid assets and the lapse rate.

A heat map visually indicates whether developments are benign (in white) or signal elevated liquidity risk (in red). The indicators are organised along entity types, and within each entity type along the relevant dimensions of funding risk. This produces a list of key indicators that are broken down into relevant risk dimensions (rollover, redemption and margining risk) for all entity types in scope (Chart 5). The colour coding is based on a dual approach. For each set of indicators, a simple z-score – which measures the deviation of a given value from the mean scaled by the standard deviation – is used, where a red shade in the heat map indicates elevated liquidity stress. The use of z-scores comes with some important caveats. Since the data period for most of the supervisory indicators is relatively limited, the z-score should be interpreted with care: the limited number of observations make it sensitive to outliers in the data and might cause a bias in the observed mean and standard deviation. However, the use of z-scores is still preferable to alternatives (such as percentiles), since they are easy to interpret, signal changes in the underlying indicators and offer comparability between different data series. Their reliability will also improve over time, as more data becomes available. In the case of a subset of indicators for which historical data might be systematically biased (e.g. due to long periods during which observations deviated from norms as a result of policy actions), we construct z-scores that are corrected for such biases.[16] For a second set, a known regulatory minimum (or the minimum plus an additional safety

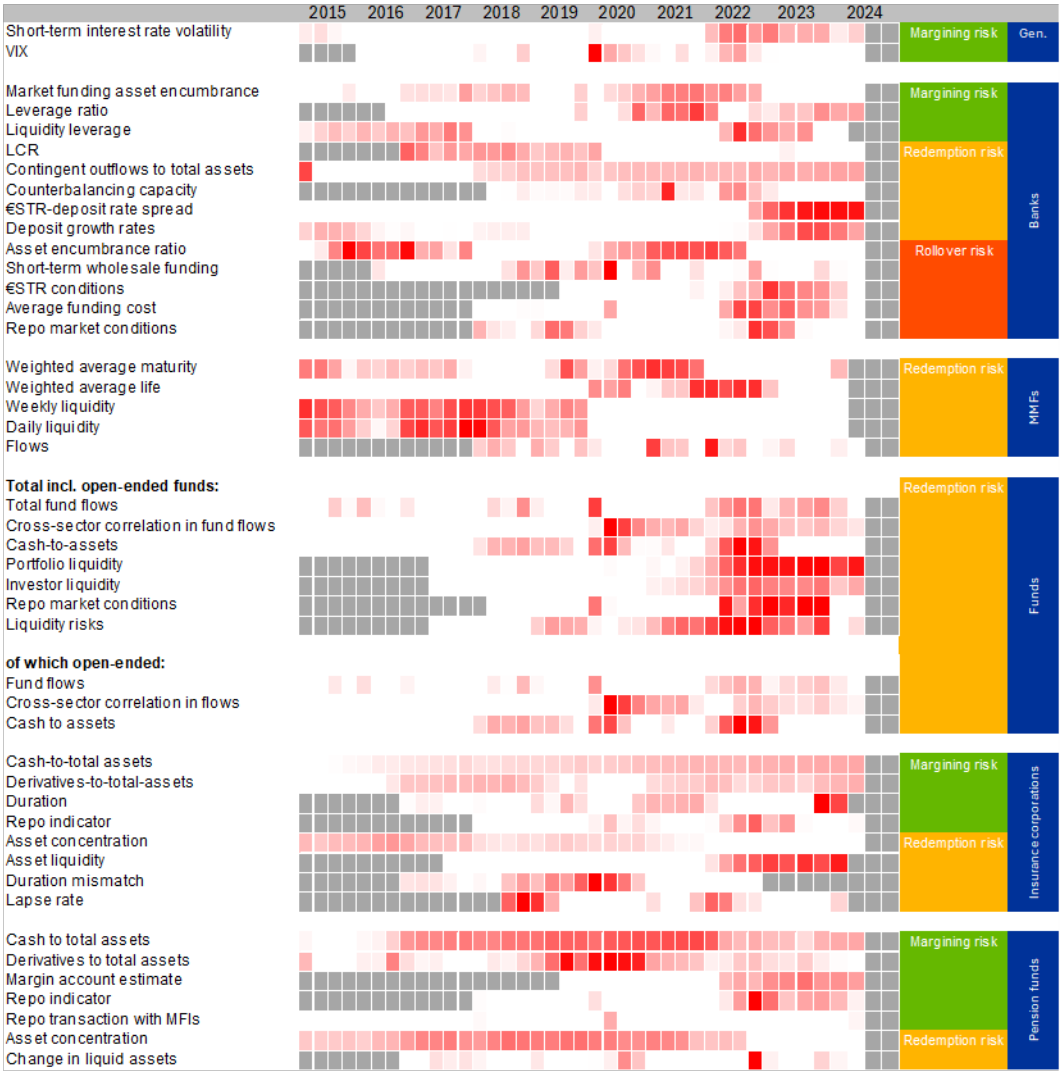
[15] A higher spread between market rates and deposit rates could incentivise bank depositors to switch to higher-yielding alternatives. However, this measure can also be seen as a proxy of the bank's deposit franchise, as higher spreads might not always be associated with deposit outflows. In 2023, for example, the spread increased but EU banks did not experience a noticeable reallocation of deposits into alternative assets. Instead, there was a reallocation between overnight and time deposits within the banking sector.

[16] For instance, the asset encumbrance ratio was heavily impacted by the third series of targeted longer-term refinancing operations (TLTRO III) during the pandemic, when high levels of assets were encumbered at the central bank. To balance out this period, the asset encumbrance ratio has been taken as the average of the z-score for market funding asset encumbrance, which saw declining momentum during the same period, and the total asset encumbrance ratio.

buffer) is used rather than the sample average to calculate the z-score. Using a known threshold as a substitute for the mean in the z-score calculations also improves the signalling power of the indicator in the event of limited data availability.

Chart 5

Heat map of funding liquidity risks for the euro area – by sector and funding liquidity risk dimension



Sources: ECB, FINREP/COREP, BSI, MIR, SHSS, S&P Down Jones Indices LLC and/or its affiliates, AIFMD, MMFR and MMSR.

Notes: All variables in z-scores; red signals higher liquidity risks. For an explanation and calculation of the indicators, see Annex C. Data from Q1 2015 to Q2 2024. Quarterly data are used and, where relevant, the data for the indicators has been aggregated to quarterly averages for investment fund flows (including MMFs) and repo market data.

The individual indicators are aggregated in a composite index of funding liquidity risks. This aggregation is performed by summing up the z-scores of individual indicators for each type of entity and subsequently weighting the individual sectors (banks, investment funds, MMFs, insurance

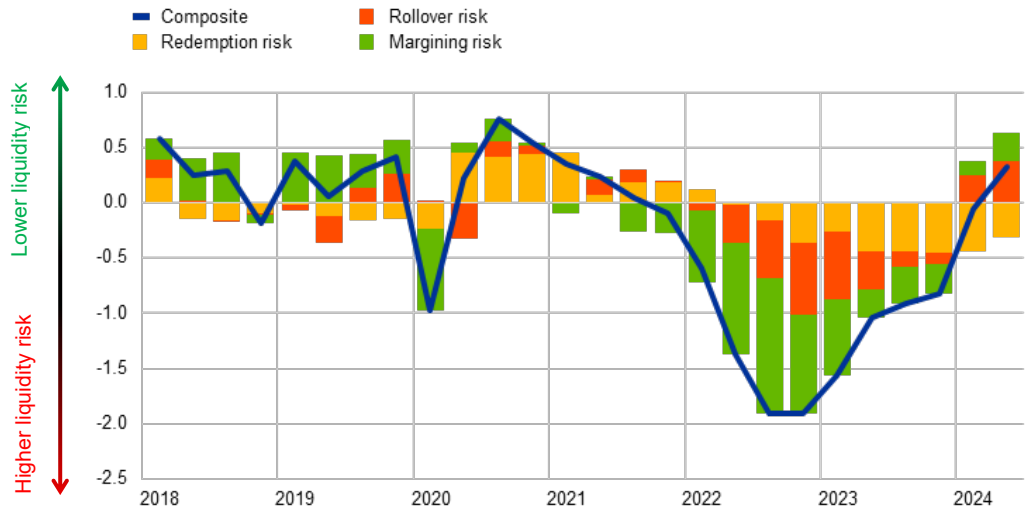
corporations and pension funds) with their share of total financial system assets (Chart 4, panel b). In any given month, an indicator takes on a shade of red if the indicator is below its historical average – indicating lower-than-average funding liquidity and therefore elevated risks. Otherwise, it is coloured white. If the data has a missing observation, the cell is left grey. Within each sector, the rollover, redemption and margin risk sub-dimensions are assigned an equal weight for the sake of simplicity and transparency.

The composite indicator for systemic funding liquidity in the euro area is shown in Chart 6. The overall evolution of the indicator can be attributed to changes in the underlying dimensions of liquidity risk, which are visible in stacked bars. Improvements in funding liquidity (i.e. lower risks) are reflected in an increase in the composite indicator. Given the relatively short history of the underlying data, the indicator is more suited for signalling changes in the underlying indicators over time, rather than assessing the level of funding liquidity risks in the system. The latter requires expert judgement and knowledge about the specific features of the period covered, starting in 2015.

Chart 6

Composite indicator for systemic funding liquidity risk in the euro area

(Q1 2018 – Q2 2024)



Sources: ECB, FINREP/COREP, MIR, SHSS, S&P Down Jones Indices LLC and/or its affiliates, AIFMD, MMFR, MMSR and QSA.
Notes: The aggregation is performed by aggregating the z-scores of individual indicators for each type of entity and subsequently weighting the individual sectors with their share in total financial system assets. Within each sector, the rollover, redemption and margin risk sub-dimensions are assigned an equal weight for the sake of simplicity and transparency.

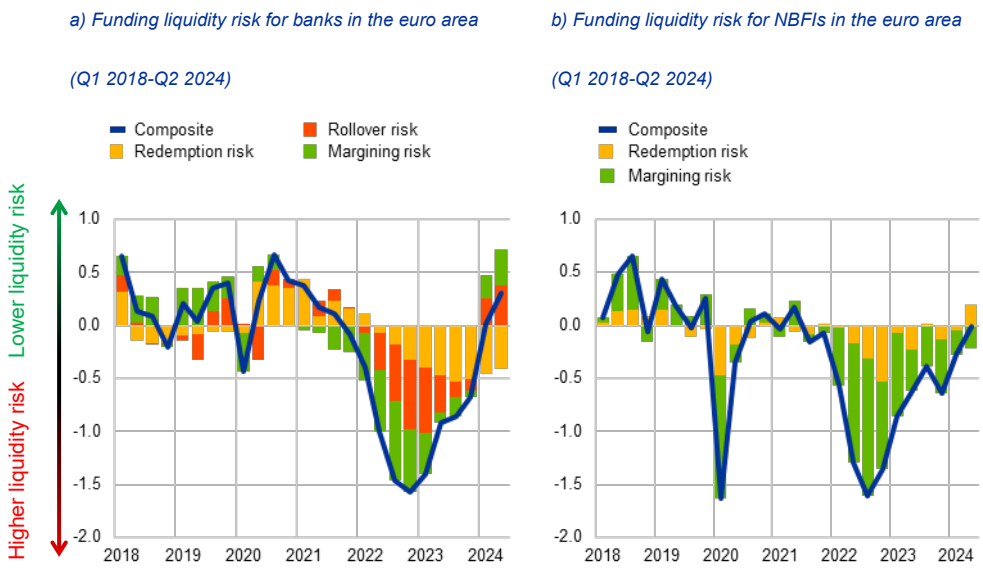
The overall index of funding liquidity for the euro area indicates that funding conditions worsened during 2022 but have recently fully recovered. All components in the composite index show noticeable deterioration around the start of monetary tightening in the euro area. The deterioration reflects lower bank deposit growth as other asset classes offered more attractive remuneration to investors; higher spreads on wholesale bond market funding; and the high economic uncertainty prevailing in 2022. In addition, redemption risks for banks rose due to higher

contractual gaps, i.e. the relatively long maturity of illiquid assets compared with liabilities.[17] More recently, rollover and margining risks have faded as financial conditions have started to ease, and equity market volatility remained largely subdued in the first half of 2024. However, the recent financial market volatility (which occurred after the cut-off date for data) and ongoing high level of interest rate uncertainty show that risks persist.[18]

The overall index of funding liquidity also identifies past periods of heightened liquidity stress, including the key drivers of the declining momentum. The composite indicator saw a significant decline during the pandemic, which caused a brief but sharp drop in all dimensions of funding liquidity. Large drawdowns on credit lines and outflows from MMFs and other investment funds, i.e. the "dash for cash", contributed to high redemption risk, while higher risk premia and financial uncertainty led to an increase in both margining and rollover risk for all types of entities.[19] However, the dynamics that unfolded in the first quarter of 2020 quickly reversed following the introduction of additional longer-term central bank refinancing operations and asset purchases. In addition, excess savings were deposited in the banking system (for further details, see the case study on the pandemic outbreak in Box 5).[20]

Chart 7

Composite indicator for systemic funding liquidity risk: banks vs NBFIs



Sources: ECB, FINREP/COREP, BSI, MIR, SHSS, S&P Down Jones Indices LLC and/or its affiliates, AIFMD, MMFR and MMSR.
Notes: The indicator is constructed as the simple mean z-score weighted by entity share in total financial assets. A lower index value signals higher liquidity risk.

17 Contractual gap refers to the mismatch between inflows and outflows of liquidity arising from long-term illiquid assets and liquid liabilities.

18 Volatility started increasing at the beginning of the third quarter, following the outcome of the French elections, and spiked in August as a result of a global sell-off in the stock markets. However, these trends fall outside the time frame of the current analysis.

19 See, for example, Carpantier (2021).

20 See Lane (2020).

The increase in funding liquidity risks within the euro area banking sector during 2022 has been fully reversed and currently only redemption risks appear elevated (Chart 7, panel a). The elevated level of redemption risk can be attributed to moderating bank deposit growth rates as a result of overall weaker macroeconomic dynamics and better remuneration of other safe and liquid assets. However, no actual deposit outflows have been observed in aggregate and banks' liquidity buffers remain robust. By contrast, margining and rollover risks have normalised since the start of the year as financial conditions have eased, accompanied by reductions in both equity market volatility and market funding encumbrance ratios.

Funding conditions for NBFIs in the euro area have been predominantly influenced by high volatility (Chart 7, panel b). NBFIs experienced a pronounced spike in volatility at the onset of the pandemic, leading to a marked increase in margining and redemption risk. However, this spike was short-lived and eased with the announcement of public support measures. Since the beginning of the interest rate hiking cycle, non-banks have been affected by heightened interest rate volatility, prompting margin calls for insurance corporations and pension funds with significant interest rate risk exposures, as well as some investment funds that use interest rate derivatives to increase their duration (EU GBP liability-driven investment funds in particular).[21] These periods were accompanied by procyclical selling and synchronised fund outflows from investment funds, which contributed to a considerable increase in redemption risks in 2022.[22] More recently, redemption conditions have normalised, and margining risks have reduced significantly.

Country-specific funding liquidity risks can differ substantially from the euro area-wide example. These differences can arise due to country-specific developments in funding liquidity risk within sectors, but also varying financial structures. As Chart 4 shows, while a majority of EU countries have a traditional bank-based financial system (which is the case for the euro area as a whole), this is by no means true of all Member States. In Luxembourg (see Box 4 on systemic liquidity monitoring for UCITS) and Ireland, the resilience of investment funds is of key importance and can therefore result in distinctly different patterns of risk. By contrast, pension funds play a much more important role in the Netherlands compared with the rest of the EU (see also the application of the framework to the Netherlands, in Annex A.1).

21 See CSSF (2024a).

22 See De Nederlandsche Bank (2022).

4.3 Market liquidity risk indicators

A comprehensive set of indicators is used to measure all relevant dimensions of market liquidity risk. Market liquidity is broken down into **tightness** (the cost of transactions), **immediacy** (the pace of execution), and **depth** and **breadth** (the size and scope of possible transactions). Given its importance, the resilience of market liquidity (i.e. liquidity provision during challenging market conditions) is also considered. The technical annex to this report includes the full list of indicators, including explanations of their properties, details of their computation, and relevant data sources.

Most market liquidity indicators are available at daily (or higher) frequency, but differences in coverage present a challenge. In case of the euro area, the data for the indicators come from a set of commercial data providers. Coverage can therefore vary substantially from one indicator to another.[23] Even though missing values are a concern, the large number of indicators helps to make the composite numbers more robust. Data are available from 2012 onwards for most indicators, which means the indicators can be used to evaluate several stress episodes over the last decade.

For sovereign bond markets, indicators are based on previous work by the ECB. In line with ECB (2023b), tightness is measured by bid-ask and high-low spreads and the quote slope. Immediacy is captured by the number of market-makers, transaction frequency, trade size and dealer inventories. Depth is measured by quoted and traded volume, turnover ratio and effective spreads. Breadth indicators rely on spread dispersion, volume concentration and the share of non-quoted (traded) securities. Resilience is assessed using the market efficiency coefficient, the Amihud ratio and the spline spread. Two additional indicators are introduced: the liquidity of sovereign bond collateral based on a regular ECB survey[24] and the exchange-traded fund (ETF) NAV spread, which measures the difference between the price of the ETF and the price of the underlying basket.[25] In terms of application to specific countries, market liquidity indicators might vary to reflect the specific features of domestic sovereign bond markets (see Box 3 for an overview of the structure of German and Italian sovereign bond markets).

A similar approach is used for other markets, depending on data availability. Indicators are provided for a broad set of asset classes (FX market, unsecured money markets, interest rate derivatives, corporate bonds and covered bonds). For each dimension of market liquidity (tightness, immediacy, depth, breadth and resilience) a range of indicators are calculated, depending on data availability and the nature of the market. Some indicators are identical across all markets (such as bid-ask spreads or trade volumes), while others are only available for some asset classes.

A heat map signals visually whether developments are benign (in white) or cause for concern (in shades of red). For the euro area, the heat map for market liquidity risk is constructed using 66 indicators broken down into key markets and, within markets, into market liquidity risk

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23 For example, the range of bonds traded on MTS (the largest sovereign bond trading platform in the EU and one key data source for sovereign bond indicators) is different from the coverage in iBoxx (a benchmark provider), whose data is used for other indicators.

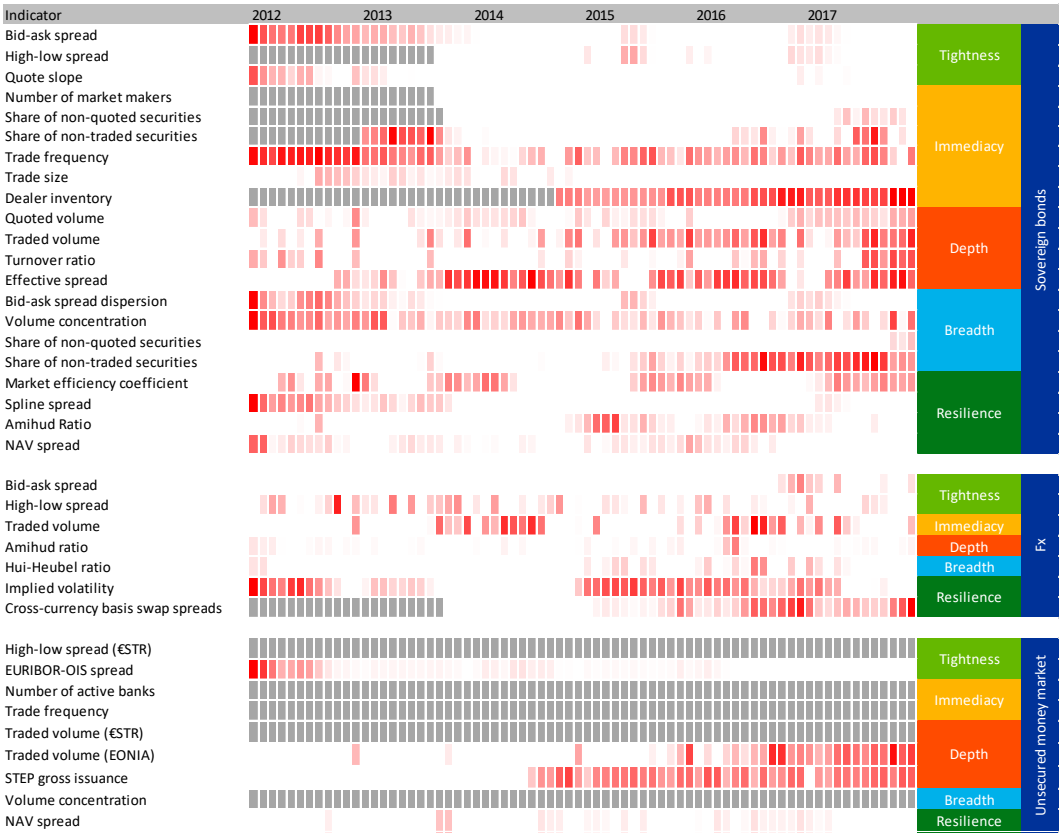
24 Survey on credit terms and conditions in euro-denominated securities financing and over-the-counter derivatives markets (SESFOD).

25 This indicator measures arbitrage opportunities. If the ETF price is higher than that of the underlying basket, authorised participants can buy the underlying basket of securities and deliver it to the ETF sponsor, thereby earning a profit. For further analysis, see Bae and Kim (2020).

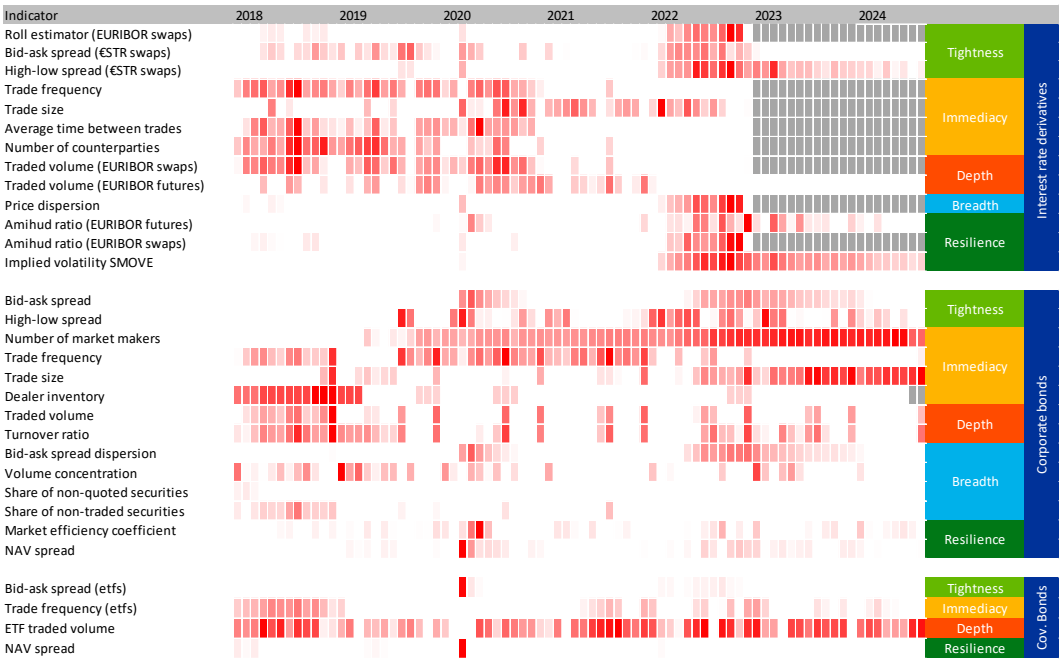
dimensions (Chart 8). The colour coding is based on z-scores, which are calculated to identify large deviations from historical averages. For each indicator, a simple z-score – which measures the deviation of a given value from the mean scaled by the standard deviation – is used. High z-scores indicate high market liquidity (or low market liquidity risks). In any given month, an indicator takes on a shade of red if it is below its historical average – indicating lower-than-average market liquidity. Otherwise, it is coloured white. Where relevant, data for the indicators has been aggregated to monthly frequency, either as monthly averages or as sums (for some of the quantity-based indicators).

Chart 8

Heat map of market liquidity risks for the euro area – by market and market liquidity risk dimension




Indicator
2018
2019
2020
2021
2022
2023
2024
Bid-ask spread
High-low spread
Quote slope
Number of market makers
Share of non-quoted securities
Share of non-traded securities
Trade frequency
Trade size
Dealer inventory
Quoted volume
Traded volume
Turnover ratio
Effective spread
Bid-ask spread dispersion
Volume concentration
Share of non-quoted securities
Share of non-traded securities
Market efficiency coefficient
Spline spread
Amihud Ratio
NAV spread
Tightness
Immediacy
Depth
Breadth
Resilience
Sovereign bonds
Bid-ask spread
High-low spread
Traded volume
Amihud ratio
Hui-Heubel ratio
Implied volatility
Cross-currency basis swap spreads
Tightness
Immediacy
Depth
Breadth
Resilience
Fx
High-low spread (€STR)
EURIBOR-OIS spread
Number of active banks
Trade frequency
Traded volume (€STR)
Traded volume (EONIA)
STEP gross issuance
Volume concentration
NAV spread
Tightness
Immediacy
Depth
Breadth
Resilience
Unsecured money market
Indicator
2012
2013
2014
2015
2016
2017
Roll estimator (EURIBOR swaps)
Bid-ask spread (€STR swaps)
High-low spread (€STR swaps)
Trade frequency
Trade size
Average time between trades
Number of counterparties
Traded volume (EURIBOR swaps)
Traded volume (EURIBOR futures)
Price dispersion
Amihud ratio (EURIBOR futures)
Amihud ratio (EURIBOR swaps)
Implied volatility SMOVE
Tightness
Immediacy
Depth
Breadth
Resilience
Interest rate derivatives
Bid-ask spread
High-low spread
Number of market makers
Trade frequency
Trade size
Dealer inventory
Traded volume
Turnover ratio
Bid-ask spread dispersion
Volume concentration
Share of non-quoted securities
Share of non-traded securities
Market efficiency coefficient
NAV spread
Tightness
Immediacy
Depth
Breadth
Resilience
Corporate bonds
Bid-ask spread (etfs)
Trade frequency (etfs)
ETF traded volume
NAV spread
Tightness
Immediacy
Depth
Resilience
Cov. Bonds



Sources: S&P Down Jones Indices LLC and/or its affiliates, MTS, Bloomberg Finance L.P., Trax, ECB, SHS, LSEG and Boudiaf et al. (2024).
Notes: All variables in z-scores; red signals higher liquidity risks. For explanation and calculation of the indicators, see Annex C.

A composite index of market liquidity risk is constructed by aggregating the individual indicators using a simple average. While alternative weighting schemes could be used, for example based on the size of the markets, their turnover, or the relative exposures of key entities to those markets, the chosen approach relies on a simple average.[26] This is because (i) some of the markets are global in nature (FX and interest rate derivatives markets), (ii) activity across markets might not be captured by the same metric (e.g. turnover for FX and notionals for interest rate derivatives), and (iii) entities' exposures to those markets might vary substantially across jurisdictions.

The composite market liquidity indicator for the euro area is currently markedly above its historical average, indicating better-than-average market liquidity (Chart 9). The index shows a sharp deterioration around March 2020, followed by a rebound as public support measures were announced and implemented. From 2022 to 2023, the indicator points to severely impaired market liquidity in the wake of the Russian invasion of Ukraine and monetary policy tightening. This period was characterised by low liquidity and high volatility across all key markets. The composite index was lower in this period than during the first and second quarters of 2020. However, looking at monthly frequency in the same index, the dry-up of market liquidity in March and April 2020 was more intense than in 2022, but quickly recovered. This resulted in a peak effect that is not fully visible at quarterly frequency (for further details, see Chart 10, which shows indicators of systemic market liquidity risk for each key market at monthly frequency, and the case study in Box 5, which

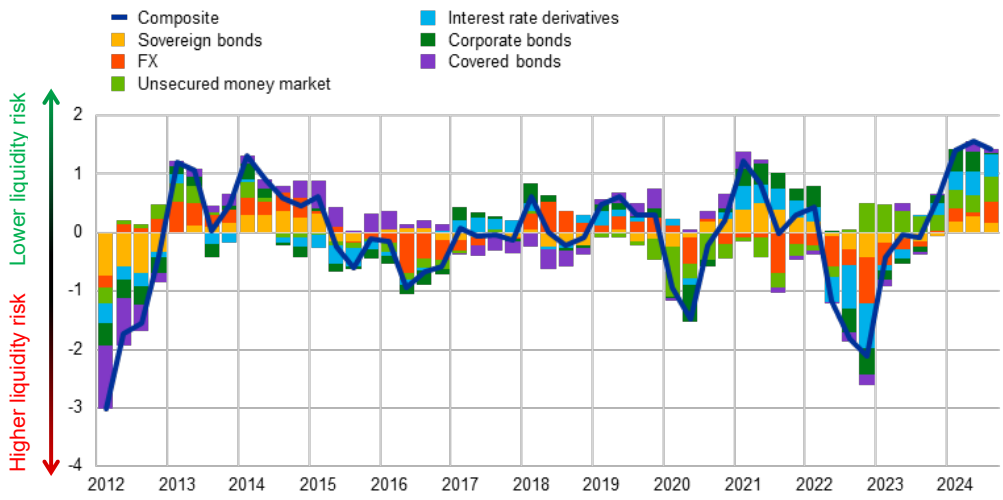
[26] As an illustration, if trading volumes were used, the composite indicators would be almost entirely driven by FX markets (75% weight based on daily turnover of €2.23 trillion) and to a lesser extent by sovereign markets (10% weight based on daily turnover of €0.3 trillion), with a more marginal role played by interest rate derivatives, unsecured short-term funding markets and corporate bond markets.

focuses on the pandemic outbreak). Market liquidity has substantially improved since mid-2023, and as of the second quarter of 2024, the composite indicator points to low liquidity risk across markets.

Chart 9

Composite indicator for systemic market liquidity risk in the euro area

(Q1 2012-Q3 2024)



Source: ECB.
Notes: Markets have equal weights. A lower index value signals higher liquidity risk.

Zooming in on individual key markets in the euro area confirms that market liquidity is currently better than historical averages for most[27], but also indicates heterogeneity during stress episodes (Chart 10). The "dash for cash" in March 2020 severely impaired market liquidity in all key markets (see also the case study in Box 5 on the pandemic outbreak), but the dry-up of liquidity was particularly severe and unusual in sovereign bond markets (Chart 10, panel a), unsecured money markets (Chart 10, panel c) and covered bond markets (Chart 10, panel e). In contrast, illiquidity related to monetary tightening and the Russian invasion of Ukraine in 2022 was relatively more pronounced in FX (Chart 10, panel b) and interest rate derivatives markets (Chart 10, panel d), which probably reflects uncertainty around the expected path of interest rates. In contrast, the unsecured money market remained liquid from 2022-23.[28] Market liquidity has increased notably since mid-2023 and, as of the second quarter of 2024, was above historical averages in most markets. This demonstrates the added value of assessing market liquidity across key markets, as dynamics can vary substantially, especially in times of stress. Market liquidity varies more from month to month in FX and corporate bond markets than in other markets.

27 It is well above average for three of them, explaining the overall finding of better-than-average market liquidity for the composite index.

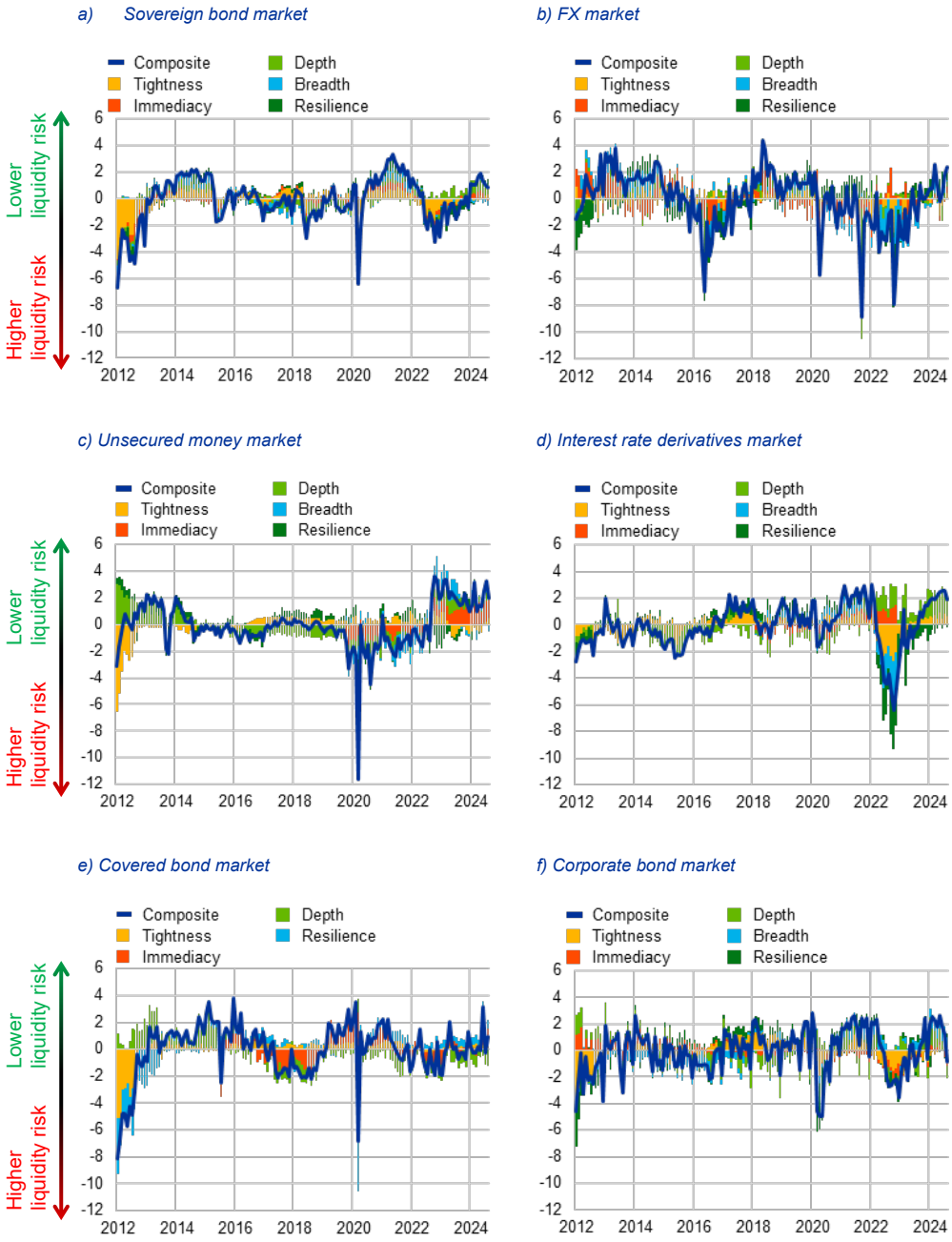
28 Unsecured short-term funding markets were the only key markets that showed significant liquidity issues around the time of the Fed's taper tantrum in 2013.

However, this may be partly because data availability differs across markets. For example, if only bid-ask spreads are considered for each market, the picture looks smoother.

Chart 10

Composite indicator for systemic market liquidity risk in the euro area: underlying markets at monthly frequency

(Jan. 2012-Aug. 2024)



Source: ECB.
Note: A lower index value signals lower liquidity.

4.4 Indicators for contagion and amplification risks: interactions between market and funding liquidity

Measures of systemic liquidity risk need to account for the risk of contagion and amplification. A review of the economic literature suggests that four important factors can result in an elevated risk of strong contagion effects: (i) tight monetary and financial conditions (which are associated with tight funding constraints), (ii) elevated volatility (which is associated with tight VaR constraints), (iii) falling asset values (which are associated with binding leverage constraints), and (iv) an increase in complexity and interconnectedness in the financial system (which act as direct contagion channels). Our monitoring framework therefore includes a dedicated block setting out the variables that capture these dimensions.

By constructing a composite index of contagion and amplification risks, we can measure the risk of localised liquidity stress morphing into a system-wide crisis. The composite index takes the average z-score for indicators that measure contagion and amplification risks, and is constructed in a similar way to the other composite indicators in this report, where a lower score indicates higher risk. Indicators relate to overall financial and monetary conditions (measured by both credit risk premia and interest rates), interconnectedness (such as direct holdings of debt securities of other key entities), portfolio similarity, the use of leverage and financial market volatility.

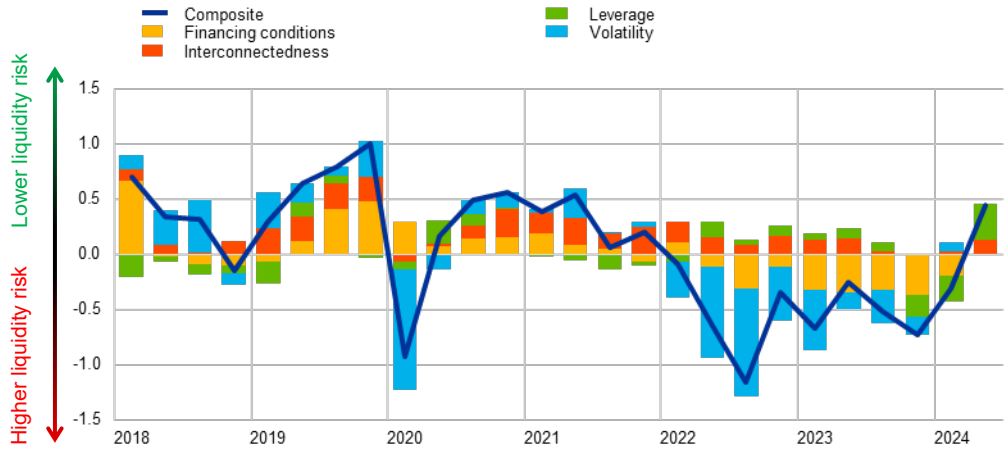
I**ndicators for financing conditions, interconnectedness, leverage and volatility capture contagion and amplification risks**. **Financing conditions** are captured by repo market rates and volumes for both banks and non-banks, €STR rates and volumes, and the average z-spread on covered and senior bail-inable and senior unsecured bank debt. **Interconnectedness** is measured by the degree of portfolio overlap for sovereign debt between banks and other financial institutions, the probability of default of two or more systemically important banks, the asset concentration ratios for insurance corporations and pension funds, the cross-sector correlation in (open-ended) fund flows and the collateral reuse ratio. **Leverage** is measured by duration for insurance corporations, liquidity leverage for banks (short-term liabilities to liquid assets), leverage of AIFs and the leverage ratio for banks. **Volatility** is measured in both equity and sovereign debt markets by including the VIX index and the volatility in the German Bund.

The composite index for the euro area shows that contagion and amplification risks have declined by mid-2024 (Chart 11). Throughout the tightening cycle contagion and amplification risks remained above their historical averages. This reflected elevated volatility in safe assets and tighter monetary and financing conditions while leverage indicators remained in line with their historical averages. Contagion and amplification risks started easing in early 2024. In the second quarter of 2024, the composite indicator signalled risks that are somewhat lower, driven by improvements in leverage and interconnectedness, while financing conditions eased and appeared in line with their historic average.

Chart 11

Indicators for contagion and amplification risks

(Q1 2018-Q2 2024)



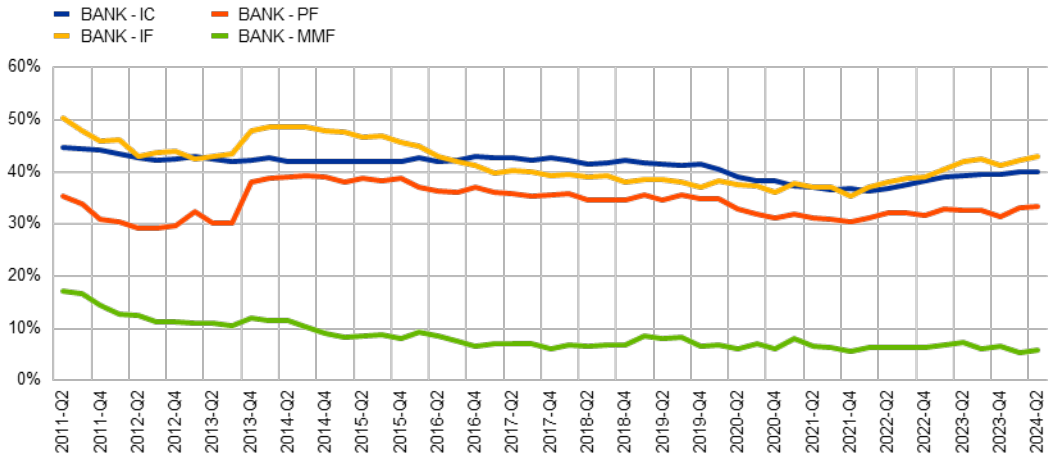
Sources: ECB, ICE, FINREP/COREP, SHSS, S&P Down Jones Indices LLC and/or its affiliates, AIFMD and MMSR.
Notes: All variables in z-scores. The index includes duration for insurance corporations, asset concentration ratios for insurance corporations and pension funds, cross-sector correlation in open-ended fund flows, absolute repo-deposit facility rate (DFR) spreads for banks and non-banks, the collateral reuse ratio, short-rate volatility, €STR conditions as the average of €STR volumes and the rate differential at the 25th and 75th percentile of the trading volume, the probability of default of two or more systemically important banks, the average funding spread as the average z-spread on covered, senior bail-inable and senior unsecured debt, portfolio similarity with the banking sector, the VIX index, the leverage ratio, liquidity leverage and domestic holdership of (non-)bank debt obligations by other domestic (non-)banks.

Some of the amplification risks for the euro area stem from key entities that hold a similar investment portfolio. Portfolio similarity measures – which estimate the degree of portfolio overlap across sectors by underlying instruments and issuers – point to a high degree of overlap across financial sectors. For sovereign bonds, there is a high level of overlap between banks, insurance corporations, pension funds and investment funds (Chart 12), which implies that any stress to the sovereign bond market would affect those sectors simultaneously. For short-term debt securities, there is a high level of overlap between MMFs and other investment funds. The analysis helps to identify how stress in certain markets could trigger liquidity issues for key entities. It also shows how asset sales in those markets could amplify market liquidity issues in other sectors exposed to the same asset class.

Chart 12

Portfolio similarity of sovereign debt holdings across financial sectors

(Q1 2011-Q2 2024)



Source: ECB.

Notes: The portfolio similarity indicator compares the portfolio weights (at individual ISIN levels) between institutional sectors. The indicator equals one if the compared portfolios are identical (similar exposures to individual ISINs), and zero if there are no common elements in them. Only sovereign debt is taken into account.

5 Conclusion

This report provides a comprehensive indicator-based surveillance framework for risks to systemic liquidity. It expands existing frameworks to cover entities beyond banks, markets beyond the sovereign bond market and the propensity for stress transmission and amplification. It presents a set of composite liquidity risk indicators that cover funding liquidity risks, market liquidity risk and a dedicated index of transmission and amplification risks in an intuitive visual form.

The surveillance framework is particularly useful for identifying a gradual build-up of liquidity vulnerabilities. Given the relatively long reporting lags for some of its elements, only a subset of the indicators included in our framework is suitable for real-time monitoring of liquidity stress (see the case study in Box 5 on the pandemic outbreak). The indicators that rely on financial market prices or measure market liquidity are in principle available at daily frequency and are therefore useful for measuring liquidity conditions in virtually real time. By contrast, the indicators that rely on regulatory reporting data or financial flows have a longer time lag. They are useful for identifying a build-up of vulnerabilities and could inform macroprudential policy that aims to address this.

While the proposed surveillance indicators are a good starting point for the assessment of systemic liquidity risks, sound expert judgement must be used when interpreting them. The relatively short time series for some input variables and the z-score methodology mean the framework is more suitable for assessing the dynamics (e.g. increase vs decline) rather than the absolute level of systemic liquidity risks. As a result, expert judgement must be used when interpreting the indicators, particularly when their values have been affected by policy choices or unusual developments over a period of time. These limitations will improve gradually, with the availability of a longer time dimension for the underlying variables. A comprehensive assessment of systemic liquidity risk would also need to factor in any mitigating measures taken by macro- and microprudential authorities (or authorities operating in other relevant domains like fiscal and monetary policy) and the specific features of the financial system safety net. This also requires an expert level of judgement.

The framework could be usefully complemented and expanded in several ways. First, the monitoring framework could be used to devise indicators with early warning properties for systemic illiquidity. Second, it could be used to design stress test scenarios, and could itself be refined based on the outcome of systemic liquidity stress tests. Third, it could provide a basis for measuring global liquidity and the global dimension of systemic liquidity risks. All of these avenues merit further investigation but fall beyond the scope of this report.

Annex A: Country applications

A.1: Application to the Netherlands

Identification of key entities and markets in the Netherlands

Key entities

We have followed the same approach as that used for the euro area as a whole. The indicators that are part of the systemic liquidity framework for the Netherlands are determined by the country's financial structure. As such, the key entities are identified using the criteria outlined in Section 4.1 of this report. For the Netherlands, this means that banks, insurance corporations, pension funds and investment funds are defined as key entities. The weighting scheme for the financial sectors is based on total financial assets. This leads to a significantly larger share for non-banks, mainly due to pension funds, compared with the euro area (Chart 4, panel b). Given that MMFs account for less than 0.01% of total financial assets in the Netherlands, they are outside the scope of the national framework. Based on supervisory statistics, MMSR, AIFMD, Solvency II and commercial data, all variables in the funding liquidity indicator are available for the Netherlands. MMSR data are included in the aggregate index calculations but cannot be displayed in the heat map due to the limited amount of banks that report MMSR rates in the Netherlands.

Key markets

Application of the market liquidity monitoring framework to the Netherlands poses challenges due to a lack of data availability and different market structures from the euro area. Access to commercial databases is not shared within the Eurosystem, and therefore it is not always possible to filter out Dutch bonds from a euro area dataset, for example. Market structures and trading conventions also differ across countries. For example, there are no futures on Dutch sovereign bonds, unlike their German and Italian counterparts.

In order to assess liquidity in the Netherlands, we have taken into account five key markets: the Dutch sovereign and covered bond markets, and the euro area FX, unsecured money and interest rate derivatives markets. The latter three are essentially euro area-wide markets. We have therefore taken into account the euro area market liquidity indicators for these markets when calculating the Dutch composite market liquidity index.

Results

Funding liquidity

The overall index of funding liquidity in the Netherlands reflects the acute stress experienced during the pandemic but shows less deterioration during the recent hiking cycle. Cyclical trends in the composite indicator for the Netherlands are closely aligned with those of the euro area index. For instance, all components of the index for the Netherlands show a noticeable deterioration around the start of monetary tightening in the euro area. These policies led to slower bank deposit growth, as other asset classes offered more attractive returns to deposit holders, and money creation in the banking system stalled amid weak credit growth. The underlying drivers during this period were the same, such as a sharp rise in both redemption and margin risk, driven by high fund outflows and increasing market volatility. However, redemption risks in the Netherlands now appear to be less persistent compared with the euro area as a whole: they are returning to historical averages, driven by both compositional differences and structural factors.

The recent increase in funding risk within the banking sector in the Netherlands is slightly less pronounced than that in the euro area aggregate. This reflects several underlying structural factors. First, Dutch banks have relatively sticky deposits due to low competition for deposits and a relatively high deposit beta, making deposit outflows a smaller factor. Over the past three years, for instance, only 3% of customers have switched to another bank because of higher interest rates. [29] Due to this higher rate pass-through, the spread between the €STR and deposit rates is somewhat narrower than in other euro area countries. Second, rollover risks for the Netherlands have been contained, during both the pandemic and the recent tightening cycle. This reflects relatively stable developments in funding costs for Dutch banks, especially compared with historical fluctuations. At the same time, margining risks are somewhat higher for Dutch banks due to a relatively high market funding asset encumbrance ratio and higher liquidity leverage compared with the historical average.

Funding liquidity for non-banks has improved considerably on account of slightly lower market volatility and low fund outflows. Historical trends in the indicator for the Netherlands have been very similar to that for the euro area. However, several differences emerge. First, systemic redemption pressure on Dutch investment funds has been lower compared with the euro area, reflecting both lower outflows and less synchronised outflows across different investment fund types over recent periods. Second, margining risks have been a bigger factor for Dutch systemic funding liquidity, especially during the onset of the hiking cycle in 2022. This is mainly attributable to the greater weight of pension funds – which have faced significant margin calls – in the indicator.[30] Finally, pension funds in the Netherlands have increased their liquid asset holdings relatively strongly, building some resilience to higher margin calls.[31] Over the most recent period, the index for non-banks shows funding liquidity conditions above the long-term average. This is mainly driven by slightly lower volatility, benign repo market conditions and inflows into investment funds.

29 See Doll et al. (2023).

30 See De Nederlandsche Bank (2022a).

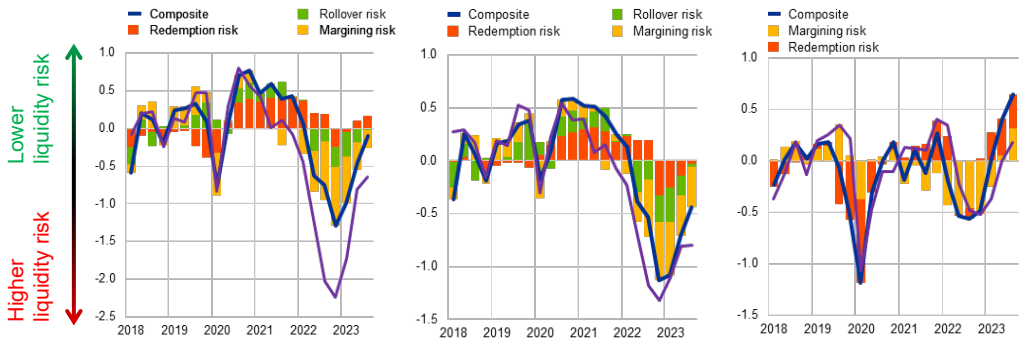
31 See De Nederlandsche Bank (2024).

Chart A.1.1

Composite indicator for systemic funding liquidity risk in the Netherlands compared with the euro area

(Q1 2018-Q3 2023)

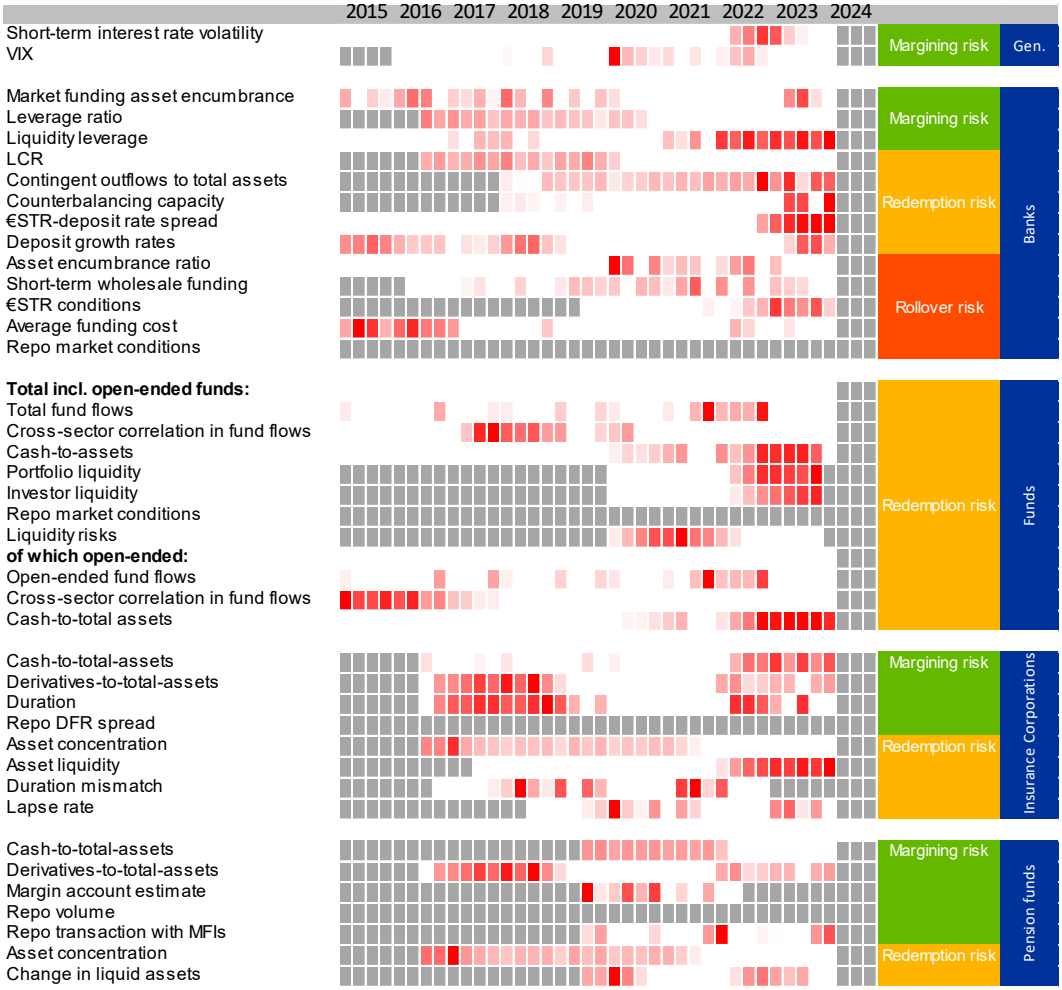
a) Composite index *b) Banks index* *c) Non-banks index*



Sources: DNB, Solvency II reporting, ECB, FINREP/COREP, BSI, MIR, SHSS, S&P Down Jones Indices LLC and/or its affiliates, AIFMD and MMSR.
Note: Purple line reflects the euro area composite index.

Chart A.1.2

Heat map of funding liquidity risks for the Netherlands – by sector and funding liquidity risk dimension

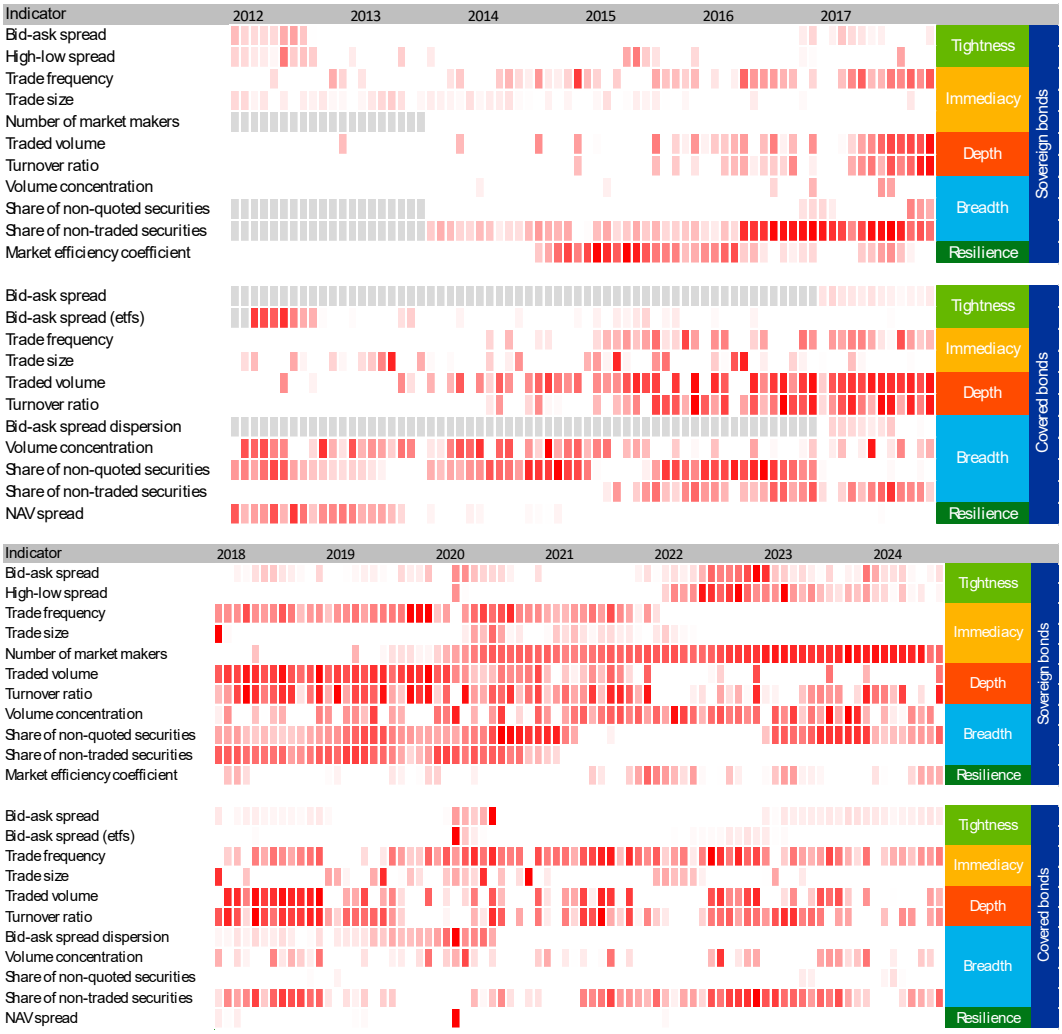


Sources: DNB, Solvency II reporting, ECB, FINREP/COREP, BSI, MIR, SHSS, S&P Down Jones Indices LLC and/or its affiliates, AIFMD and MMSR.
Note: See notes for Chart 5.

Market liquidity

Chart A.1.3

Heat map of market liquidity risks in the Netherlands – by market and liquidity dimension



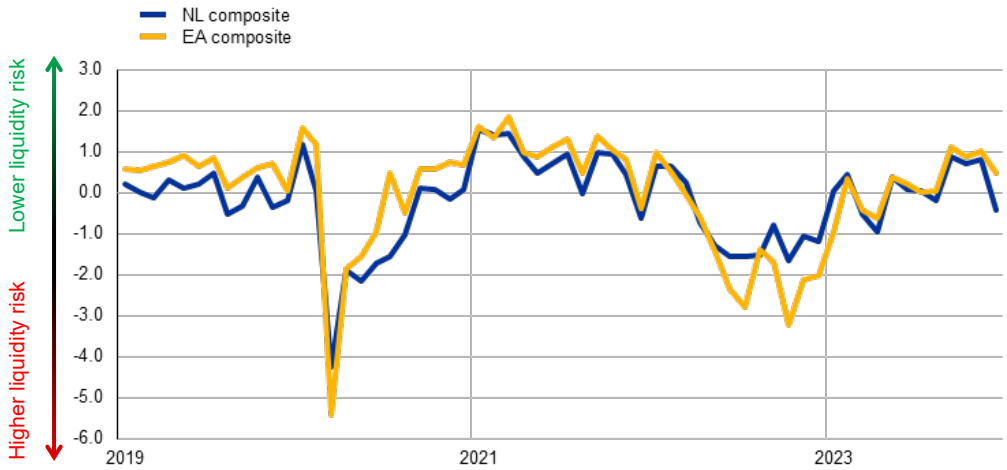
Sources: DNB, ECB, Bloomberg Finance L.P., Trax, S&P Down Jones Indices LLC and/or its affiliates and DSTA.
Note: See notes for Chart 8.

Market liquidity in the Netherlands is currently above average. Chart A.1.4 shows the composite index calculated using the indicators in Chart A.1.3 and following the same methodology as for the euro area. Market liquidity was broadly in line with historical averages in 2023 and rose to above-average levels in 2024. The Dutch index is also slightly below the euro area market liquidity index, as it was for most of 2019 to 2022. Generally, there is a strong correlation with the euro area index, since three out of the five market sub-indices are the same. Looking at a longer time frame (since 2012), liquidity in key markets for the Netherlands has fared slightly better than in the euro area as a whole during stress periods, such as during the sovereign debt crisis in 2012 and the recent monetary tightening episode.

Chart A.1.4

Composite market liquidity index for the Netherlands and the euro area

(Q1 2019-Q3 2024)



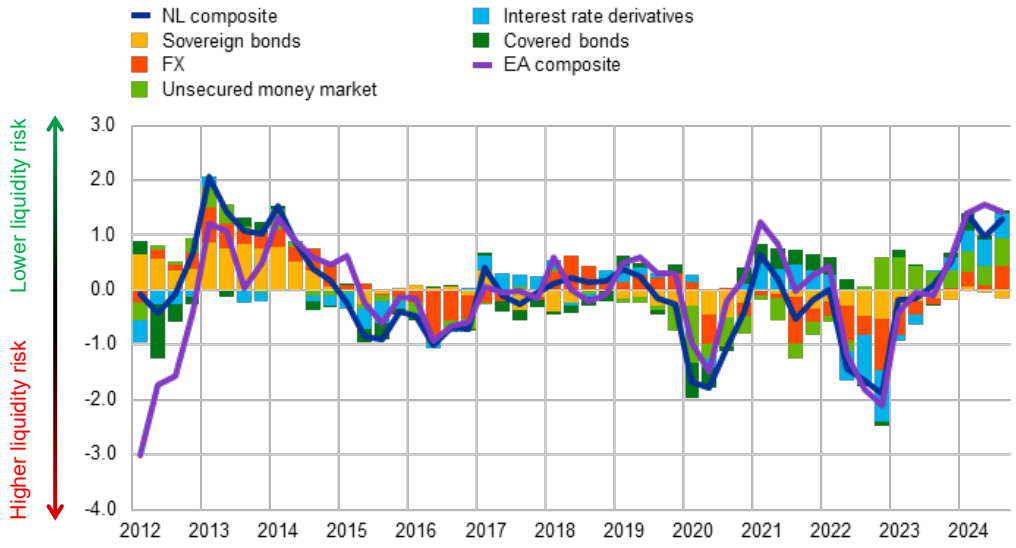
Sources: DNB, ECB, Bloomberg Finance L.P., Trax, S&P Down Jones Indices LLC and/or its affiliates and DSTA.

Market liquidity in the Netherlands deteriorated sharply in 2020 and again in 2022. Chart A.1.3 shows the composite index for the Netherlands on a quarterly basis and indicates that the pandemic shock in the first and second quarters of 2020 led to a sharp decline in market liquidity. Liquidity also deteriorated sharply in 2022, in connection with the tightening of monetary policy and increased volatility in bond markets. However, whereas in 2020 the deterioration was visible across all markets, in 2022 improvements in the covered bond and unsecured markets mitigated the drop in liquidity observed in other markets. By 2023, market liquidity had recovered to normal levels. Looking at the breakdown by market, the Dutch sovereign bond market has had consistently below-average market liquidity in recent years. The FX and interest rate derivatives markets contributed most to the decline in overall market liquidity in 2022, but this was partially offset by better-than-average liquidity in covered bonds and the unsecured money market.

Chart A.1.5

Composite market liquidity index for the Netherlands and the euro area

(Oct. 2012-Aug. 2024)



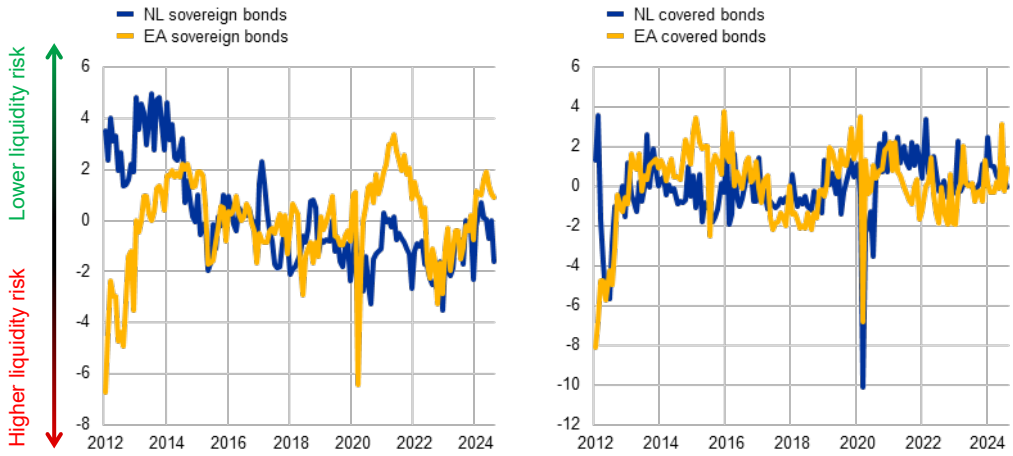
Sources: DNB, ECB, Bloomberg Finance L.P., Trax, S&P Down Jones Indices LLC and/or its affiliates, and DSTA.

Liquidity in the Dutch sovereign bond market seems to be more resilient to stress episodes, but faces structural challenges. The liquidity of Dutch sovereign bonds was high during the sovereign debt crisis in 2012 and did not decline significantly (on a monthly basis) in 2020, unlike the wider euro area sovereign bond market (Chart A.1.6). This might be related to its status as a safe asset, meaning it attracts liquidity during stress periods. However, the longer-term trend is one of a structural decline in market liquidity in Dutch sovereign bonds, which is not the case in the euro area data. This might be due to the size of the Dutch market or to other factors such as the lack of sovereign bond futures, which leads to a slow migration of liquidity towards larger markets. In covered bonds, trends are also closely aligned with the euro area. The pandemic shock seems to have lingered for a few months longer in the Dutch market, but liquidity was also unusually strong in 2021 and 2022.

Chart A.1.6

Sovereign covered bond market liquidity index in the Netherlands and the euro area

(Jan. 2012-Aug. 2024)



Sources: DNB, ECB, Bloomberg Finance ,Trax, S&P Down Jones Indices LLC and/or its affiliates and DSTA.

A.2: Application to Finland

Identification of key entities and markets in Finland

Key entities

Banks dominate the financial sector in Finland. The Finnish financial system is very bank-centric, as can be seen in the large size of the banking sector relative to the rest of the financial system. Other key entities are employee pension insurance companies and investment funds. However, pension insurance companies are excluded from this report as they are part of the public sector in Finland.[32] The third largest sector is investment funds. Many Finnish investment funds invest globally, and some of the largest are real estate and private equity funds. Many of these funds are closed-ended, and since their investment activities are limited to a narrow niche they do not have an impact on wider financial market liquidity.

Key markets

Domestic sovereign and covered bond markets are key in Finland. Both sovereign and covered bond markets are important in Finland. Covered bonds are a significant source of funding for Finnish banks, which are quite dependent on wholesale funding in general. This dependence means that the Finnish covered bond market is relatively large compared with that of countries of a similar size. Finnish non-financial corporations (NFCs) issue bonds, but often elsewhere in the euro area rather than in Finland. The number of issuing entities is relatively small, but the stock of NFC bonds is relatively large in relation to the size of the economy.

Euro-area-wide markets are also important. Because Finland is a small country, many of its financial market participants operate in the broader euro area market. As a result, the functioning of the euro area market – rather than solely the Finnish market – is crucial for Finnish entities in many ways. In addition, some key markets are integrated at euro area level, as was also seen in the case of the Netherlands. This includes unsecured short-term money markets, FX and interest rate derivatives markets.

[32] Employers' pension insurance companies in Finland are part of the public sector (social security) and are not subject to Solvency II or Directive 2016/2341 on the Institutions for Occupational Retirement Provision (IORP II).

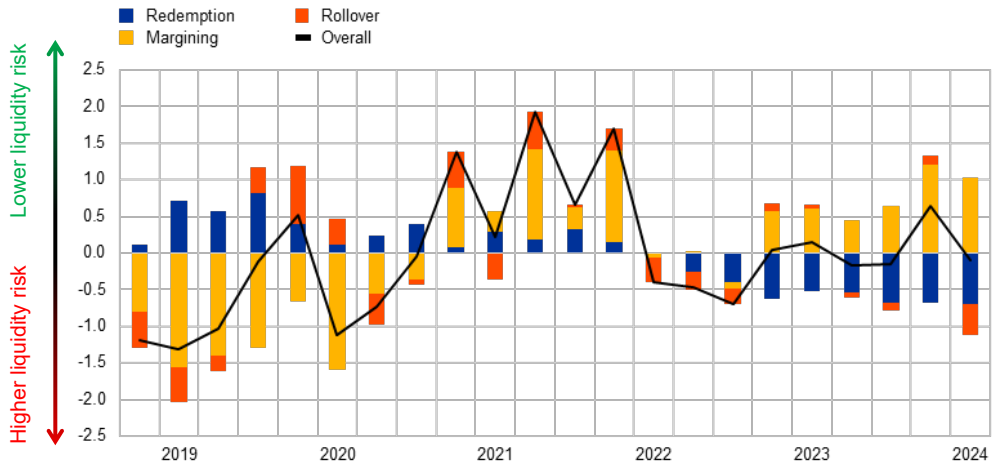
Results

Funding liquidity

Chart A.2.1

Systemic funding liquidity risk indicators for Finland

(Q4 2018-Q1 2024)



Sources: FIN-FSA, ECB and Suomen Pankki – Finlands Bank calculations.

On aggregate, funding liquidity risks currently appear to be quite balanced in Finland. While this overall picture includes both banks and investment funds, banks are the primary driver. This balanced situation contrasts with funding liquidity indicators for the euro area, where a clear deterioration in funding liquidity was recorded in 2022 and 2023.

- Margining risk in Finland is mitigated by a relatively strong and stable leverage ratio and a fairly stable market funding encumbrance ratio in recent years. The recent growth in deposits has slightly shifted the composition of Finnish banks' funding from wholesale funding towards deposits.[33]

- Redemption risk remains stable and below its historical average values due to a combination of opposing factors. While liquidity coverage ratios have improved in Finland, a decline in NFC deposits and outflows from AIFs have resulted in higher liquidity risk.

[33] One bank in Finland is significantly larger than the others. This creates a range of challenges when interpreting data, including confidentiality issues, as it is not possible to report some indicators. The bank's change of domicile from Sweden to Finland in 2018 also created a significant structural break in many banking and market-related indicators (for example, concerning the repo market). This structural break has been accounted for in the z-scores in the funding liquidity analysis. Z-scores are calculated separately for two time periods: before and after the fourth quarter of 2018. As the two time periods are not comparable, only results for after the fourth quarter of 2018 are shown here.

- In terms of rollover risk, domestic banks have a relatively stable share of short-term wholesale funding. In general, Finnish banks have a structural dependence on wholesale funding, but the maturity of this funding is quite long (covered and other bonds). Finnish banks also have a higher-than-average asset encumbrance ratio, which reflects the use of covered bonds. The variables behind the indicators included in rollover risk are very stable over time, which means that changes in the value of this indicator reflect relatively random and often small changes.

Challenges in interpreting funding liquidity indicators. In general, this framework does not directly discuss structural vulnerabilities or levels of risks, as the indicators are based on changes in the values of the variables. The levels of many funding indicators were very stable in Finland during the sample period, so even a small change can cause a large swing in the z-scores. This complicates the process of interpreting the indicators. For example, a relatively high reliance on wholesale funding is one of the recognised structural vulnerabilities of the Finnish banking sector, but the indicators do not reflect this because the share of wholesale funding has remained very stable over time.

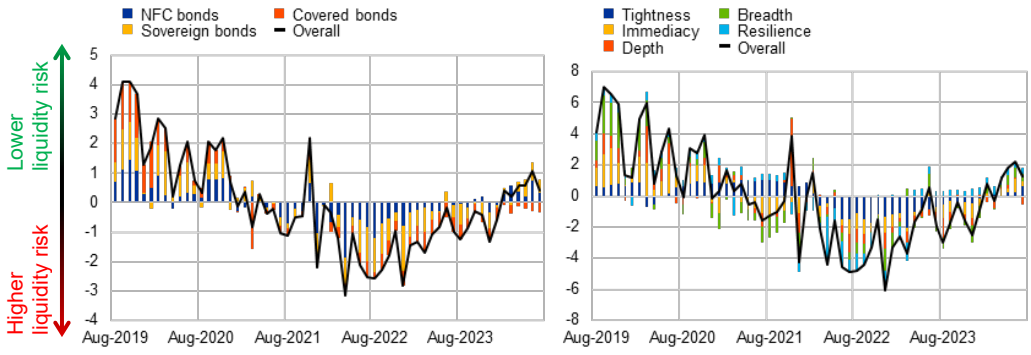
Market liquidity

Chart A.2.2

Composite indicators for systemic market liquidity risk

(Aug. 2019-July 2024)

a) Finnish bond market indicators *b) Systemic liquidity indicator for Finnish markets*



Sources: Bloomberg Finance L.P. and Suomen Pankki – Finlands Bank calculations.
Note: Composites are constructed from Finnish sovereign, NFC and covered bond data. Panel a: indicators are weighted by the total amount issued in each bond category. Panel b: indicators are equally weighted in each bond category.

Composite bond market liquidity did not weaken much in Finland during the pandemic, which contrasts with the results for the euro area.[34] One reason for this could be that demand for Finnish sovereign and covered bonds remained robust, even in spring 2020. However, the interest rate hike cycle led to a clear deterioration in market liquidity, both in Finland and in the euro area. This lower market liquidity did not lead to any significant widening in the risk premia of Finnish bond issuers, including the spread between Finnish and German sovereign bonds and the asset swap spreads of Finnish covered bonds. Both banks and NFCs have been active in their primary market issuance in 2024, which reflects overall good global and European investor appetite for fixed income instruments.

Overall, movements in these market liquidity indicators are typically aligned with events in the broader euro area market. It is possible that country risk will begin to play a larger role in future, due to increasing Finnish sovereign debt and geopolitical risk factors.

Challenges in compiling market liquidity indicators. Indicators were calculated for the sovereign, covered and corporate bond markets, although it was not possible to compute all indicators due to data gaps.[35]

[34] This could be partly because the Finnish sample begins in the fourth quarter of 2019, which is slightly later than the euro area sample. Liquidity did weaken slightly in 2020, but the deterioration was far more pronounced in 2022. The Finnish application of the framework is based on a more limited set of indicators, so it might not reflect all the events that occurred in 2020.

[35] For example, we do not have access to transaction-level data for NFC bonds. There are also no Finland-specific NFC or covered bond ETFs.

Annex B: Boxes

Box 1

System-wide liquidity stress testing − a framework

Prepared by Emilio Hellmers (Danish Financial Supervisory Authority) and Arianna Santone (ESRB)

In September 2022, the European Systemic Risk Board (ESRB) issued a warning about the increased likelihood of tail-risk events materialising in the EU, following a series of global liquidity disruptions since 2020 (i.e. the “dash for cash” in 2020, energy crisis in 2022 and US banking turmoil in 2023). This warning highlighted the risk of a sharp and broad-based asset price correction, leading to mark-to-market losses and amplified market volatility. The ESRB warned that this could in turn result in exacerbated liquidity tensions in the financial system, posing a severe systemic risk.

With this in mind, the ESRB has been investigating interconnectedness across and within EU sectors (i.e. identifying contagion channels, risk concentrations and dependencies) and developing stress test illustrations of system-wide liquidity risk. The work was divided into a number of steps: survey, data, scenario and illustrations.

Survey on system-wide liquidity stress testing (SLST). A survey of 22 EU authorities (i.e. central banks and national supervisors) was conducted to gather information on SLST frameworks. The main findings are set out below.

- SLST frameworks are common among EU authorities (82%), although there is no common definition of this type of framework. SLST frameworks are primarily used for the purposes of supervision and macroprudential monitoring, with an emphasis on banks. Very few have broad sectoral coverage.
- Most SLST frameworks use multiple scenarios, and idiosyncratic shocks are widely used in the design of liquidity stress test scenarios. The typical stress window ranges from one to 12 months, with some frameworks able to consider even shorter stress windows.
- Top-down stress tests and sensitivity analysis are the most common tools in SLST frameworks. Many of them assume static balance sheets and do not model agents’ behaviour.
- SLST frameworks do not often consider contagion effects, feedback loops or links to solvency stress testing. Risk metrics are often built from the results of system-wide liquidity stress tests. Interconnection analyses are not widely used.

Data identification and mapping. A comprehensive dataset of cross-sectoral exposures was compiled. The primary aim of this dataset was to present illustrations of key direct and indirect financial exposures in the EU and to prepare the input data for the SLST illustrations (i.e. the final

step). The comprehensive dataset can be used to construct matrices (e.g. holder vs issuer) at both the euro area and country level, with different layers of granularity.

- Direct exposures: The banking sector is the most interconnected sector in the financial system. Banks have significant links with other banks, households, NFCs and the rest of the world. As a result of geographical dispersion, half of the exposures held by investment funds are issued by entities domiciled outside the euro area.
- Indirect exposures: Investment fund asset portfolios overlap with each other but also with other institutional sub-sectors. There are significant common exposures between Luxembourg, Irish and German investment funds, which also are the major investment fund jurisdictions in the EU.

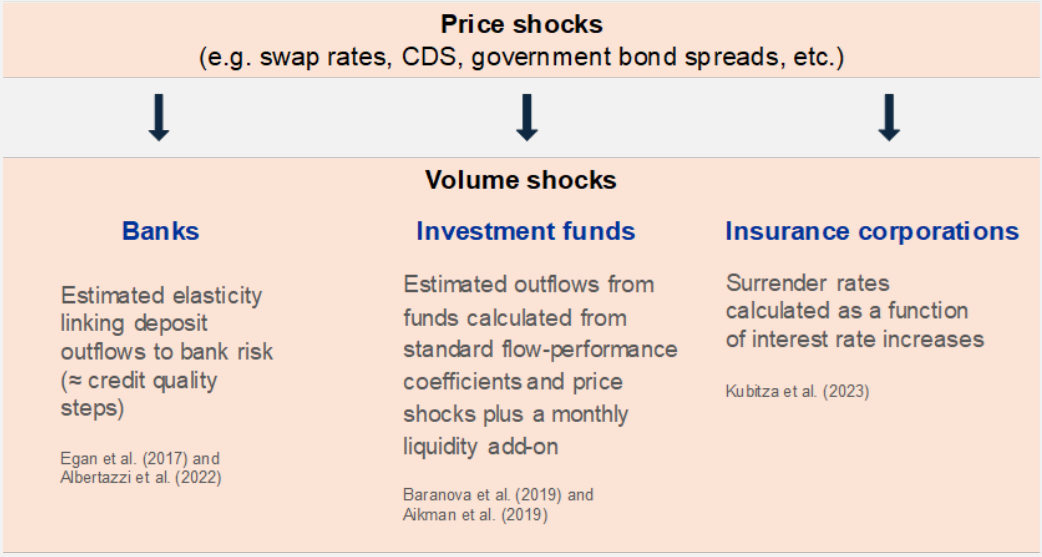
SLST scenario. A system-wide adverse liquidity scenario was calibrated. The narrative used in this scenario considered liquidity challenges experienced since 2020. The scenario was calibrated with two separate layers that are consistent with each other: price market shocks and volume shocks.

The narrative emphasised the solvency impact on banks of mark-to-market losses and portfolio revaluations, which result in a partial loss of confidence in the EU banking sector and trigger deposit outflows. To stay above minimum liquidity requirements, banks sell assets at depressed prices, which in turn reduces their profitability. Increased uncertainty means that investment funds face redemption calls, forcing them to sell large amounts of assets. Insurance companies are impacted by higher lapse rates due to a significant decline in disposable incomes and an increase in surrender rates as policyholders shift towards more remunerative products.

Volume shocks were segmented into banking institutions, investment funds and insurance corporations. For banks, run-off rates were calibrated based on estimated elasticity linking deposit outflows to bank credit risk. For investment funds, monthly outflows were calculated using standard flow-performance coefficients. A redemption rate add-on by asset class was also included to capture the possible steepening in the relationship between asset price shocks and redemption rates under stressed liquidity conditions. For insurance corporations, surrender rates were derived as a function of government bond yields in line with academic studies.

Chart B.1.1

Link between price and volume shocks in the system-wide liquidity stress test scenario



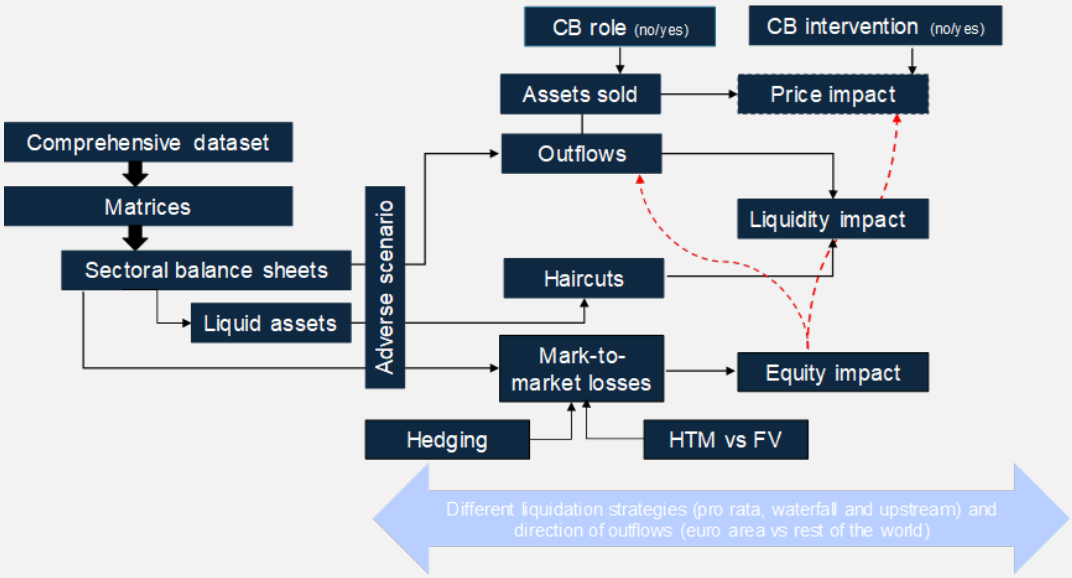
Illustrations from system-wide liquidity stress tests. The final step was to provide illustrations from system-wide liquidity stress tests. For this purpose, the Task force on Stress Testing organised a desktop liquidity stress test exercise to quantify the impact of an aggregate liquidity shock in the EU. This purely top-down exercise consisted of two legs. The first leg relied on existing SLST models in different jurisdictions. In total, 13 jurisdictions participated, including ECB Banking Supervision, ESMA and the European Insurance and Occupational Pensions Authority. Banks, investment funds and insurance corporations were included in the scope. The second leg involved developing a simple stress test tool that was inspired by original IMF SLST tools (the "ESRB top-down balance sheet tool").

Both legs used a set of instructions and a common reporting template. These were developed to ensure a minimum level of harmonisation and facilitate interpretation and comparability of the results, in particular regarding the amount of assets sold as a consequence of the aggregate liquidity shock. Both legs also used the same adverse system-wide liquidity scenario that was calibrated in the previous step.

In addition to illustrating the liquidity impact of an adverse scenario in the EU financial system, the results were also used to calculate first and second-round price impacts following a forced sell-off of liquid assets, taking into consideration cross-sectoral interactions. The results were still being analysed when this report was prepared.

Chart B.1.2

Flow chart of ESRB top-down balance sheet tool model



Box 2

Market liquidity in the Danish covered bond market

Prepared by Lizette Eistrup Jensen and Magnus Stenfeldt Madsen (both Danmarks Nationalbank)

The Danish covered bond market is the largest market for covered bonds in Europe[36] **and essential for domestic mortgage origination.** As of June 2024, five key Danish mortgage credit institutions were responsible for 70% of mortgage lending to domestic firms and households in Denmark (Chart B.2.1, panel a). Mortgage loans are funded through the daily issuance of covered bonds.37 Covered bonds also play a crucial role as high-quality liquid assets (HQLA) for Danish banks and as long-term assets for insurance companies and pension funds, partially due to limited government debt issuance in Denmark. There are therefore significant interconnections between the covered bond market and Danish financial institutions.

Danish mortgage credit institutions finance all their lending via covered bonds.[38] The bonds are sold in the primary market to a small group of financial institutions (primary dealers). These financial institutions have agreements with mortgage credit institutions to buy their newly issued bonds (see Chart B.2.1, panel a for an overview of mortgage credit institutions and primary dealers

[36] See European Mortgage Federation – European Covered Bond Council (2023), p.142.

[37] See Jensen and Bentsen (2023) for more information about daily issuance of covered bonds in the Danish primary market.

[38] They are not allowed to take deposits.

in Denmark). Some of the primary dealers (Danske Bank, Jyske Bank, Nordea Bank and Nykredit Bank) are affiliated with a mortgage credit institution. The primary dealers then sell the bonds to investors in the secondary market.

The link between the underlying pool of mortgage loans and the respective covered bonds is very tight in the case of Danish covered bonds. Danish mortgage credit institutions are subject to the "balance principle", which means that they must continuously sell bonds to finance the disbursement of new loans or the conclusion of fixed-rate agreements. Legislation governing the balance principle requires a close link between the loan and the bonds: there is a one-to-one relationship between the payment received from the borrower to the mortgage institution, and the payment from the mortgage institution to the bond investors. This is known as the "match funding principle". Given the central role played by mortgage credit institutions in Denmark, they can be considered key entities in the systemic liquidity framework. In other countries in Europe and Scandinavia, loans are not closely linked to issued covered bonds in the same way as in Denmark. This gives issuers in other European countries more flexibility to decide when they want to issue their bonds. As a result, covered bond markets in other countries may be closed for shorter or longer periods during times of financial turmoil.

Use of Danish covered bonds as highly liquid assets and collateral for repo borrowing

Danish covered bonds are a crucial source of liquidity for domestic financial institutions. Danish covered bonds are AAA-rated, so it is only the size of the bonds that determines whether they can be classified as level 1, 2 or non-liquid under the LCR regulation. Around 90% of the outstanding amount of Danish covered bonds are HQLA. Financial intermediaries in Denmark, such as banks, insurance companies and pension funds, use covered bonds as a source of liquidity. Around 50% of HQLA held by Danish banks are Danish covered bonds. In addition, covered bonds can be pledged as collateral in the repo market and used by banks to access central bank liquidity.

Covered bonds play a key role in secured money markets in Denmark. Around 86% of collateral in the repo market is made up of Danish covered bonds.[39].Banks use the bonds received in repo transactions to manage their holding of bonds as part of their roles as market-makers in the Danish covered bond market. The Danish repo market therefore supports the Danish covered bond market, as the banks can cover short positions if it is not possible to buy the bond on the market for a short period or if the price is assessed to be too high. In this way, the Danish repo market reduces the risk for banks purchasing bonds in turbulent times, which in turn lowers bid-ask spreads in the Danish covered bond market.

Resilience of the Danish covered bond market

The Danish covered bond market has proved resilient during turbulent periods. Danish mortgage credit institutions have always been able to issue bonds on a daily basis – even during times of turmoil in the financial markets (Chart B.2.1, panel b). This is a strength of the Danish covered bond market, which ensures transparent prices and market terms for the financing of properties for both households and businesses. However, financial turbulence can affect the Danish covered bond market in the form of lower demand for bonds and lower market liquidity.

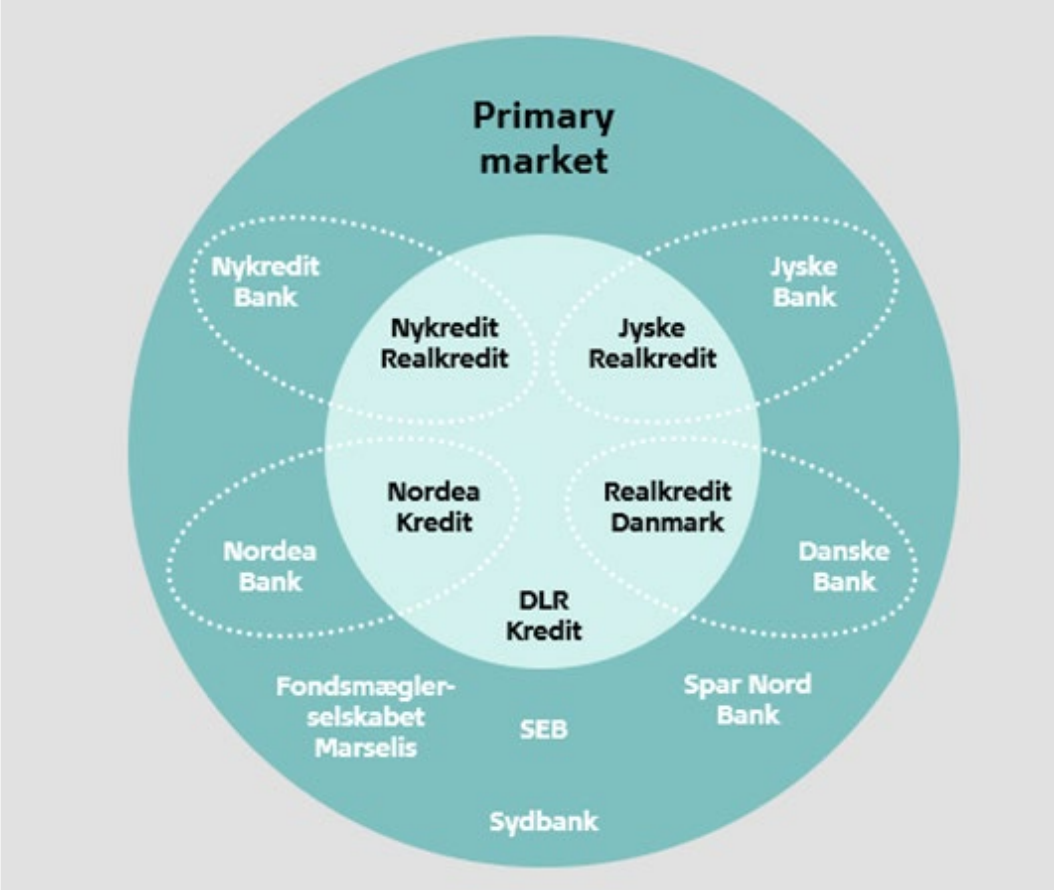
[39] See Danmarks Nationalbank (2024), p.29.

During volatile periods, equilibrium prices in the market can be subject to considerable uncertainty, which increases market risk. This can cause market players to reduce their trading activity, resulting in lower market liquidity. Such bouts of volatility have occurred occasionally in covered bond markets in Denmark and other European countries. Recent turbulent episodes occurred in March 2020, during the pandemic outbreak, and in autumn 2022, amid a tightening of the monetary policy stance and increased uncertainty about future rate levels (Chart B.2.1, panel c).40 Since then, market liquidity has improved on the Danish covered bond market.

Chart B.2.1

Market liquidity in the Danish covered bond market

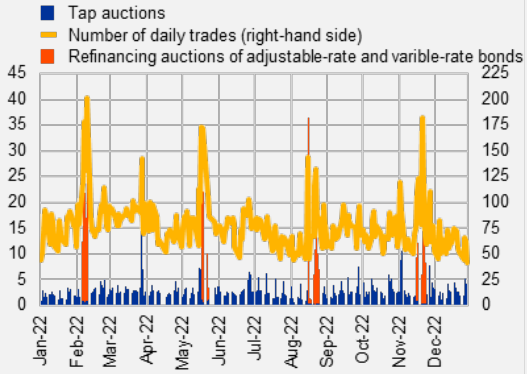
a) Mortgage credit institutions and primary dealers



40 For more information, see Danmarks Nationalbank (2015), pp. 7-48, and Halsnæs et al. (2020).

b) Issuance activity

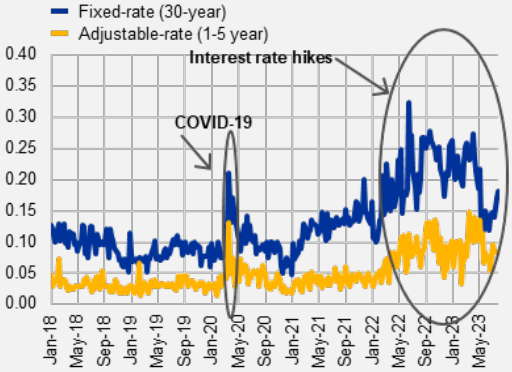
(left-hand side: DKK billions, right-hand side: number of daily trades)



Sources: MiFIR reports and Danmarks Nationalbank calculations.
Notes: Refinancing auctions of adjustable-rate and variable-rate bonds include sales from mortgage credit institutions to banks with primary dealer agreements on auction days for their refinancing. Tap auctions include sales of all covered bonds from mortgage credit institutions to banks with primary dealer agreements, but not on days for refinancing of adjustable-rate and variable-rate bonds. If long-term fixed-rate bonds are sold on days of refinancing auctions, those trades are included in the calculation of tap auctions.

c) Price sensitivity

(percentage price change)



Sources: MiFIR reports and Danmarks Nationalbank calculations.
Notes: Price sensitivity measures how a single trade affects the price of a bond. It is calculated by determining the percentage price difference between the two most recent trades. The chart shows the weekly median. The adjustable-rate bonds have maturities of one to five years.

Box 3
The structure of sovereign bond markets in Germany and Italy: common features and differences

Prepared by Michael Schmidt (Deutsche Bundesbank), Alessio Ruggieri (Banca d'Italia) and Gibran Watfe (De Nederlandsche Bank)

EU sovereign bond markets share some features, but country-specific features remain significant. This box outlines common features and differences across EU sovereign bond markets. It focuses on Germany and Italy, two large sovereign bond markets with quite distinct market structures. We distinguish between cash, repo and futures markets. Secondary markets for government bonds are closely linked with activity in the repo and futures markets, as participants fund their activities in repo markets using government bonds as collateral, or arbitrage differences in the prices of the futures and cash markets (Financial Stability Board, 2022).

Trading in the cash market is primarily over the counter in most countries, with the notable exception of Italy. In Italy, on-exchange trading dominates, with interdealer daily turnover on MTS Cash reaching €27 billion in the first quarter of 2024 (Chart B.3.1, panel b). MTS Cash is a regulated, quote-driven market with market-makers (mostly primary dealers) actively supporting both sides of the order book. Trades are anonymous and the market is fully centrally cleared. In contrast, German government bonds are predominantly traded over the counter, with a volume of around €20 billion per day in normal market conditions (Chart B.3.1, panel a). The market relies on primary dealers that can participate in government bond auctions. Unlike in other countries, primary dealers have no obligations on secondary markets, for example in relation to bid-ask spreads (in France, Italy and Spain), trading volumes (France) or quotation quality (Italy), according to the International Capital Market Association (2024).

Repo markets have a key role in supporting secondary markets for government bonds, but market structures vary. Repo trades backed by Italian government bonds are mostly traded on a fully electronic order-driven market with central clearing. Daily turnover has grown significantly in the last decade, reaching record highs in 2024. MTS Repo is by far the most used trading venue, with daily turnover of around €160 billion (Chart B.3.1, panel d). In Germany, the repo market is dealer-centric and a few large dealer banks account for most of the trading volume. Around 65% of the trading volume is centrally cleared. Overall repo volumes for trades backed by German government bonds are around €200 billion daily (Chart B.3.1, panel c), which is roughly 20% of the entire euro repo market, and ten times larger than the daily volume in cash markets.

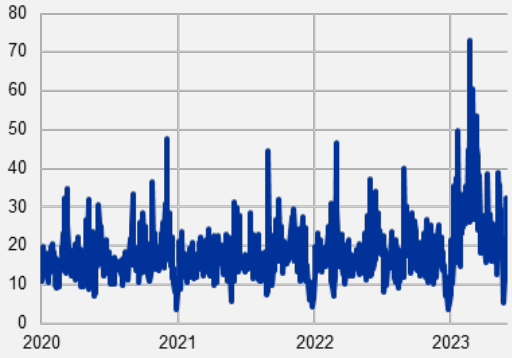
Futures on sovereign bonds from Germany and Italy are actively traded on the same exchange. Eurex is an electronic order-driven platform based on a central limit order book. German bond futures are highly liquid, with an average daily trading volume of €200 billion, which is roughly ten times the volume of the cash market. This volume rises to up to €1 trillion ahead of the quarterly delivery dates (Chart B.3.1, panel e). Primary dealers are significant players in this market, accounting for 20-30% of daily volumes. Italian bonds, which are traded on the same exchange, are also highly liquid, but the average daily trading volume is only €30 billion, which is similar to the cash market volume (Chart B.3.1, panel f).

Chart B.3.1

Volumes in the German and Italian government bond markets

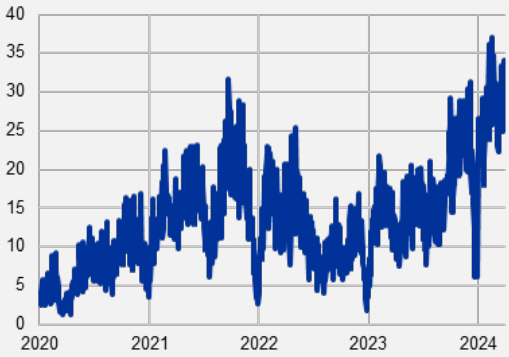
a) German primary dealer cash market

(EUR billions, Jan. 2020-May 2023)



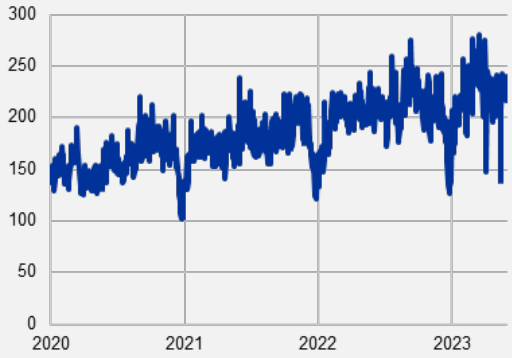
b) Italian interdealer cash market – MTS Cash

(EUR billions, daily turnover, Jan. 2020-March 2024)



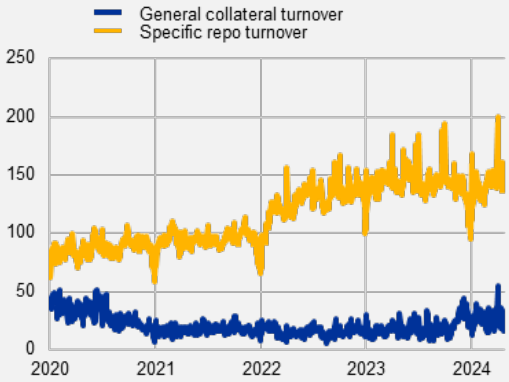
c) European and German MMSR banks – repo market

(EUR billions, Jan. 2020-May 2023)



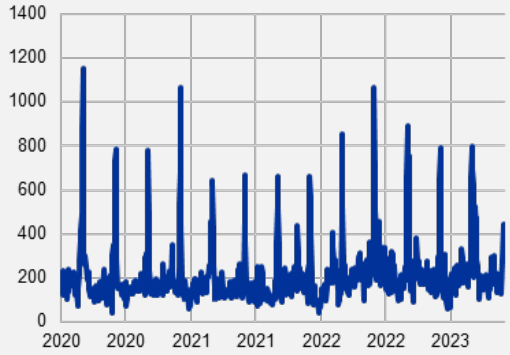
d) Italian interdealer repo market – MTS Repo

(EUR billions, daily turnover, Jan. 2020-April 2024)



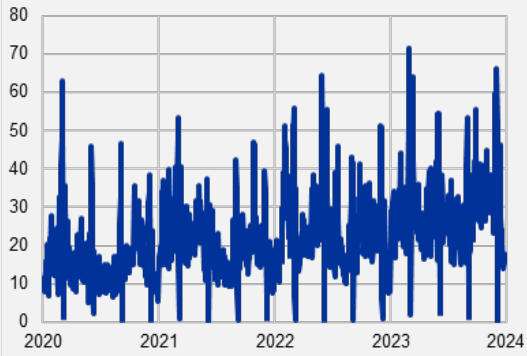
e) German futures – FGBL, FGBM, FGBS and FGBX

(EUR billions, daily, Jan. 2020-May 2023)



f) Italian futures – FBTP and FBTS

(EUR billions, daily, Jan. 2020-Dec. 2023)



Sources: MiFIR, MMSR, MTS, LSEG, Banca d'Italia and Deutsche Bundesbank.
Notes: Panel a: average daily buy and sell cash transaction volume. Panel c: average daily repo and reverse repo transaction volume.

Box 4

Monitoring systemic liquidity risks in the UCITS sector – the example of Luxembourg

Prepared by Michael Böhl and Laurent Goergen (both CSSF)

This box outlines the systemic liquidity risk monitoring performed by the Commission de Surveillance du Secteur Financier (CSSF) for Luxembourg UCITS. UCITS account for two-thirds of the EU investment fund industry, and Luxembourg is home to 38% of total assets managed by EU UCITS. Total net assets (TNA) of the UCITS segment of Luxembourg's authorised investment fund sector stand at €4.5 trillion (as of the end of the first quarter of 2024), with the main investment policies being equity funds (around 40%), bond funds (30%) and mixed funds (20%), leaving 10% for MMFs (operating as UCITS) and residual categories. While AIFs and MMFs are subject to harmonised reporting across the EU, there is no harmonised reporting for UCITS. The systemic liquidity risk indicators developed in this report (calculated for the Luxembourg UCITS segment) are therefore complemented by more granular and qualitative information from the

national UCITS reporting system that Luxembourg's financial supervisory authority, the CSSF, introduced in 2016.[41]

To better understand how liquidity risk developed in the Luxembourg UCITS sector over the observed period, we first present the risk indicators included in this monitoring framework (Chart B.4.1) and then add additional details on available liquidity risk mitigation tools.

Asset liquidity

On the assets side, liquidity risk for UCITS can be measured by the ratio of liquid assets (i.e. cash or high-quality liquid assets) to total assets, or portfolio liquidity over different time horizons (measuring the share of assets that can be liquidated within a time frame under normal trading conditions).[42] Cash ratios vary across investment fund types and are structurally highest for MMFs and lowest for equity funds.

Over the observation period, cash ratios fluctuated mildly and in fact rose (visible in higher z-scores) during periods of elevated financial market volatility. This represents a precautionary response from fund managers to manage liquidity demands in a context of uncertainty (see the periods of the pandemic outbreak and of the rapid monetary policy tightening thereafter).

Z-scores for portfolio liquidity were signalling slightly higher risks until the first quarter of 2020 and have been positive and increasing since then.

The improvement in portfolio liquidity over time is particularly pronounced for bond funds, which reflects a combination of factors. First, in a context of rising short-term interest rates, bond funds reduced the maturity and credit risk of their portfolios, and less risky bonds tend to be more liquid than other bonds. Second, positive changes in portfolio liquidity reflect post-pandemic adjustments as a result of supervisory actions taken by national competent authorities in order to reduce liquidity risk.[43] Finally, bond purchase programmes launched by major central banks supported the liquidity of bonds over the period. Expressed as a percentage of net assets, seven-day portfolio liquidity reached 90% for all investment policies as of the end of the first quarter of 2024, and therefore stands at the upper end of the range observed since the third quarter of 2016.[44]

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41 The CSSF publishes information about reporting coverage, times series of all collected risk indicators and a brief assessment of the risk situation annually, in a **dedicated dashboard for Luxembourg UCITS**, complemented by further dashboards for **MMFs** (which predominantly operate under the UCITS legal framework) and **AIFs.** In addition to these comprehensive annual risk dashboards, the CSSF publishes **statistics monitoring the development of the Luxembourg investment fund sector** (including UCITS) at a higher (usually monthly) frequency.

42 This indicator represents the investment fund manager's own assessment (as is also the case in EU AIFMD reporting) of their portfolio's liquidity, and is not a homogeneous measurement. For example, investment fund managers use heterogeneous approaches to estimate liquidity depending on their asset liquidation strategy, and might assign different liquidity figures to the same assets, i.e. a security might be considered as liquid within one day for one fund, and longer for another fund. Alternatively, the investment fund manager's assessment of a fund's portfolio liquidity could be based on the average daily trading volume multiplied by a discount factor (participation rate or market-based assessment). Different approaches result in different assessments.

43 See, for example, ESMA (2020).

44 While aggregating such (static) portfolio liquidity indicators across funds provides a useful basis for assessing sector-wide/systemic liquidity risk, macroprudential stress tests that assess portfolio liquidity on a dynamic basis also play an important role for financial stability. Macroprudential features (amplification and contagion mechanisms) should be incorporated into these stress testing frameworks, to reflect the potentially systemic dimension of liquidity shocks. For an application, see Lô and Carpantier (2023).

Liquidity risk on the liabilities side

On the liabilities side, the funding liquidity risk of UCITS can be measured by their redemption features (investor liquidity), investor concentration[45] and net outflows. Investor liquidity within seven days is close to 100% across all investment policies, as almost all UCITS offer daily redemptions to investors with notice periods shorter than seven days. However, redemption risk can be mitigated by the use of liquidity management tools such as redemption gates, which are available for most Luxembourg UCITS and typically limit daily redemptions to 10% of net assets.

If the gating mechanism is integrated, investor liquidity stays close to 70% of net assets over the observation period. Its z-score starts at a lower level due to an initially slightly lower availability of gating mechanisms (Table B.4.2) and continues to fluctuate mildly due to a few funds adjusting their notice periods, among other factors. Because investor liquidity does not vary much (as a percentage of net assets), the z-score of the average of liquidity shortage and liquidity mismatch (see "liquidity risks" in Chart B.4.1) mostly follows the evolution of the portfolio liquidity's z-score.

Since the end of the first quarter of 2016, net outflows have been observed during March 2020 (pandemic-related stress) and since the rise of inflation and monetary policy rates. **For bond, equity and mixed funds, monthly net flows (subscriptions – redemptions) beyond +/-5% of total net assets are hardly ever observed.**[46] However, MMF flows are more volatile, with monthly net flows exceeding 10% of total net assets (in both directions) in some periods. This reflects the use of MMFs by institutional investors as a cash management vehicle. If net subscriptions are viewed in relation to valuation effects of the preceding period (approximated by changes in total net assets not due to net subscriptions), there are low positive correlation coefficients (between 0.1 and 0.3) for all fund types. This indicates slightly procyclical investor behaviour, where increasing (stock and bond) market valuations are followed by net subscriptions in the subsequent quarter (and analogously for decreasing market values and net redemptions). Regarding cross-sector correlation in fund flows (Chart B.4.1), we observe a period of decorrelation in 2018-19, a rebound at the onset of the pandemic, and a clear increase since the end of 2021, which is driven by net outflows across all investment policies except for MMFs.

Risk mitigation instruments

An interpretation of liquidity risk indicators must also consider the existence of instruments to mitigate liquidity risks. The high level of availability and use of liquidity management tools is a key feature of the Luxembourg investment fund sector (Table B.4.2). Almost all Luxembourg UCITS have at least one liquidity management tool at their disposal. Quantity-based tools (temporary redemption suspensions, redemption gates or deferred redemptions) are available to more than 98% of funds, while price-based tools in the form of swing pricing and antidilution levies are available to two-thirds and a quarter of funds respectively. Luxembourg investment fund managers

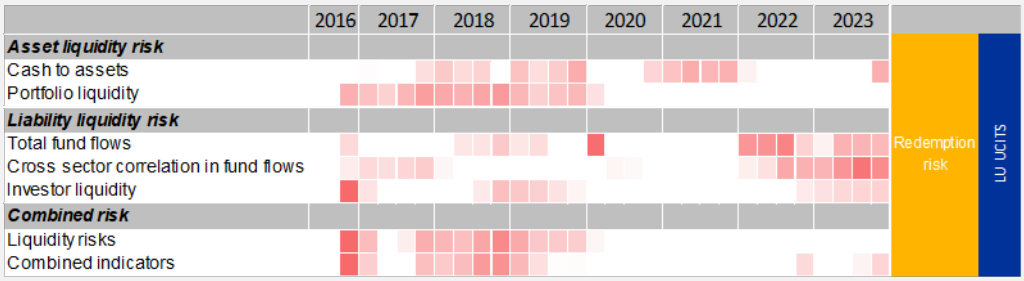
[45] Large investor bases generally contribute to more financial stability, while higher investor concentration is found to cause higher funding fragility (see Carpantier, 2021).

[46] For a comprehensive empirical analysis of the significance of various fund-specific risk drivers in explaining (large) redemptions, see Carpantier (2021).

regularly use price-based tools, particularly swing pricing.[47] Since the end of 2016, more than 30% of UCITS (in terms of total net assets) have (at least once) used swing pricing within the observed half-year periods. During the systemic liquidity shock caused by the pandemic outbreak in spring 2020, Luxembourg UCITS managing well above 40% of total net assets used swing pricing (at least once) to manage their liquidity situation. This positive experience confirms the importance of the recent revisions at EU level in the context of the AIFM and UCITS Directives, in relation to wider availability, selection and use of liquidity management tools by investment fund managers for their managed funds.[48]

Chart B.4.1

Heat map of liquidity risk indicators by risk dimension for Luxembourg UCITS



47 Swing pricing is a mechanism by which the NAV of the units or shares of an investment fund is adjusted by the application of a factor ("swing factor") that reflects the cost of liquidity. When swing pricing is activated, all transacting investors (both subscribing and redeeming) must transact on the basis of the swung NAV, so that they bear the cost of liquidity while remaining investors are not affected.

48 See also CSSF (2024b) and Lewrick et al. (2022). For corporate debt and real estate funds, increasing the availability and use of liquidity management tools was also identified as a priority area in ESMA (2020). Regarding anti-dilution liquidity management tools specifically, the International Organization of Securities Commissions (2023) has recently issued implementation-oriented guidance.

Chart B.4.2

Availability and usage of liquidity management tools in the Luxembourg UCITS sector

(end-2016-end-2023; percentage of total net assets)

Date (YE)	Gates/ deferrals		Antidilution levy		Swing pricing		Temporary suspensions	
	Available	Used	Available	Used	Available	Used	Available	Used
2016	78.4	0.0	12.4	0.9	60.8	32.1	87.2	0.3
2017	89.2	0.0	13.2	0.8	60.8	33.4	98.8	0.2
2018	88.7	0.0	19.4	1.4	62.3	33.5	98.2	0.0
2019	88.9	0.0	17.3	2.0	63.4	34.9	97.8	0.0
2020	93.6	0.0	15.3	2.9	67.7	36.5	97.9	0.1
2021	93.5	0.0	19.6	2.6	65.9	35.5	97.0	0.2
2022	91.9	0.0	20.3	3.0	70.9	35.5	98.1	0.0
2023	91.5	0.0	24.0	2.9	65.3	34.5	98.1	0.1

Box 5

Case study: Systemic illiquidity during the COVID-19 outbreak

Prepared by Desislava Andreeva (ECB), Antoine Bouveret (ESMA) and Petya Radulova (ECB)

Systemic liquidity has been impaired several times in the recent past. Shocks that triggered liquidity stress stemmed from a range of sources: some outside the financial system, like the outbreak of the COVID-19 pandemic in March 2020, and others within the financial system, such as the funding liquidity issues faced by US regional banks and a Swiss global systemically important bank in March 2023. These episodes can help to assess how well the monitoring framework for systemic liquidity presented in this report captures risks, and which elements of the framework are particularly useful for real-time monitoring.

Funding liquidity during the pandemic

The outbreak of the pandemic in the euro area can be used as a case study of funding liquidity risks. As mentioned in the main body of this report, the overall index for funding liquidity captures the pandemic episode well (Charts 6 and 7), but several input variables are only available with a substantial lag. At the time of the outbreak, only data for the fourth quarter of 2019 were available and would have signalled relatively contained funding liquidity risks for banks along all three dimensions (redemption, rollover and margining risk). By contrast, indicators would have pointed to elevated and increasing redemption risks for NBFIs ahead of the pandemic shock.

Focusing on bank funding risks, some elements of the framework are also suitable for real-time monitoring. Specifically, the z-spreads on bank bonds (included in the indicators for contagion and amplification risks and for funding liquidity risk) capture funding strains in a timely manner, since they are available at daily frequency (Chart B.5.1, panel a). The assessment can be usefully complemented with data on issuance volumes to identify instances of outright market closure. The explanation below focuses on the developments observed throughout 2020.

Euro area banks' access to bond funding deteriorated rapidly after the pandemic outbreak. Before this, euro area banks' bond issuance costs had reached a trough in late August/early September 2019 and subsequently increased moderately. The increase was driven by slightly higher long-term risk-free interest rates, while z-spreads continued to tighten across the creditor hierarchy (Chart B.5.1, panel a), which supported robust issuance activity until mid-February 2020.

Chart B.5.1

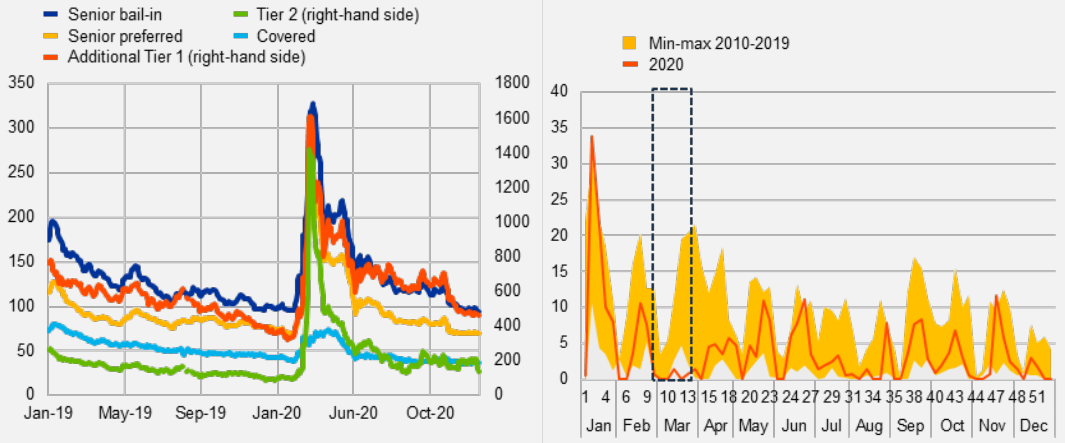
Evolution of euro area banks' bond spreads and bank issuance during 2020

a) Euro area bank bond spreads

(Jan. 2020-Feb. 2021, z-spread)

b) Gross bank bond issuance volume

(y-axis: weekly bond issuance, EUR billions; x-axis: week number)

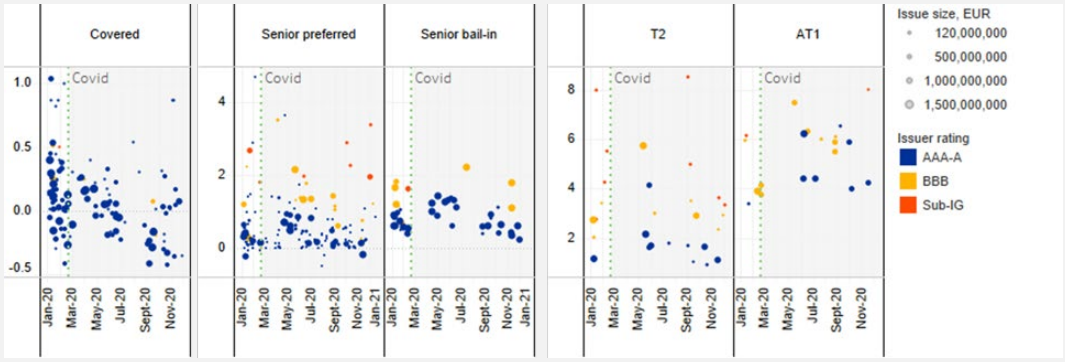


Sources: Dealogic and S&P Down Jones Indices LLC and/or its affiliates.

The situation reversed abruptly after 21 February 2020. Bank bond spreads widened rapidly across the entire creditor hierarchy and issuance stopped in late February (Chart B.5.1, panels a and b). Zooming in by instrument, issue size and issuer rating reveals a complete market closure for T2 and AT1 instruments for more than two months (Chart B.5.2). Similar effects are visible for senior bank bonds. By contrast, the covered bond segment was the first to reopen in late March, even though issuance activity was concentrated among high-rated issuers.

Chart B.5.2

Bank bond issuance by instrument type, issue size and issuer rating



Source: Dealogic.

Liquidity stress was relatively short-lived due to the swift policy response. The ECB's pandemic response measures were key for market stabilisation in the early periods of turmoil and for easing euro area bank funding conditions throughout the pandemic crisis. Gross bond issuance continued to be low by historical standards in late 2020/early 2021, reflecting the availability of TLTRO III funding at more attractive costs rather than impaired access to bond markets for euro area banks.

Market liquidity and amplification factors during the pandemic outbreak

Market liquidity metrics allow for real-time monitoring across asset classes. Most market-based indicators are available at high frequencies (up to daily) and can therefore signal tensions in a more timely manner than funding liquidity indicators. Timely and granular market data from commercial data sources or activity-based regulatory reporting (such as EMIR reporting for derivatives and SFTR reporting for securities financing transactions) enable authorities to assess the evolution of market liquidity in near real time.

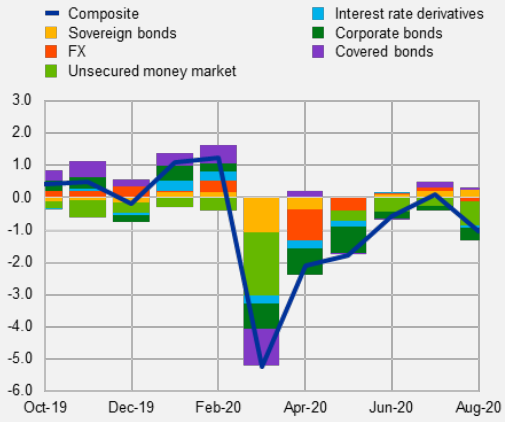
Composite indicators point to a sharp drop in liquidity in March 2020 across markets. Chart B.5.3 (panel a) shows the evolution of the composite indicator for market liquidity at monthly frequency. Market liquidity plummeted in March 2020 to well below the historical average, especially for unsecured money markets and sovereign, corporate and covered bonds. The deterioration observed between February and March 2020 was particularly severe for sovereign bonds, covered bonds and the unsecured money market. High-frequency indicators (Chart B.5.3, panel b) show that liquidity in the FX market initially started to decline in the last week of February 2020, followed by a sharp decline in the corporate and covered bond markets in early and mid-March respectively. The indicators also point to different durations of stress: while market liquidity tensions receded quickly in covered bond markets, conditions remained volatile for corporate bonds, with a bout of illiquidity in April, and in FX markets.

Chart B.5.3

High-frequency indicators of market liquidity

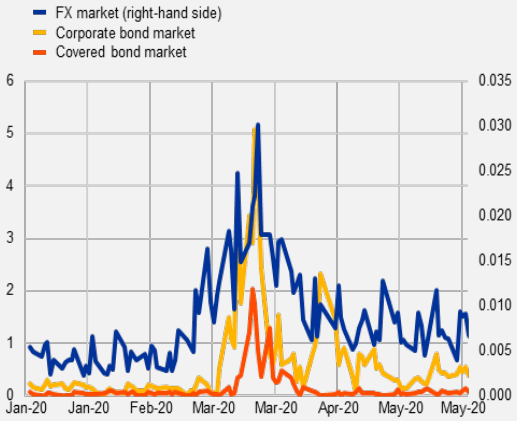
a) Composite indicator of market liquidity

(Oct. 2019-Aug. 2020, z-score)



b) Market liquidity indicators at daily frequency

(Jan. 2020-May 2020, ETF premium/discount and percentage intraday volatility in percent)



Note: Panel b: average ETF premium/discount on EUR corporate and covered bond ETFs, in percent. For the FX market, liquidity is estimated using intraday EUR/USD volatility, which is defined as the difference between the highest and lowest intraday exchange rates divided by the average intraday value, expressed as a percentage.

The deterioration in market liquidity was visible across indicators. Broad-based selling related to risk aversion and precautionary demand for liquidity by investors resulted in a sharp drop in market liquidity across key markets. These moves are visible in a range of indicators. Spreads increased markedly for sovereign bond markets, and market-makers stopped providing liquidity, as indicated by the jump in the number of bonds without quotes. Unsecured short-term funding markets froze, as shown by the sharp drop in commercial paper issuance (Chart B.5.4, panel a) and the jump in ETF mispricing (Chart B.5.4, panel b).

Chart B.5.4

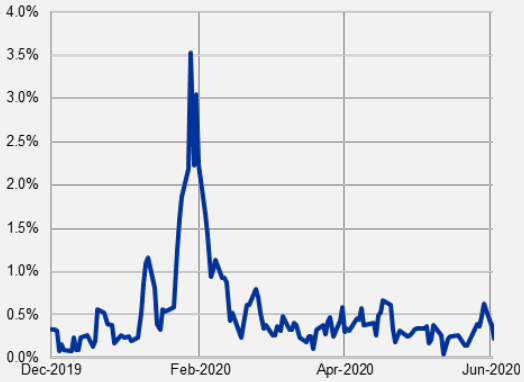
Illiquidity in unsecured short-term funding markets

a) Sharp drop in financial commercial paper outstanding

(outstanding amounts rebased at 17 March 2020=100)

b) Spike in illiquidity on short-term markets

(average ETF premium/discount to NAV, percentage)



Sources: LSEG and ECB.
Notes: Panel a: outstanding amounts of short-term European paper (STEP) rebased at 17 March 2020=100. Panel b: average premium/discount of ETFs investing in EUR ultra-short corporate debt.

The broad-based deterioration in funding and market liquidity was amplified by volatility. High demand for liquidity combined with a sharp reduction in the supply of market liquidity, as market-makers withdrew due to balance sheet constraints and risk aversion, resulted in an outsized decline in market prices. In turn, valuation losses triggered further liquidity demands (reflecting margin calls and collateral requests) and more forced sales, as entities reached their risk limits (including their VaR). This amplification factor can be clearly seen in Chart 11, where volatility accounts for most of the deterioration in the composite indicators for contagion and amplification risks.

This case study shows how the systemic liquidity framework can be used for monitoring purposes. Funding liquidity metrics provide an overview of risks by types of entities across several dimensions, and can be used to identify structural vulnerabilities. While time lags for some indicators might make them less useful for monitoring risks in real time, market-based measures of funding liquidity can provide insights. Market liquidity metrics tend to be more timely, as they are available at higher frequencies than entity-based information. By using both types of metrics, it is possible to assess systemic liquidity risks across entities and markets.

Annex C: Technical annex

This annex provides detailed information on the definition and calculation of each systemic liquidity risk indicator used in the report, to ensure transparency and support the implementation of the framework by EU authorities.

For each indicator, information is provided on the definition used, the dimension of liquidity risk that the indicator seeks to measure, and the scope, frequency, source and nature of the data used (e.g. regulatory data or commercial data). Finally, details are provided of how the indicator is calculated and the reasons for its inclusion in the systemic liquidity monitoring framework. Some of the market liquidity indicators are applicable for several markets (e.g. bid-ask spreads). The charts are shown to illustrate the evolution of an indicator for a selected market, while the information provided in the annex should allow for a complete replication of the data.

Liquidity risk

Funding liquidity

		Dimension	Indicator of funding liquidity	Source	Type
1	Gen.	Margining risk	Short-term interest rate volatility	Deutsche Bundesbank	Commercial data
2	Gen.	Margining risk	VIX	CBOE	Commercial data
3	Banks	Margining risk	Market funding asset encumbrance	COREP	Regulatory data
4	Banks	Margining risk	Leverage ratio	COREP	Regulatory data
5	Banks	Margining risk	Liquidity leverage	QSA	Regulatory data
6	Banks	Redemption risk	LCR	COREP	Regulatory data
7	Banks	Redemption risk	Contingent outflows to total assets	COREP	Regulatory data
8	Banks	Redemption risk	Counterbalancing capacity	COREP	Regulatory data
9	Banks	Redemption risk	€STR-deposit rate spread	MIR	Regulatory data
10	Banks	Redemption risk	Deposit growth rates	BSI	Regulatory data

		Dimension	Indicator of funding liquidity	Source	Type
11		Rollover risk	Asset encumbrance ratio	FINREP	Regulatory data
12			Short-term wholesale funding	COREP	Regulatory data
13			€STR conditions	ECB	Regulatory data
14			Average funding cost	S&P Down Jones Indices LLC and/or its affiliates	Commercial data
15			Repo market conditions	MMSR	Regulatory data
16	MMFs	Redemption risk	Weighted average maturity	Fitch Ratings	Commercial data
17			Weighted average life	Fitch Ratings	Commercial data
18			Weekly liquidity	Fitch Ratings	Commercial data
19			Daily liquidity	Fitch Ratings	Commercial data
20			Flows	EPFR	Commercial data
21	Funds	Redemption risk	Total fund flows (incl. open-ended)	ECB, IVF statistics	Regulatory data
22			Cross-sector correlation in fund flows	ECB, IVF statistics	Regulatory data
23			Cash-to-assets	ECB, IVF statistics	Regulatory data
24			Portfolio liquidity	ESMA AIFMD	Regulatory data
25			Investor liquidity	ESMA AIFMD	Regulatory data
26			Repo market conditions	MMSR	Regulatory data
27			Liquidity risks	ESMA AIFMD	Regulatory data
28			Open-ended fund flows	ECB, IVF statistics	Regulatory data
29			Open-ended funds: Cross-sector correlation in flows	ECB, IVF statistics	Regulatory data
30			Open-ended funds: Cash-to-assets	ECB, IVF statistics	Regulatory data

		Dimension	Indicator of funding liquidity	Source	Type
31	Insurance corporations	Margining risk	Cash to total assets	SDW	Regulatory data
32			Derivatives to total assets	SDW	Regulatory data
33			Duration	Solvency II	Regulatory data
34			Repo indicator	MMSR	Regulatory data
35		Redemption risk	Asset concentration	QSA	Regulatory data
36			Asset liquidity	SDW, Solvency II	Regulatory data
37			Duration mismatch	SDW	Regulatory data
38			Lapse rate	SDW, Solvency II	Regulatory data
39	Pension funds	Margining risk	Cash to total assets	SDW	Regulatory data
40			Derivatives to total assets	SDW	Regulatory data
41			Margin account estimate	SDW	Regulatory data
42			Repo indicator	MMSR	Regulatory data
43			Repo transactions with MFIs	SDW, BSI	Regulatory data
44		Redemption risk	Asset concentration	SDW	Regulatory data
45			Change in liquid assets	SDW	Regulatory data

Contagion and amplification

	Dimension	Indicator of funding liquidity	Source	Type
1	Financing conditions	€STR conditions	ECB	Regulatory data
2		Average funding cost	S&P Down Jones Indices LLC and/or its affiliates	Market data
3		Repo market conditions	MMSR	Regulatory data
4	Interconnectedness	Holdings of bank bonds by investment funds	SHS	Regulatory data
5		Holdings of bank bonds by other MFIs	SHS	Regulatory data
6		Holdings of bank bonds by non-MMFs	SHS	Regulatory data
7		Holdings of bank bonds by pension funds	SHS	Regulatory data
8		Probability of default of two or more systemically important banks	SDW	Commercial data
9		Portfolio similarity with the banking sector	ESRB	Regulatory data
10		Asset concentration ratio for insurance corporations and pension funds	SDW	Regulatory data
11		Cross-sector correlation in fund flows	ECB, IVF statistics	Regulatory data
12		Collateral reuse ratio	COREP	Regulatory data
13	Leverage	Duration	Solvency II	Regulatory data
14		Leverage ratio	COREP	Regulatory data
15		AIF leverage	ESMA AIFMD	Regulatory data
16		Liquidity risks	ESMA AIFMD	Regulatory data
17		Liquidity leverage	QSA	Regulatory data
18	Volatility	Short-term interest rate volatility	Deutsche Bundesbank	Commercial data
19		VIX	CBOE	Commercial data

Market liquidity

		Dimension	Indicator of market liquidity	Source	Type
1	Sovereign bonds	Tightness	Bid-ask spread	S&P Down Jones Indices LLC and/or its affiliates	Commercial data
2			High-low spread	S&P Down Jones Indices LLC and/or its affiliates	Commercial data
3			Quote slope	MTS	Commercial data
5		Immediacy	Number of market-makers	Trax	Commercial data
8			Trade frequency	MTS	Commercial data
9			Trade size	Trax	Commercial data
10			Dealer inventory	FINREP	Regulatory data
12		Depth	Quoted volume	MTS	Commercial data
13			Traded volume	Trax	Commercial data
14			Turnover ratio	Trax, SHS	Commercial and regulatory data
15			Effective spread	MTS	Commercial data
17		Breadth	Bid-ask spread dispersion	MTS	Commercial data
18			Volume concentration	MTS	Commercial data
19			Share of non-quoted securities	Trax	Commercial data
20			Share of non-traded securities	Trax	Commercial data
22		Resilience	Market efficiency coefficient	S&P Down Jones Indices LLC and/or its affiliates	Commercial data
23			Spline spread	Bloomberg Finance L.P	Commercial data
24			Amihud ratio	MTS	Commercial data
25			NAV spread	Bloomberg Finance L.P., LSEG	Commercial data

		Dimension	Indicator of market liquidity	Source	Type
26	FX	Tightness	Bid-ask spread	Bloomberg Finance L.P.	Commercial data
27			High-low spread	Bloomberg Finance L.P.	Commercial data
29		Immediacy	Traded volume	Bloomberg Finance L.P.	Commercial data
31		Depth	Amihud ratio	Bloomberg Finance L.P.	Commercial data
33		Breadth	Hui-Heubel ratio	Bloomberg Finance L.P.	Commercial data
35		Resilience	Implied volatility	Bloomberg Finance L.P.	Commercial data
36			Cross-currency basis swap spreads	Bloomberg Finance L.P.	Commercial data
37	Unsecured money market	Tightness	High-low spread (€STR)	MMSR	Regulatory data
38			EURIBOR-OIS spread	Bloomberg Finance L.P.	Commercial data
39		Immediacy	Number of active banks	MMSR	Regulatory data
40			Trade frequency	MMSR	Regulatory data
41		Depth	Traded volume (€STR)	Bloomberg Finance L.P.	Commercial data
42			Traded volume (EONIA)	MMSR	Regulatory data
43			STEP gross issuance	SDW	Regulatory data
44		Breadth	Volume concentration	MMSR	Regulatory data
45		Resilience	NAV spread	Bloomberg Finance L.P., LSEG	Commercial data

		Dimension	Indicator of market liquidity	Source	Type
46	Interest rate derivatives	Tightness	Bid-ask spread (Roll estimator) (EURIBOR swap)	EMIR	Regulatory data
47			Bid-ask spread (€STR swaps)	Bloomberg Finance L.P.	Commercial data
48			High-low spread (€STR swaps)	Bloomberg Finance L.P.	Commercial data
49		Immediacy	Trade frequency	EMIR	Regulatory data
50			Trade size	EMIR	Regulatory data
51			Average time between trades	EMIR	Regulatory data
52			Number of counterparties	EMIR	Regulatory data
53		Depth	Traded volume (EURIBOR swap)	EMIR	Regulatory data
54			Traded volume (EURIBOR futures)	Bloomberg Finance L.P.	Commercial data
55		Breadth	Price dispersion	EMIR	Regulatory data
56		Resilience	Amihud ratio (EURIBOR futures)	Bloomberg Finance L.P.	Commercial data
57			Amihud ratio (EURIBOR swaps)	EMIR	Regulatory data
58			Implied volatility SMOVE	Bloomberg Finance L.P.	Commercial data

		Dimension	Indicator of market liquidity	Source	Type
59	Corporate bonds	Tightness	Bid-ask spread	S&P Down Jones Indices LLC and/or its affiliates	Commercial data
60			High-low spread	S&P Down Jones Indices LLC and/or its affiliates	Commercial data
61		Immediacy	Number of market-makers	Trax	Commercial data
62			Trade frequency	Trax	Commercial data
63			Trade size	Trax	Commercial data
64			Dealer inventory	FINREP	Regulatory data
65		Depth	Traded volume	Trax	Commercial data
66			Turnover ratio	Trax, SHS	Commercial and regulatory data
67		Breadth	Bid-ask spread dispersion	S&P Down Jones Indices LLC and/or its affiliates	Commercial data
68			Volume concentration	Trax	Commercial data
69			Share of non-quoted securities	Trax	Commercial data
70			Share of non-traded securities	Trax	Commercial data
71		Resilience	Market efficiency coefficient	S&P Down Jones Indices LLC and/or its affiliates	Commercial data
72			NAV spread	Bloomberg Finance L.P., LSEG	Commercial data
73	Cov. bonds	Tightness	Bid-ask spread (ETFs)	LSEG	Commercial data
74		Immediacy	Trade frequency (ETFs)	Bloomberg Finance L.P.	Commercial data
75		Depth	ETF traded volume	LSEG	Commercial data
76		Resilience	NAV spread	Bloomberg Finance L.P., LSEG	Commercial data

1. Funding liquidity indicators

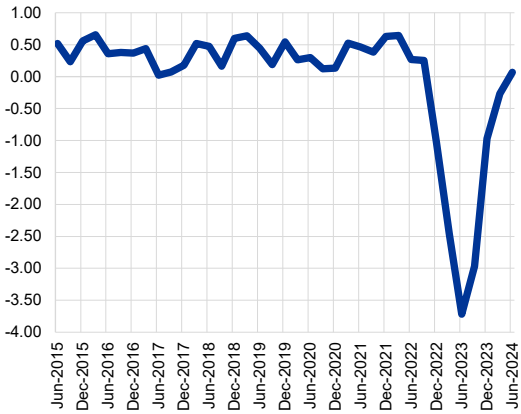
Short-term interest rate volatility (all entities)

- Definition: Average z-score of the realised 90-day standard deviation in Schatz volatility:

  BBSIS.D.I.ZST.ZI.EUR.S1311.B.A604.R005X.R.A.A._Z._Z.

- Dimension of funding liquidity covered: Redemption risk
- Scope: All entities
- Frequency: Quarterly
- Data source: Deutsche Bundesbank
- Type of data source: Market data
- Transformation into z-score: Relative to historical average
- Reason for inclusion: Volatility in the German Schatz relates to margining risk, as it reflects fluctuations in the value of a key asset used as collateral in repo markets and derivatives. When volatility rises, the value of Schatz bonds can change rapidly, triggering margin calls and requiring institutions to post additional collateral. High volatility in Schatz returns often coincides with periods of broader market stress or interest rate uncertainty, further increasing the risk of margin adjustments and liquidity pressures. For institutions that rely on the German Schatz for funding or hedging, higher return volatility directly translates into elevated margining risk.

Chart C.1.1
Change in short-term interest rate volatility (all entities), z-score, June 2015-June 2024

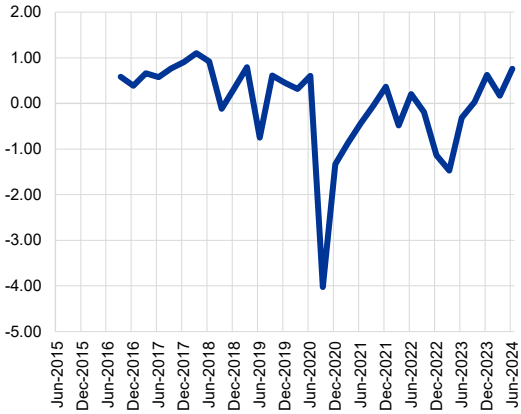


Source: Deutsche Bundesbank.

VIX index (all entities)

- Definition: Average z-score of the VIX index
- Dimension of funding liquidity covered: Margining risk
- Scope: All entities
- Frequency: Quarterly
- Data source: CBOE
- Type of data source: Market data
- Transformation into z-score: Relative to historical average
- Reason for inclusion: The VIX index is a measure of margining risk because it reflects market expectations of future volatility, which directly influence the value of collateral and the likelihood of margin calls. A rising VIX signals increased market uncertainty, tighter liquidity conditions and greater collateral requirements, all of which amplify the risk of margin calls. Institutions with leveraged positions or derivative exposures are particularly vulnerable to spikes in the VIX, as they may face sudden and significant demands for additional collateral, raising their overall margining risk.

Chart C.1.2
Change in VIX index (all entities), z-score, Sep. 2016-June 2024



Source: CBOE.

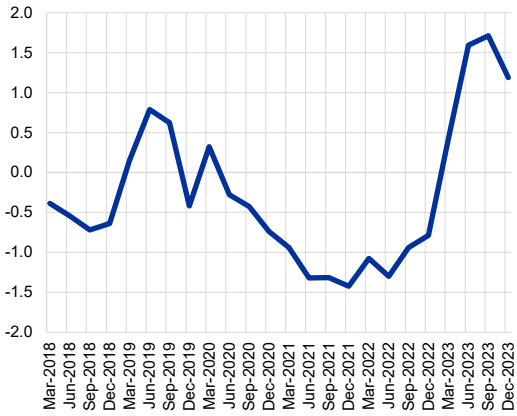
Market funding asset encumbrance

- Definition: The share of assets encumbered for market funding:

  (F_3204a_r0050_c0010 - F_3204a_r0060_c0010 + F_3204a_r0020_c0010) / F_3204a_r0170_c0010

- Dimension of funding liquidity covered: Margin risk
- Scope: Banks
- Frequency: Quarterly
- Data source: FINREP reporting
- Type of data source: Regulatory
- Transformation into z-score: Relative to historical average
- Reason for inclusion: The indicator measures banks' exposure to fluctuations in collateral value. The more collateral is encumbered for market funding, the lower the buffer available to compensate for depreciations in asset value. Higher values of the indicator signal exposure to margin risk.

Chart C.1.3
Change in market funding asset encumbrance ratio, z-score, Jan. 2018-Dec. 2023



Sources: FINREP and ECB calculations.

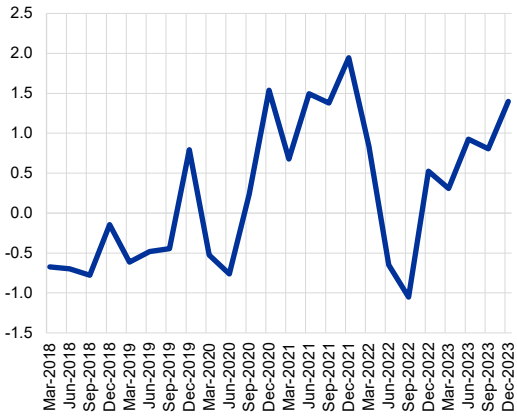
Leverage ratio

- Definition: The ratio of Tier 1 capital to total non-risk-weighted assets (regulatory reporting):

  C_4700_r0330_c0010

- Dimension of funding liquidity covered: Margin risk
- Scope: Banks
- Frequency: Quarterly
- Data source: COREP reporting
- Type of data source: Regulatory
- Transformation into z-score: Relative to historical average
- Reason for inclusion: The indicator measures the ability of banks to meet margin calls during market stress. A higher leverage ratio means that banks are better positioned to accommodate margin calls. Lower values signal exposure to margin risk.

Chart C.1.4
Change in leverage ratio, z-score, Jan. 2018-Dec. 2023



Sources: COREP and ECB calculations.

Liquidity leverage ratio

- Definition: Short-term liabilities as a share of liquid assets:

  (QSA.Q.N.I9.W0.S12K.S1.N.L.LE.F2M.T._Z.XDC._T.S.V.N._T+

  QSA.Q.N.I9.W0.S12K.S1.N.L.LE.F3.S._Z.XDC._T.S.V.N._`+

  QSA.Q.N.I9.W0.S12K.S1.N.L.LE.F89.T._Z.XDC._T.S.V.N._T-

  QSA.Q.N.I9.W2.S12K.S1M.N.L.LE.F2M.T._Z.XDC._T.S.V.N._T)/

  (QSA.Q.N.I9.W0.S12K.S1.N.A.LE.F21.T._Z.XDC._T.S.V.N._T+

  QSA.Q.N.I9.W0.S12K.S1.N.A.LE.F2M.T._Z.XDC._T.S.V.N._T+

  QSA.Q.N.I9.W0.S12K.S1.N.A.LE.F3.T._Z.XDC._T.S.V.N._T+

  QSA.Q.N.I9.W0.S12K.S1.N.A.LE.F4.S._Z.XDC._T.S.V.N._T-

  QSA.Q.N.I9.W0.S12K.S1.N.A.LE.F511._Z._Z.XDC._T.S.V.N._T-

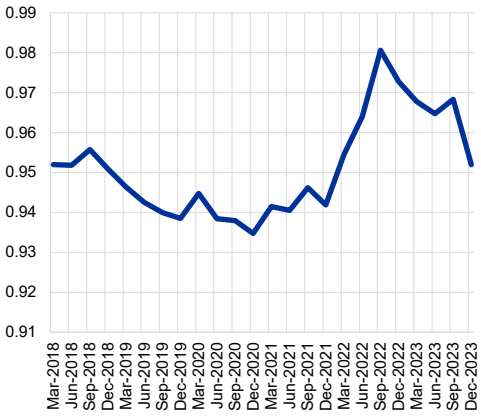
  QSA.Q.N.I9.W2.S12K.S12K.N.A.LE.F3.S._Z.XDC._T.S.V.N._T-

  QSA.Q.N.I9.W2.S12K.S12K.N.A.LE.F3.L._Z.XDC._T.S.V.N._T

- Dimension of funding liquidity covered: Margin risk
- Scope: Banks
- Frequency: Quarterly
- Data source: QSA
- Type of data source: Regulatory
- Transformation in z-score: Relative to historical average
- Reason for inclusion: The indicator measures whether banks hold sufficient liquid assets that can be swiftly liquidated to cover margin calls arising from short-term funding. Higher values of the indicator signal exposure to margin risk.

Chart C.1.5

Change in liquidity leverage ratio, z-score, Jan. 2018-Dec. 2023



Sources: QSA and ECB calculations.

LCR

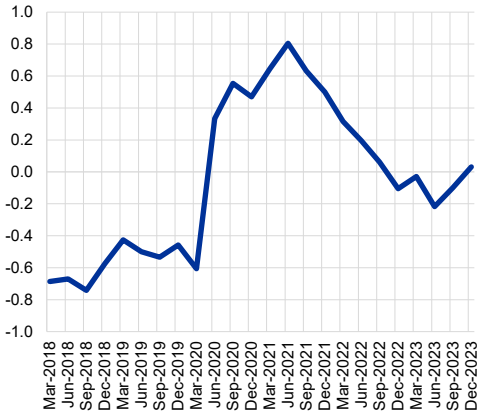
- Definition: High-quality liquid assets as a share of expected 30-day cash outflows during a stressed period (regulatory reporting):

  C_7600a_r0030_c0010

- Dimension of funding liquidity covered: Redemption risk
- Scope: Banks
- Frequency: Quarterly
- Data source: COREP reporting
- Transformation into z-score: Regulatory minimum of 100% + a buffer of 20%
- Type of data source: Regulatory
- Reason for inclusion: The indicator measures banks' resilience to a 30-day liquidity stress scenario. Lower values of the indicator signal exposure to redemption risk.

Chart C.1.6

Change in LCR, z-score, Jan. 2018-Dec. 2023



Sources: COREP and ECB calculations.

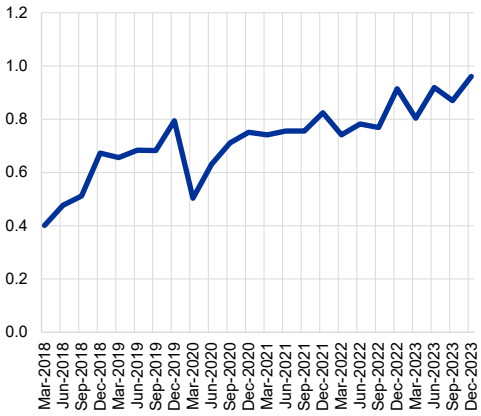
Contingent outflows to total assets

- Definition: Outflows from committed facilities with maturities of up to 30 days:

  (C_6601a_r1090_c0020 + C_6601a_r1090_c0030 +C_6601a_r1090_c0040 + C_6601a_r1090_c0050 +C_6601a_r1090_c0060 + C_6601a_r1090_c0070 +C_6601a_r1090_c0080 + C_6601a_r1090_c0090 +C_6601a_r1090_c0100 + C_6601a_r1090_c0110) / F_0101_r0380_c0010

- Dimension of funding liquidity covered: Redemption risk
- Scope: Banks
- Frequency: Quarterly
- Data source: COREP reporting
- Type of data source: Regulatory
- Transformation into z-score: Relative to historical average
- Reason for inclusion: The indicator measures expected contractual outflows due to committed facilities with maturities of up to 30 days. The indicator supplements the LCR assessment of banks' resilience to redemption risk by accounting for possible additional outflows. Higher values of the indicator signal exposure to redemption risk.

Chart C.1.7
Change in contingent outflows to total assets, z-score, Jan. 2018-Dec. 2023



Sources: COREP and ECB calculations.

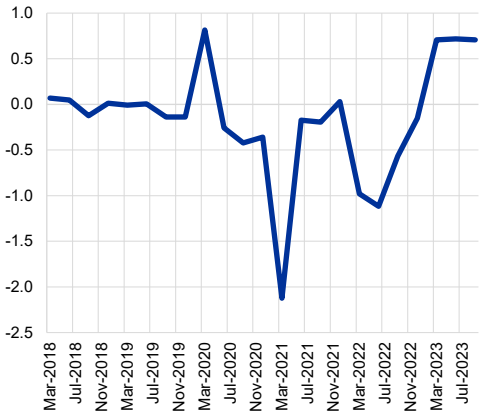
Counterbalancing capacity

- Definition: Net contractual gap as a share of stock of counterbalancing capacity with maturities of up to 30 days:

  (C_6601a_r0720_c0110 / C_6601a_r1080_c0110)

- Dimension of funding liquidity covered: Redemption risk
- Scope: Banks
- Frequency: Quarterly
- Data source: COREP reporting
- Type of data source: Regulatory
- Transformation into z-score: Relative to historical average
- Reason for inclusion: The indicator measures the share of cumulated net contractual gap with maturities of up to 30 days in the matching available stock of unencumbered assets. The indicator measures banks' resilience to redemption risk arising from contractual maturity mismatch between assets and liabilities. Lower values of the indicator signal exposure to redemption risk.

Chart C.1.8
Change in contingent outflows to total assets, z-score, Jan. 2018-Sep. 2023



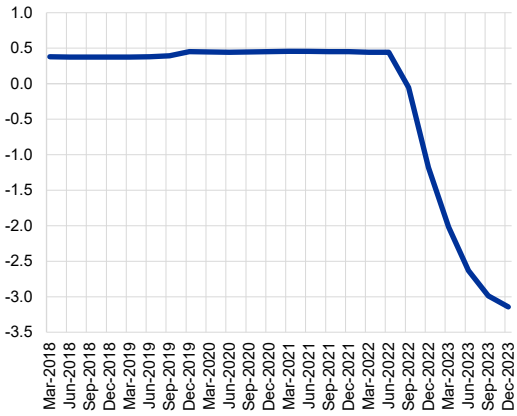
Sources: COREP and ECB calculations.

€STR-deposit rate spread

- Definition: Average differential between the rate on overnight household and NFC deposits and €STR
- Dimension of funding liquidity covered: Redemption risk
- Scope: Banks
- Frequency: Quarterly
- Data source: MFI interest rate statistics (MIR)
- Type of data source: Regulatory
- Transformation into z-score: Relative to historical average
- Reason for inclusion: The indicator measures the relative attractiveness of bank deposits versus MMFs. Lower values of the indicator signal exposure to deposit redemption risk.

Chart C.1.9

Change in €STR-deposit rate spreads, z-score, Jan. 2018-Dec. 2023



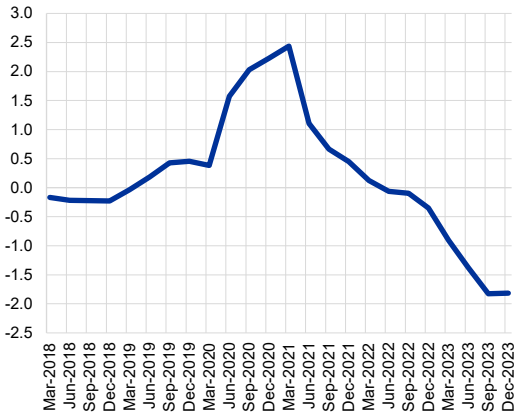
Sources: MIR and ECB calculations.

Deposit growth rate

- Definition: Average growth rate of household and NFC deposits
- Dimension of funding liquidity covered: Redemption risk
- Scope: Banks
- Frequency: Quarterly
- Data source: BSI
- Type of data source: Regulatory
- Transformation into z-score: Relative to historical average
- Reason for inclusion: The indicator measures realised changes in deposit stocks. Negative values of the indicator signal outflow of deposits and increased exposure to redemption risk.

Chart C.1.10

Change in deposit growth rate, z-score, Jan. 2018-Dec. 2023



Sources: BSI and ECB calculations.

Asset encumbrance ratio

- Definition: Encumbered assets as a share of unencumbered assets:

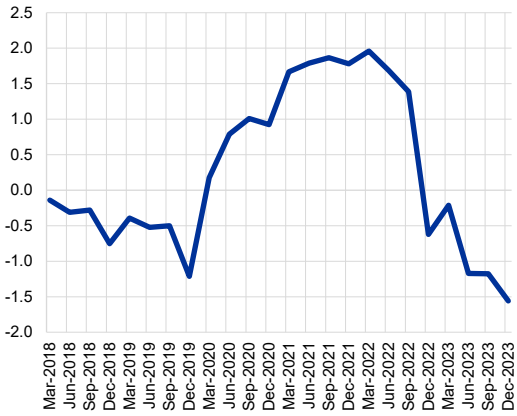
  (F_3201_r0010_c0010 + F_3202a_r0130_c0010) /

  (F_3201_r0010_c0010 + F_3201_r0010_c0060 + F_3202a_r0130_c0010 + F_3202a_r0130_c0040)

- Dimension of funding liquidity covered: Rollover risk
- Scope: Banks
- Frequency: Quarterly
- Data source: FINREP
- Type of data source: Regulatory
- Transformation into z-score: Relative to historical average
- Reason for inclusion: The indicator measures the share of assets pledged as collateral divided by total asset holdings. Higher values of the indicator signal increased exposure to rollover risk.

Chart C.1.11

Change in asset encumbrance ratio, z-score, Jan. 2018-Dec. 2023



Sources: FINREP and ECB calculations.

Short-term wholesale funding

- Definition: Wholesale funding with maturities of up to 30 days as a share of total funding:

  Short-term wholesale funding = (Short-term funding - Short-term retail funding) / Total funding

  Total funding = (C_6900a_r0010_c0020+ +C_6900a_r0010_c0040 +C_6900a_r0010_c0060 +C_6900a_r0010_c0080 +C_6900a_r0010_c0100 +C_6900a_r0010_c0120 +C_6900a_r0010_c0140 +C_6900a_r0010_c0160 + C_6900a_r0010_c0180)

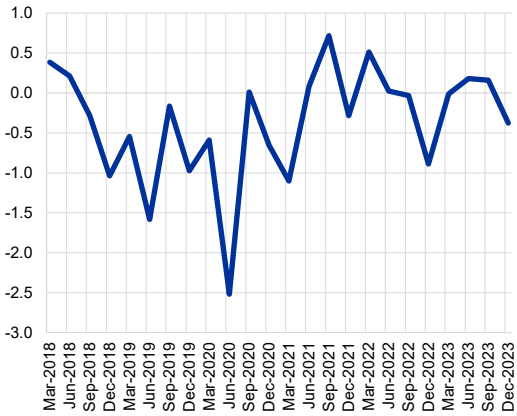
  Short-term retail funding = (C_6900a_r0020_c0020 + C_6900a_r0020_c0040 + C_6900a_r0020_c0060)

  Short-term funding = (C_6900a_r0010_c0020 + C_6900a_r0010_c0040 + C_6900a_r0010_c0060)

- Dimension of funding liquidity covered: Rollover risk
- Scope: Banks
- Frequency: Quarterly
- Data source: COREP
- Type of data source: Regulatory
- Transformation into z-score: Relative to historical average
- Reason for inclusion: The indicator measures the reliance on short-term wholesale funding, which tends to be vulnerable to runs from wholesale creditors during crisis periods. Higher values of the indicator signal increased exposure to rollover risk.

Chart C.1.12

Change in short-term wholesale funding, z-score, Jan. 2018-Dec. 2023

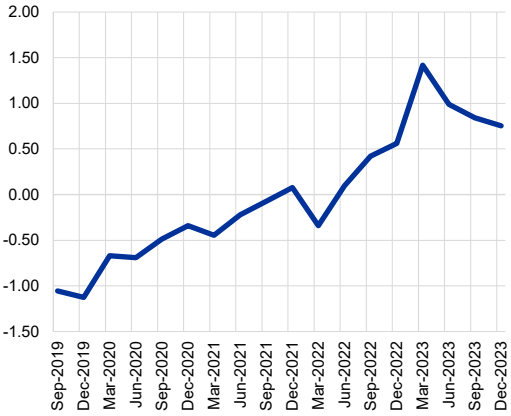


Sources: COREP and ECB calculations.

€STR conditions

- Definition: Average z-score of €STR volumes and the rate differential at the 25th and 75th percentile of the trading volume
- Dimension of funding liquidity covered: Rollover risk
- Scope: Banks
- Frequency: Daily
- Data source: ECB
- Type of data source: Regulatory data
- Transformation into z-score: Relative to historical average
- Reason for inclusion: The indicator measures the ease of access to overnight unsecured interbank borrowing. Lower trading volumes and/or higher interest rates could challenge the rollover of short-term funding. Higher values of the indicator signal increased exposure to rollover risk.

Chart C.1.13
Change in €STR conditions, z-score, Sep. 2019-Dec. 2023

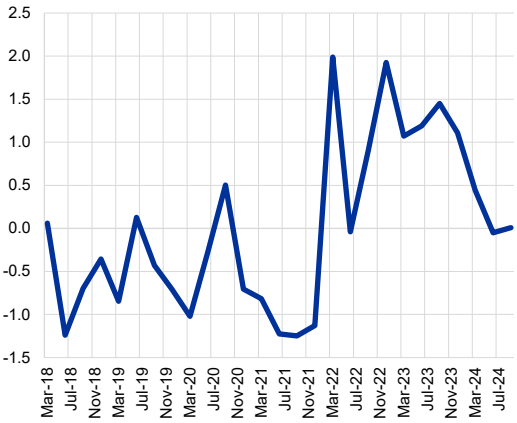


Sources: ECB and ECB calculations.

Average funding costs

- Definition: Average z-spread on euro-denominated covered, senior preferred and senior bail-inable bonds
- Dimension of funding liquidity covered: Redemption risk
- Scope: Banks
- Frequency: Quarterly
- Data source: S&P Down Jones Indices LLC and/or its affiliates
- Type of data source: Market data
- Transformation into z-score: Relative to historical average
- Reason for inclusion: The indicator measures the reliance on short-term wholesale funding, which tends to be vulnerable to runs from wholesale creditors during crisis periods. Higher values of the indicator signal increased exposure to rollover risk.

Chart C.1.14
Change in average funding cost, z-score, Jan. 2018-Sep. 2024



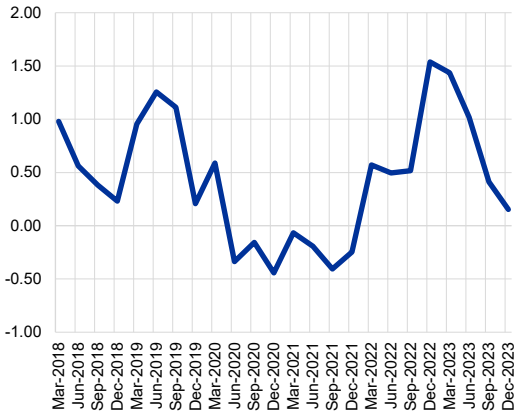
Sources: S&P Down Jones Indices LLC and/or its affiliatesand ECB calculations.

Repo market conditions

- Definition: Average z-score of banks' repo trading volumes and volume-weighted repo rates on bilateral transactions using government bonds as collateral
- Dimension of funding liquidity covered: Rollover risk
- Scope: Banks
- Frequency: Daily
- Data source: MMSR
- Type of data source: Regulatory data
- Transformation into z-score: Relative to historical average
- Reason for inclusion: The indicator measures the ease of access to overnight collateralised market borrowing. Lower trading volumes and/or higher interest rates could challenge the rollover of short-term funding. Higher values of the indicator signal increased exposure to rollover risk.

Chart C.1.15

Change in repo market conditions, z-score, Jan. 2018-Dec. 2023



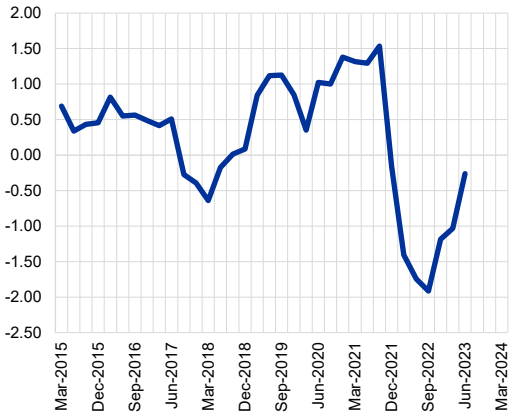
Sources: MMSR and ECB calculations.

Weighted average maturity (MMFs)

- Definition: Z-score of the weighted average maturity. The weighted average maturity is the average length of time to legal maturity or, if shorter, to the next interest rate reset of a money market rate, of all of the underlying assets in MMF portfolios. See **ESMA (2023)** for further details.
- Dimension of funding liquidity covered: Redemption risk
- Scope: MMFs
- Frequency: Quarterly
- Data source: Fitch Ratings
- Type of data source: Commercial data
- Transformation into z-score: Relative to historical average
- Reason for inclusion: The indicator measures sensitivity to interest rates. Lower values indicate that MMFs are reducing the maturity of their portfolio.

Chart C.1.16

Change in weighted average maturity (MMFs), z-score, March 2015-June 2023

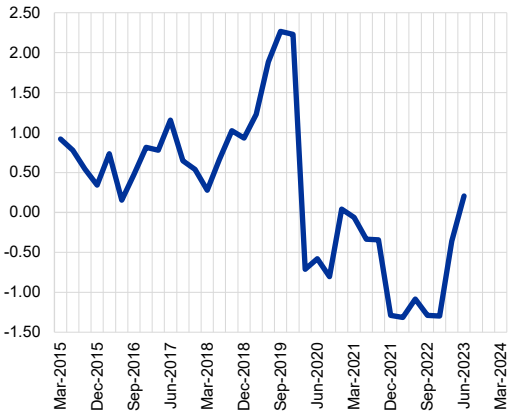


Source: Fitch Ratings.

Weighted average life (MMFs)

- Definition: Z-score of the weighted average life. The weighted average life is the average length of time to legal maturity of all of the underlying assets in MMF portfolios. See **ESMA (2023)** for further details.
- Dimension of funding liquidity covered: Redemption risk
- Scope: MMFs
- Frequency: Quarterly
- Data source: Fitch Ratings
- Type of data source: Commercial data
- Transformation into z-score: Relative to historical average
- Reason for inclusion: The indicator measures sensitivity to credit risk.

Chart C.1.17
Change in weighted average life (MMFs), z-score, March 2015-June 2023

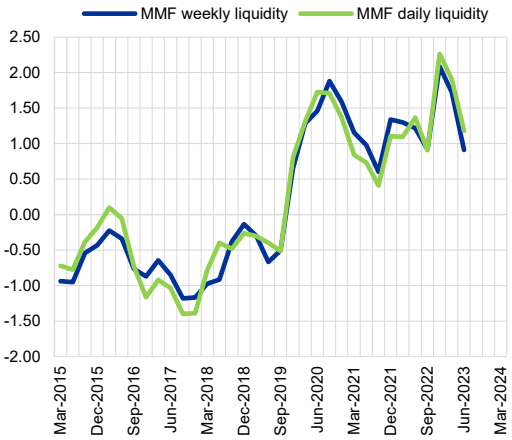


Source: Fitch Ratings.

Daily/Weekly liquidity (MMF)

- Definition: Z-score of daily and weekly liquid assets. MMFs are subject to daily and weekly liquid asset requirements. Daily liquid assets comprise assets such as cash, instruments maturing within one working day and reverse repos. Weekly liquid assets typically include assets such as cash, instruments maturing within one week and reverse repos. See **ESMA (2023)** for further details.
- Dimension of funding liquidity covered: Redemption risk
- Scope: MMFs
- Frequency: Quarterly
- Data source: Fitch Ratings
- Type of data source: Commercial data
- Transformation into z-score: Relative to historical average
- Reason for inclusion: The share of liquid assets measures the ability of MMFs to meet redemptions.

Chart C.1.18 and Chart C.19
Change in daily/weekly liquidity (MMFs), z-score, March 2015-June 2023

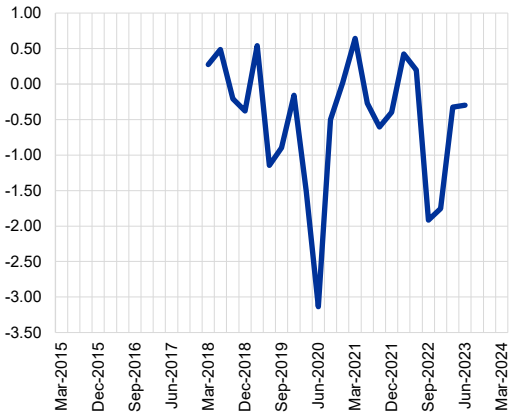


Source: Fitch Ratings.

Flows (MMFs)

- Definition: Z-score of net flows for European MMFs, as a percentage of NAV
- Dimension of funding liquidity covered: Redemption risk
- Scope: MMF
- Frequency: Daily
- Data source: EPFR
- Type of data source: Commercial database
- Transformation into z-score: Relative to historical average
- Reason for inclusion: The indicator measures net flows for MMFs. Negative values indicate high liquidity demands as investors redeem their MMF shares to obtain cash.

Chart C.1.20
Change in flows (MMFs), z-score, March 2018-June 2023



Source: EPFR.

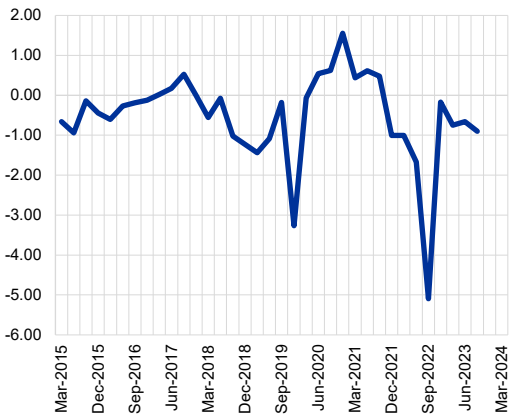
Total fund flows (investment funds incl. open-ended)

- Definition: Z-score based on monthly net issuance of investment fund shares. SDW: IVF.M.U2.N.T0.L30.A.0.Z5.0000.Z01.E,

  The indicator measures net flows, calculated as the difference between net issues and net redemptions for the entire investment fund sector (UCITS and AIFs).

- Dimension of funding liquidity covered: Redemption risk
- Scope: Investment funds
- Frequency: Monthly
- Data source: ECB, IVF statistics
- Type of data source: SDW
- Transformation into z-score: Relative to historical average
- Reason for inclusion: The indicator measures net share redemptions of total investment funds.

Chart C.1.21
Change in total fund flows (investment funds), z-score, March 2015-Sep. 2023



Sources: ECB and IVF.

Cross-sector correlation in fund flows (investment funds incl. open-ended)

- Definition: z-score based on the cross correlation in monthly net issuance of investment fund shares in equity, bond, mixed, real estate, hedge funds and other funds. SDW:

  IVF.M.U2.N.10.L30.A.0.Z5.0000.Z01.E,

  IVF.M.U2.N.20.L30.A.0.Z5.0000.Z01.E,

  IVF.M.U2.N.30.L30.A.0.Z5.0000.Z01.E,

  IVF.M.U2.N.30.L30.A.0.Z5.0000.Z01.E,

  IVF.M.U2.N.50.L30.A.0.Z5.0000.Z01.E,

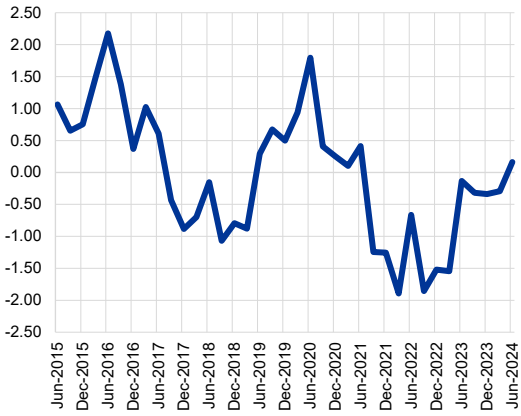
  IVF.M.U2.N.60.L30.A.0.Z5.0000.Z01.E,

  The cross correlation is calculated as follows:

  $\rho_t = \sqrt{FC_tF'}$ where F is the vector of the sub-sector flows on time t, C_t is the matrix of time-varying cross-correlation coefficients between all sub-sectors. The time-varying cross-correlations are estimated recursively on the basis of exponentially-weighted moving averages (EWMA) of respective covariances and volatilities with smoothing parameter λ=0.93. The method is similar as described in Lo Duca (**2012**).

- Dimension of funding liquidity covered: Redemption risk
- Scope: Total investment funds
- Frequency: Monthly
- Data source: ECB, IVF statistics
- Type of data source: SDW
- Transformation into z-score: Relative to historic average
- Reason for inclusion: The indicator measures synchronised flows in investment funds, thereby it captures the level of systemic flows.

Chart C.1.22
Evolution of cross-sector correlation in fund flows (investment funds), z-score, Jun 2015 – Jun 2024



Source: ECB, IVF.

Cash-to-assets (investment funds incl. open-ended)

- Definition: Z-score based on based on deposit and loan claims held by total investment funds in the euro area divided by the total assets held by total investment funds in the euro area.

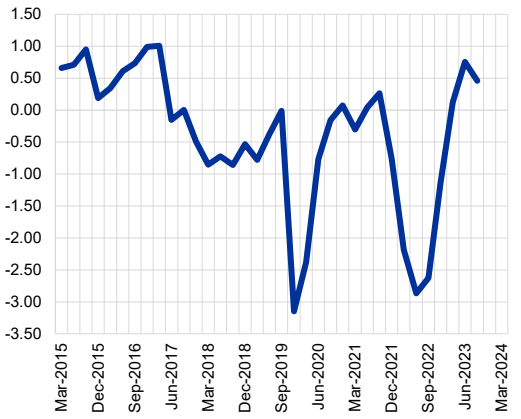
  Chart C.1.23 shows the cash defined as deposit and loan claims held: IVF.M.U2.N.T0.A20.A.1.Z5.0000.Z01.E

  as a share of assets:

  IVF.M.U2.N.T0.T00.A.1.Z5.0000.Z01.E

- Dimension of funding liquidity covered: Redemption risk
- Scope: Investment funds
- Frequency: Monthly
- Data source: ECB, IVF statistics
- Type of data source: SDW
- Transformation into z-score: Relative to historical average
- Reason for inclusion: The indicator measures the amount of cash at hand for investment funds. This can be used to meet redemptions without the need for procyclical selling behaviour, which lowers redemption risks.

Chart C.1.23
Change in cash-to-assets (investment funds), z-score, March 2015-Sep. 2023

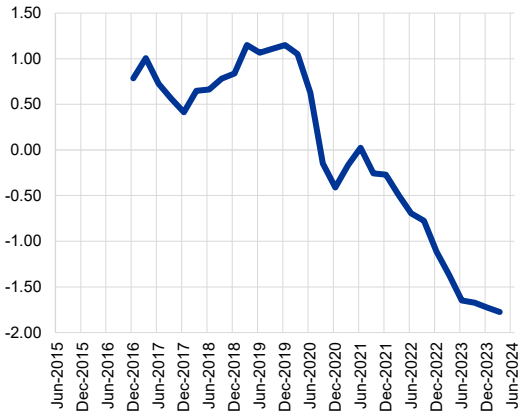


Sources: ECB and IVF.

Portfolio liquidity (investment funds incl. open-ended)

- Definition: Z-score based on the portfolio liquidity over a one-week horizon. Input values are the weighted average of individual fund values (weighted by NAV). AIFs report the portfolio liquidity profile as the percentage of an open-ended fund's portfolio that is capable of being liquidated within certain pre-defined periods (one day, one week and up to one year). See **ESMA (2024)** for further details. In our application we use the one-week horizon.
- Dimension of funding liquidity covered: Redemption risk
- Scope: Investment funds
- Frequency: Quarterly
- Data source: AIFMD
- Type of data source: Regulatory statistics
- Transformation into z-score: Relative to historical average
- Reason for inclusion: The indicator measures the estimated liquidity of assets held by AIFs. The lower this number, the higher the risk that an investment fund cannot meet redemptions.

Chart C.1.24
Change in portfolio liquidity, z-score, Dec. 2016-March 2024

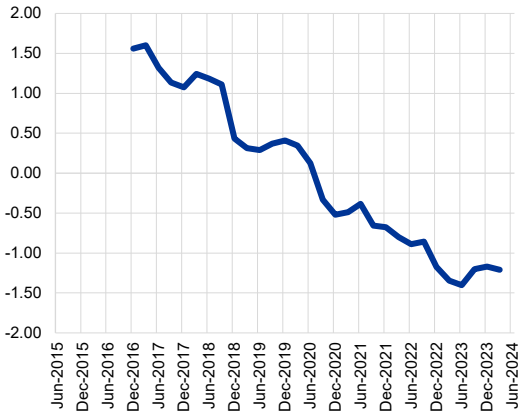


Source: AIFMD.

Investor liquidity (investment funds incl. open-ended)

- Definition: Z-score based on investor liquidity over a one-week horizon. Input values are the weighted average of individual fund values (weighted by NAV). AIFs report the investor liquidity profile as the percentage of an open-ended fund's NAV that can be redeemed by investors within certain pre-defined periods (one day, one week and up to one year). See **ESMA (2024)** for further details. In our application we use the one-week horizon.
- Dimension of funding liquidity covered: Redemption risk
- Scope: Investment funds
- Frequency: Quarterly
- Data source: AIFMD
- Type of data source: ESMA
- Transformation into z-score: Relative to historical average
- Reason for inclusion: The indicator measures the share of NAV that can be redeemed within a week. Negative values imply that the share of NAV that can be redeemed is below average: there is a lower risk of redemptions over one week.

Chart C.1.25
Change in investor liquidity (investment funds), z-score, Dec. 2016-March 2024

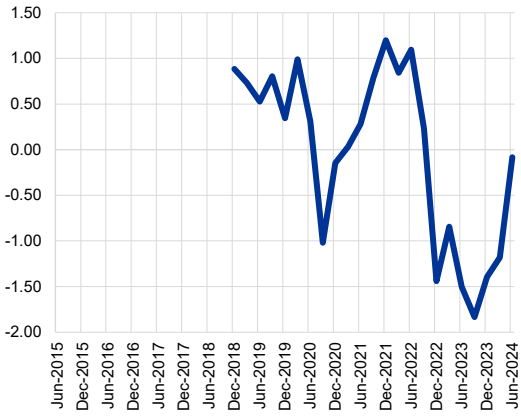


Source: ESMA.

Repo market conditions (investment funds incl. open-ended)

- Definition: Z-score based on the average historical z-score for the absolute repo-DFR spread and volumes for investment funds. The absolute repo-DFR spread is used for both negative and positive deviations from the DFR, i.e. collateral scarcity or credit risk. The repo market conditions indicator is then calculated as: $I = \frac{1}{2}\left(\frac{|repo_t - DFR_t| - \mu}{\sigma} + \frac{Volume - \mu}{\sigma}\right)$
- Dimension of funding liquidity covered: Redemption risk
- Scope: Investment funds
- Frequency: Daily
- Data source: MMSR
- Type of data source: Regulatory reporting
- Transformation into z-score: Relative to historical average
- Reason for inclusion: Repo market conditions are a measure of investment funds' redemption risk, because they directly affect a fund's ability to raise liquidity using its assets as collateral. Favourable repo market conditions reduce the need for forced asset sales, which helps funds to meet redemptions smoothly, while unfavourable conditions can heighten the risk of disruptive sales and impact investors.

Chart C.1.26
Change in repo market conditions (investment funds), z-score, Dec. 2018-June 2024

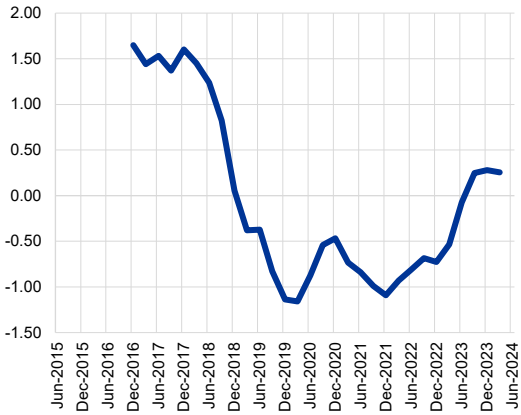


Source: MMSR.

Liquidity risk (investment funds incl. open-ended)

- Definition: Z-score based on the average historical z-score for the average of funds' weekly liquidity mismatch and weekly liquidity shortage for open-ended AIFs. **Liquidity mismatch** is the difference between portfolio and investor liquidity: positive values mean that the share of assets that can be liquidated over one week is above the share of NAV that can be redeemed. Liquidity mismatch allows compensation effects: a fund with excess liquidity can compensate for a fund with a liquidity mismatch. **Liquidity shortage** addresses this bias. The liquidity shortage is equal to the sum of liquidity mismatches (only for funds with negative values) divided by the total NAV of the AIF sector. See **ESMA (2024)** for further details.
- Dimension of funding liquidity covered: Redemption risk
- Scope: Investment funds
- Frequency: Quarterly
- Data source: AIFMD
- Type of data source: Regulatory reporting
- Transformation into z-score: Relative to historical average
- Reason for inclusion: Both indicators capture liquidity transformation risks for AIFs.

Chart C.1.27
Change in liquidity risk (investment funds), z-score, Dec. 2016-March 2024



Source: AIFMD.

Total fund flows, open-ended

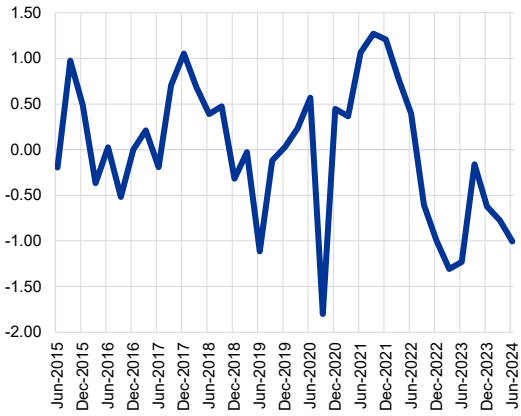
- Definition: Z-score based on monthly net issuance of investment fund shares:

  SDW: IVF.M.U2.N.TA.L30.A.0.Z5.0000.Z01.E,

  The indicator measures net flows, calculated as the difference between net issues and net redemptions for the entire investment fund sector (UCITS and AIFs).

- Dimension of funding liquidity covered: Redemption risk
- Scope: Open-ended investment funds
- Frequency: Monthly
- Data source: ECB, IVF statistics
- Type of data source: SDW
- Transformation into z-score: Relative to historical average
- Reason for inclusion: The indicator measures net share redemptions of total investment funds.

Chart C.1.28
Change in total fund flows (investment funds), z-score, June 2015-June 2024



Sources: ECB and IVF.

Cross-sector correlation in open-ended fund flows

- Definition: Z-score based on the cross-correlation in monthly net issuance of investment fund shares in equity, bond, mixed, real estate, hedge funds and other funds. SDW:

  IVF.M.U2.N.1A.L30.A.0.Z5.0000.Z01.E,

  IVF.M.U2.N.2A.L30.A.0.Z5.0000.Z01.E,

  IVF.M.U2.N.3A.L30.A.0.Z5.0000.Z01.E,

  IVF.M.U2.N.3A.L30.A.0.Z5.0000.Z01.E,

  IVF.M.U2.N.5A.L30.A.0.Z5.0000.Z01.E,

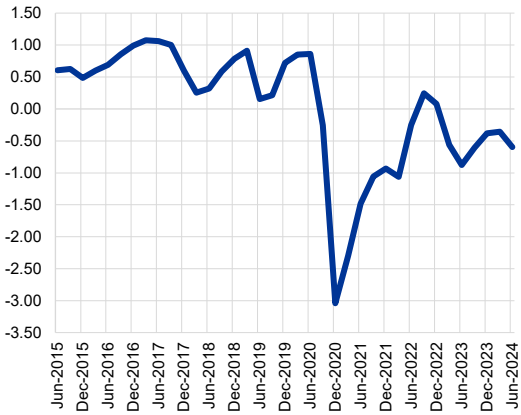
  IVF.M.U2.N.6A.L30.A.0.Z5.0000.Z01.E,

  The cross-correlation is calculated as follows:

  $\rho_t = \sqrt{FC_tF'}$ where F is the vector of the sub-sector flows on time t, and C_t is the matrix of time-varying cross-correlation coefficients between all sub-sectors. The time-varying cross-correlations are estimated recursively on the basis of exponentially weighted moving averages of respective covariances and volatilities with smoothing parameter λ=0.93. The method is similar to that described in Holló et al. (2012).

- Dimension of funding liquidity covered: Redemption risk
- Scope: Investment funds
- Frequency: Monthly
- Data source: ECB, IVF statistics
- Type of data source: SDW
- Transformation into z-score: Relative to historical average
- Reason for inclusion: The indicator measures synchronised flows in investment funds and therefore captures the level of systemic flows.

Chart C.1.29
Change in cross-sector correlation in fund flows (investment funds), z-score, June 2015-June 2024



Sources: ECB and IVF.

Cash-to-assets in open-ended funds

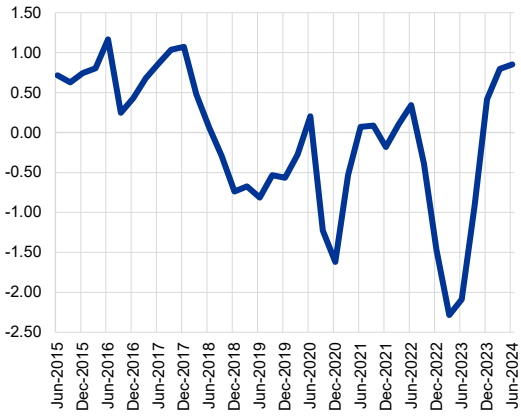
- Definition: Z-score based on deposit and loan claims held by open-end funds in the euro area divided by the total assets held by open-end funds in the euro area.

  Cash is defined as deposit and loan claims: IVF.M.U2.N.TA.A20.A.1.Z5.0000.Z01.E and total assets:

  IVF.M.U2.N.TA.T00.A.1.Z5.0000.Z01.E

- Dimension of funding liquidity covered: Redemption risk
- Scope: Investment funds
- Frequency: Monthly
- Data source: ECB, IVF statistics
- Type of data source: SDW
- Transformation into z-score: Relative to historical average
- Reason for inclusion: The indicator measures the amount of cash at hand for investment funds. This cash can be used to meet redemptions without the need for procyclical selling behaviour, which lowers redemption risks.

Chart C.1.30
Change in cash-to-assets (investment funds), z-score, March 2015-June 2024



Sources: ECB and IVF.

Cash to total assets (insurance corporations)

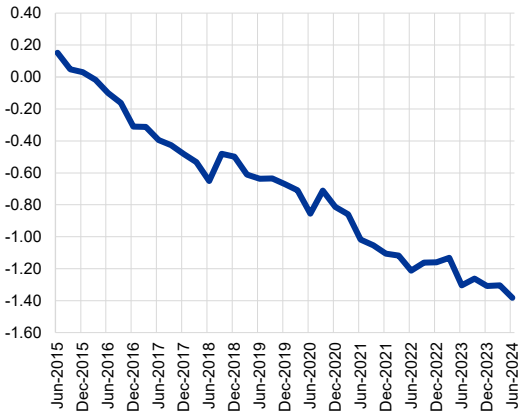
- Definition: Z-score based on the average historical observations of the ratio of cash to total assets.

  Cash: ICB.Q.U2.X.S128.A10.T.1.W0.S1._T.EUR

  Assets: ICB.Q.U2.X.S128.T00.T.1.W0.S1._T.EUR

- Dimension of funding liquidity covered: Margining risk
- Scope: Insurance corporations
- Frequency: Quarterly
- Data source: SDW
- Type of data source: Regulatory reporting
- Transformation into z-score: Relative to historical average
- Reason for inclusion: Cash is immediate liquidity to meet margins calls at insurance corporations. It reflects the company's ability to meet margin calls on its derivative positions without resorting to the forced sale of illiquid assets or borrowing under potentially unfavourable conditions. A higher ratio provides a cushion of liquidity, reducing the risk of financial distress during times of market volatility, when margin calls are more likely to occur.

Chart C.1.31
Change in cash to total assets (insurance corporations), z-score, June 2015-June 2024



Source: SDW.

Derivatives to total assets (insurance corporations)

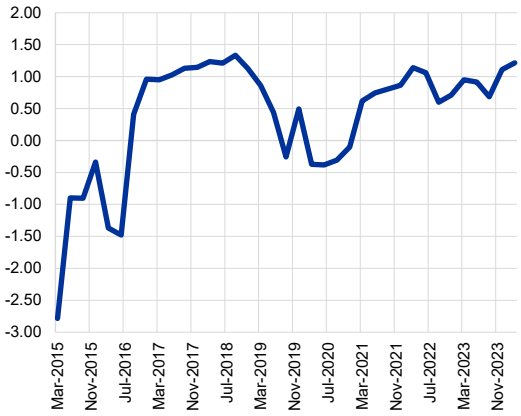
- Definition: Z-score based on the average historical observations for the ratio of cash to total assets.

  Derivatives: ICB.Q.U2.X.S128.A70.T.1.W0.S1._T.EUR

  Assets: ICB.Q.U2.X.S128.T00.T.1.W0.S1._T.EUR

- Dimension of funding liquidity covered: Margining risk
- Scope: Insurance corporations
- Frequency: Quarterly
- Data source: SDW
- Type of data source: Regulatory reporting
- Transformation into z-score: Relative to historical average
- Reason for inclusion: Reflects the extent of an institution's exposure to derivative contracts relative to its total asset base. A higher ratio means greater potential for margin calls and increased sensitivity to market volatility. This metric therefore gives an insight into how vulnerable an institution might be to sudden margining calls due to its derivative positions.

Chart C.1.32
Change in derivatives to total assets (insurance corporations), z-score, March 2015-March 2024

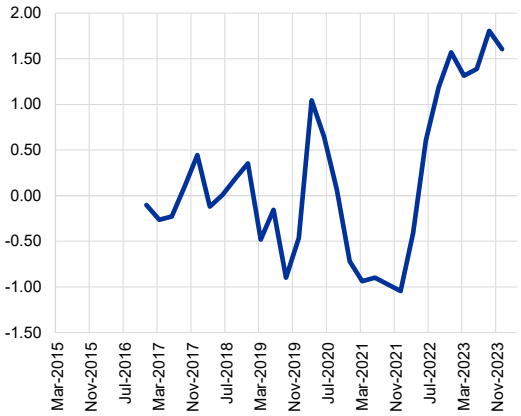


Source: SDW.

Duration (insurance corporations)

- Definition: Z-score based on the average historical z-score: LIG.Q.D0.T.WA00.TO.Y
- Dimension of funding liquidity covered: Margining risk
- Scope: Insurance corporations
- Frequency: Quarterly
- Data source: SDW, Solvency II
- Type of data source: Regulatory reporting
- Transformation into z-score: Relative to historical average
- Reason for inclusion: Reflects how sensitive an institution's assets are to changes in interest rates, which can directly affect the value of collateral backing derivative positions. The higher the duration, the more significant the potential fluctuations in asset value, leading to larger and more frequent margin calls in volatile markets.

Chart C.1.33
Change in duration (insurance corporations), z-score, Dec. 2016-Dec. 2023

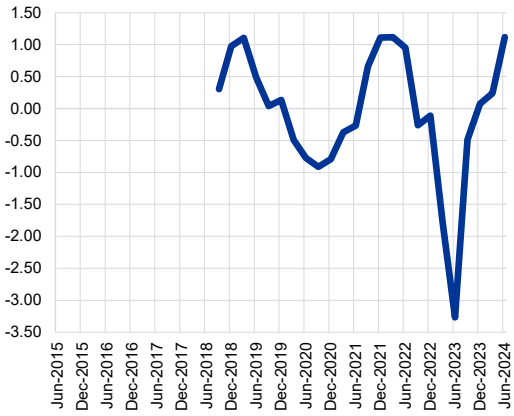


Source: Solvency II reporting.

Repo-DFR spread (insurance corporations)

- Definition: The absolute repo-DFR spread is used for both negative and positive deviations from the DFR, i.e. collateral scarcity or credit risk. The repo indicator is then calculated as: $I_t = \left(\frac{|repo_t - DFR_t| - \mu}{\sigma}\right)$
- Dimension of funding liquidity covered: Margining risk
- Scope: Insurance corporations
- Frequency: Quarterly
- Data source: MMSR
- Type of data source: Regulatory reporting
- Transformation into z-score: Relative to historical average
- Reason for inclusion: Reflects the cost and availability of short-term liquidity relative to a central bank benchmark. A widening spread signals market stress, higher borrowing costs and greater difficulty in accessing liquidity, which heightens the risk that an insurance corporation may struggle to meet margin calls on its derivative positions.

Chart C.1.34
Change in repo-DFR spread (insurance corporations), z-score, Sep. 2018-June 2024



Source: MMSR.

Asset concentration (insurance corporations)

- Definition: Z-score based on the average historical Herfindahl index for asset holdings broken down into various asset classes in insurance corporations:

  QSA.Q.N.I9.W0.S128.S1.N.A.LE.F2.T._Z.XDC._T.S.V.N._T, QSA.Q.N.I9.W0.S128.S1.N.A.LE.F3.T._Z.XDC._T.S.V.N._T,

  QSA.Q.N.I9.W0.S128.S1.N.A.LE.F4.T._Z.XDC._T.S.V.N._T,

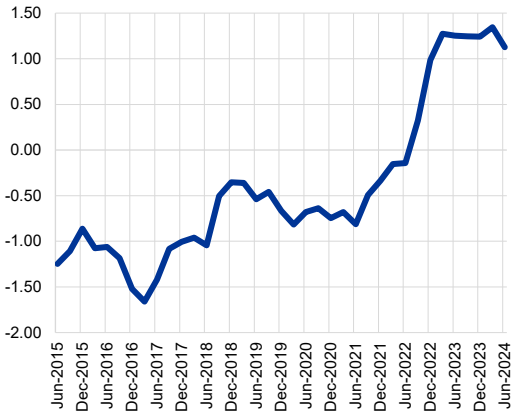
  QSA.Q.N.I9.W0.S128.S1.N.A.LE.F521._Z._Z.XDC._T.S.V.N._T,

  QSA.Q.N.I9.W0.S128.S1.N.A.LE.F522._Z._Z.XDC._T.S.V.N._T,

  QSA.Q.N.I9.W0.S128.S1.N.A.LE.F51._Z._Z.XDC._T.S.V.N._T,

- Dimension of funding liquidity covered: Redemption risk
- Scope: Insurance corporations
- Frequency: Quarterly
- Data source: QSA
- Type of data source: Regulatory reporting
- Transformation into z-score: Relative to historical average
- Reason for inclusion: A high asset concentration increases the risk that an insurer will struggle to raise sufficient cash when needed, due to either illiquidity or unfavourable market conditions. This can result in fire sales, losses and even solvency concerns, all of which amplify redemption risk.

Chart C.1.35
Change in asset concentration (insurance corporations), z-score, June 2015-June 2024



Source: QSA.

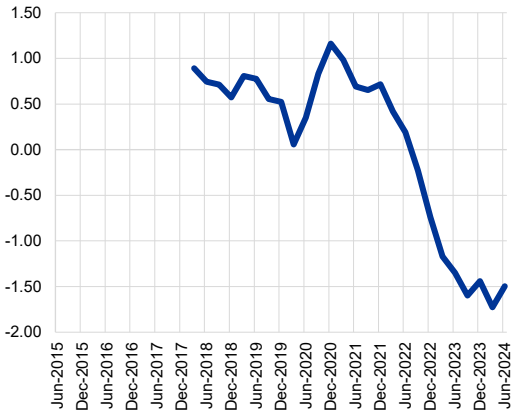
Asset liquidity (insurance corporations)

- Definition: Z-score based on the average historical asset liquidity:

  LIG.Q.D0.T.ALR.ME.F

- Dimension of funding liquidity covered: Redemption risk
- Scope: Insurance corporations
- Frequency: Quarterly
- Data source: SDW, Solvency II
- Type of data source: Regulatory reporting
- Transformation into z-score: Relative to historical average
- Reason for inclusion: Asset liquidity at insurance corporations is related to redemption risk because the more liquid the assets, the easier it is for the company to convert those assets into cash to meet claims, policyholder surrenders or other liabilities. If the company holds illiquid assets, it may struggle to raise cash quickly during periods of stress, which could potentially lead to fire sales. Maintaining a sufficient level of liquid assets therefore reduces redemption risk and ensures that the company can meet its obligations even under adverse conditions.

Chart C.1.36
Change in asset liquidity (insurance corporations), z-score, March 2018-June 2024



Source: SDW Solvency II reporting.

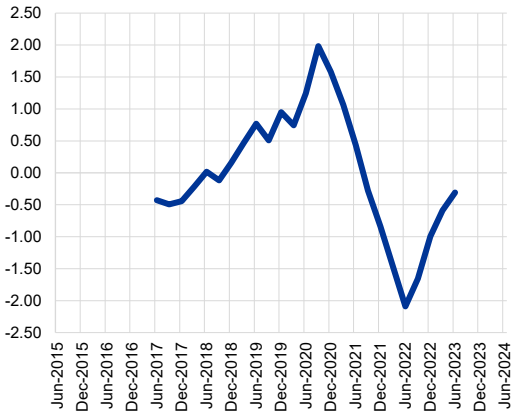
Duration mismatch (insurance corporations)

- Definition: Z-score based on the average historical duration mismatch:

  LIG.Q.D0.T.WA00.TO.Y-LIG.A.D0.T.WL00.TO.Y

- Dimension of funding liquidity covered: Redemption risk
- Scope: Insurance corporations
- Frequency: Quarterly
- Data source: SDW
- Type of data source: Regulatory reporting
- Transformation into z-score: Relative to historical average
- Reason for inclusion: A high duration mismatch creates a potential timing gap between the cash flows from the insurer's assets and the timing of its liabilities. If assets are longer in duration than liabilities, the insurer may face liquidity shortfalls when it needs to pay policyholder claims, surrenders or other liabilities. This mismatch can result in forced asset sales, potential losses and liquidity stress, all of which increase redemption risk, especially during periods of market volatility or rising interest rates.

Chart C.1.37
Change in duration mismatch (insurance corporations), z-score, June 2017-June 2023



Source: SDW.

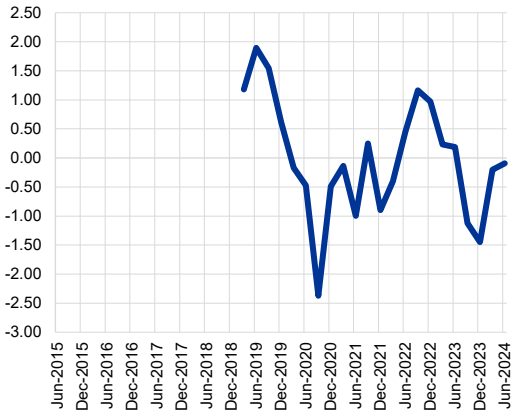
Lapse rate (insurance corporations)

- Definition: Z-score based on the average historical lapse rate (year-on-year change):

  LIG.Q.D0.L.X00.ME.F

- Dimension of funding liquidity covered: Redemption risk
- Scope: Insurance corporations
- Frequency: Quarterly
- Data source: SDW, Solvency II
- Type of data source: Regulatory reporting
- Transformation into z-score: Relative to historical average
- Reason for inclusion: A high lapse rate increases redemption risk at insurance corporations, because it forces the company to make unexpected and often large cash payouts to policyholders who surrender their policies. This creates significant liquidity demands which, if the company's assets are not sufficiently liquid, can lead to forced asset sales, financial strain and increased vulnerability to market shocks. High lapse rates can also disrupt cash flows, investment strategies, and asset-liability matching, which further amplifies the risk of liquidity shortfalls and financial instability. Given that it provides a more direct measure of redemption risk, the lapse rate is preferred over the change in liquid assets indicator also used for insurance corporations.

Chart C.1.38
Change in lapse rate (insurance corporations), z-score, March 2019-June 2024



Source: SDW, Solvency II reporting.

Cash to total assets (pension funds)

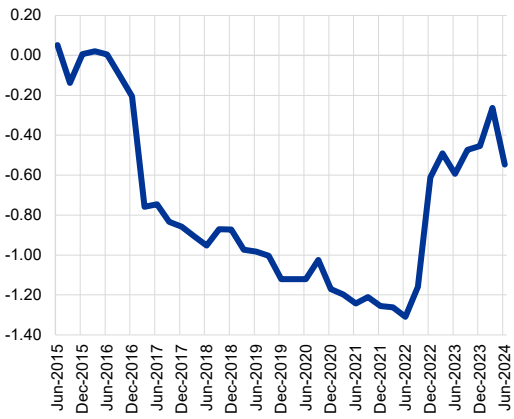
- Definition: Z-score based on the average historical z-score for the ratio of cash to total assets:

  Cash:PFBR.Q.U2.S.S129.A1N.T.1.W0.S1._T.EUR

  Assets:PFBR.Q.U2.S.S129.A00.T.1.W0.S1._T.EUR

- Dimension of funding liquidity covered: Margining risk
- Scope: Pension funds
- Frequency: Quarterly
- Data source: SDW
- Type of data source: Regulatory reporting
- Transformation into z-score: Relative to historical average
- Reason for inclusion: Cash is immediate liquidity for pension funds to meet margin calls. It reflects the company's ability to meet margin calls on its derivative positions without resorting to the forced sale of illiquid assets or borrowing under potentially unfavourable conditions. A higher ratio provides a cushion of liquidity, reducing the risk of financial distress during times of market volatility, when margin calls are more likely to occur.

Chart C.1.39
Change in cash to total assets (pension funds), z-score, June 2015-June 2024



Source: SDW.

Derivatives to total assets (pension funds)

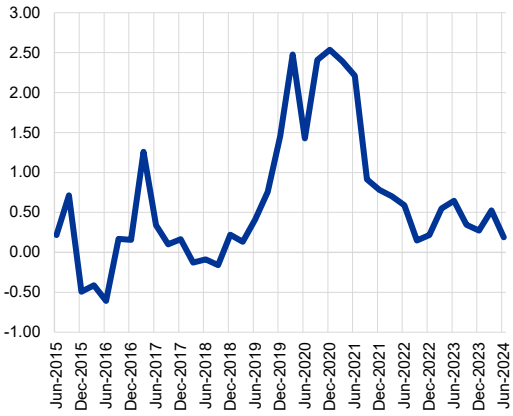
- Definition: Z-score based on the average historical z-score for the ratio of cash to total assets.

  Derivatives: PFBR.Q.U2.S.S129.A70.T.1.W0.S1._T.EUR

  Assets: PFBR.Q.U2.S.S129.A00.T.1.W0.S1._T.EUR

- Dimension of funding liquidity covered: Margining risk.
- Scope: Pension funds
- Frequency: Quarterly
- Data source: SDW
- Type of data source: Regulatory reporting
- Transformation into z-score: Relative to historical average
- Reason for inclusion: Reflects the extent of an institution's exposure to derivative contracts relative to its total asset base. A higher ratio means greater potential for margin calls and increased sensitivity to market volatility. This metric therefore gives an insight into how vulnerable an institution might be to sudden margining calls due to its derivative positions.

Chart C.1.40
Change in derivatives to total assets (pension funds), z-score, June 2015-June 2024



Source: SDW.

Margin account estimate (pension funds)

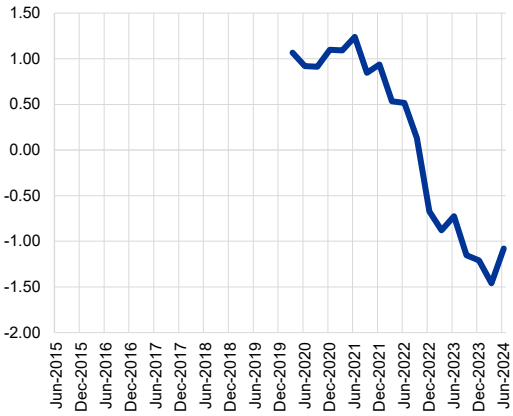
- Definition: Z-score based on the average historical z-score for the change in deposits liabilities, which include margin accounts. It is proxied by the sum of net values for:

  PFBR.Q.U2.S.S129.A1N.T.1.W0.S1._T.EUR

  PFBR.Q.U2.S.S129.L20.T.1.W0.S1._T.EUR

- Dimension of funding liquidity covered: Margining risk
- Scope: Pension funds
- Frequency: Quarterly
- Data source: SDW
- Type of data source: Regulatory reporting
- Transformation into z-score: Relative to historical average
- Reason for inclusion: Shows an approximation of the amount of margin in margin accounts and therefore reflects margin risk.

Chart C.1.41
Change in margin account estimate (pension funds), z-score, March 2020-June 2024

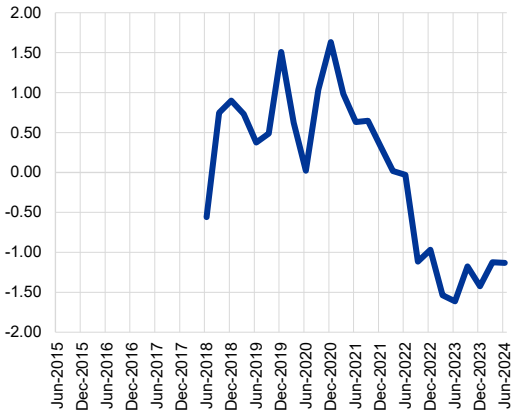


Source: SDW.

Net repo volume (pension funds)

- Definition: Z-score based on the average historical observations for the net volumes of repo transactions.
- Dimension of funding liquidity covered: Margining risk
- Scope: Pension funds
- Frequency: Quarterly
- Data source: MMSR
- Type of data source: Regulatory reporting
- Transformation into z-score: Relative to historical average
- Reason for inclusion: Pension funds are particularly reliant on repo market functioning to meet margin calls, as recent research shows.

Chart C.1.42
Change in net repo volume (pension funds), z-score, June 2018-June 2024



Source: MMSR.

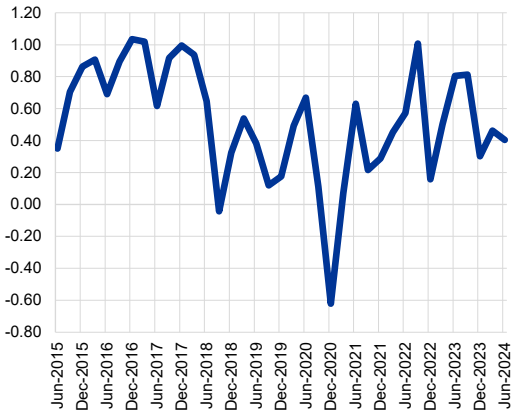
Repo transactions with MFIs (insurance corporations and pension funds)

- Definition: Z-score based on the average historical repo volumes with MFIs:

  BSI.M.U2.N.A.L24.A.1.U2.2220.Z01.E

- Dimension of funding liquidity covered: Margining risk
- Scope: Insurance Corporations and Pension funds
- Frequency: Quarterly
- Data source: SDW, BSI
- Type of data source: Regulatory reporting
- Transformation into z-score: Relative to historical average
- Reason for inclusion: Insurance corporations and pension funds usually engage in reverse repo transactions with MFIs, providing banks with liquidity. A higher level of repo transactions from insurance corporations and pension funds to MFIs therefore indicates that insurance corporations and pension funds are removing liquidity from the banking sector rather than providing this liquidity.

Chart C.1.43
Change in repo transactions with MFIs (insurance corporations and pension funds), z-score, June 2015-June 2024



Source: BSI.

Asset concentration (pension funds)

- Definition: Z-score based on the average historical Herfindahl index for asset holdings, broken down into various asset classes in pension funds:

  QSA.Q.N.I9.W0.S129.S1.N.A.LE.F2.T._Z.XDC._T.S.V.N._T,

  QSA.Q.N.I9.W0.S129.S1.N.A.LE.F3.T._Z.XDC._T.S.V.N._T,

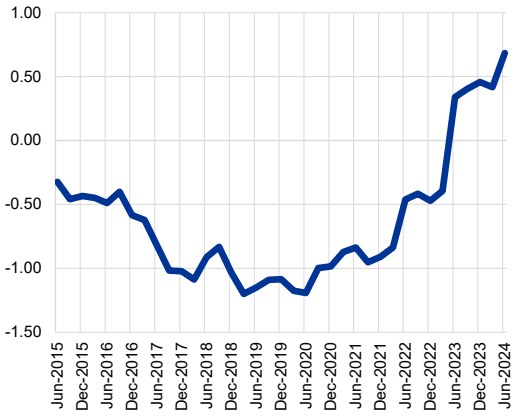
  QSA.Q.N.I9.W0.S129.S1.N.A.LE.F4.T._Z.XDC._T.S.V.N._T,

  QSA.Q.N.I9.W0.S129.S1.N.A.LE.F521._Z._Z.XDC._T.S.V.N._T,

  QSA.Q.N.I9.W0.S129.S1.N.A.LE.F522._Z._Z.XDC._T.S.V.N._T,
  QSA.Q.N.I9.W0.S129.S1.N.A.LE.F51._Z._Z.XDC._T.S.V.N._T

- Dimension of funding liquidity covered: Redemption risk
- Scope: Pension funds
- Frequency: Quarterly
- Data source: SDW
- Type of data source: Regulatory reporting
- Transformation into z-score: Relative to historical average
- Reason for inclusion: A high asset concentration increases the risk that a pension fund will struggle to raise sufficient cash when needed, due to either illiquidity or unfavourable market conditions. This can result in fire sales, losses and even solvency concerns, all of which amplify redemption risk.

Chart C.1.44
Change in asset concentration (pension funds), z-score, June 2015-June 2024



Source: SDW.

Change in liquid assets (pension funds)

- Definition: Z-score based on average historical mutation in financial asset holdings defined as the sum of equity, debt securities, MMFs and cash and cash equivalents at pension funds:

  Equity: PFBR.Q.U2.S.S129.A50.T.4.W0.S1._T.EUR

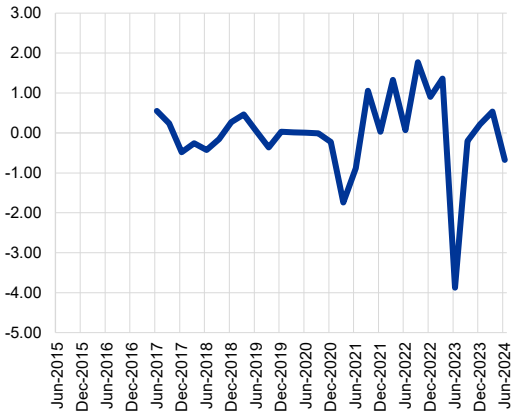
  Debt securities:
  PFBR.Q.U2.S.S129.A30.T.4.W0.S1._T.EUR

  Fund shares: PFBR.Q.U2.S.S129.A60.T.4.W0.S1._T.EUR

  Cash: PFBR.Q.U2.S.S129.A1N.T.4.W0.S1._T.EUR

- Dimension of funding liquidity covered: Redemption risk
- Scope: Pension funds
- Frequency: Quarterly
- Data source: SDW
- Type of data source: Regulatory reporting
- Transformation into z-score: Relative to historical average
- Reason for inclusion: Liquid assets provide the necessary cash to meet withdrawal demands and pension payouts. A decrease in liquid assets limits the fund's ability to quickly raise cash without selling illiquid assets at a loss, heightening redemption risk.

Chart C.1.45
Change in change in liquid assts (pension funds), z-score, June 2017-June 2024



Source: SDW.

2. Contagion and amplification indicators

- €STR conditions (see Chart C.1.13), average funding cost as the average z-spread on covered and senior bail-inable and senior unsecured debt (see Chart C.1.14), and Repo indicator (see Chart C.1.15), are classified in the “financing conditions bucket”.
- Asset concentration ratios for insurance corporations and pension funds (see Chart C.1.35 and Chart C.1.44), cross-sector correlation in open-ended fund flows (see Chart C.1.28), and the collateral reuse ratio are classified in the “interconnectedness bucket”.
- Duration (see Chart C.1.33), liquidity leverage (see Chart C.1.4), AIF leverage, Liquidity risk (see Chart C.1.27), and the Liquidity leverage ratio (see Chart C.1.5), are classified in the “leverage bucket”.
- Short-rate volatility (see Chart C.1.1), and the VIX index (see Chart C.1.2) are classified in the “volatility bucket”.

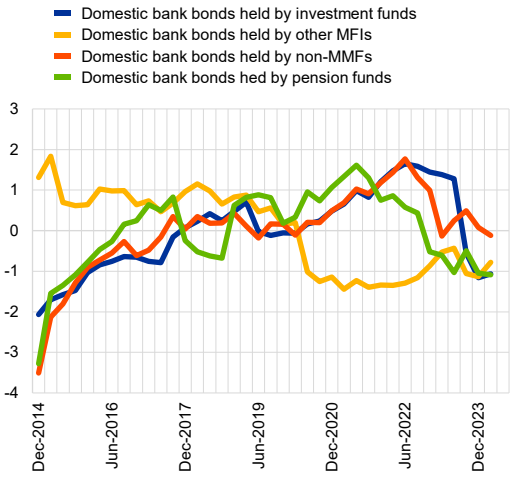
For more details on these indicators, see the “Funding liquidity” section.

Domestic bank bonds held by other domestic (non-)banks (all)

- Definition: Average z-score of the share in total assets allocated to holdings of domestic bank bonds
- Dimension of funding liquidity covered: Interconnectedness
- Scope: NBFIs and banks
- Frequency: Quarterly
- Data source: SHS
- Type of data source: Reporting
- Transformation into z-score: Relative to historical average
- Reason for inclusion: The indicator shows the potential for amplification.

Chart C.2.1

Change in the share of domestic bank bonds by other domestic (non-)banks (all), z-score, Dec. 2014-February 2024



Source: SHS.

Probability of default of two or more systemically important banks (all)

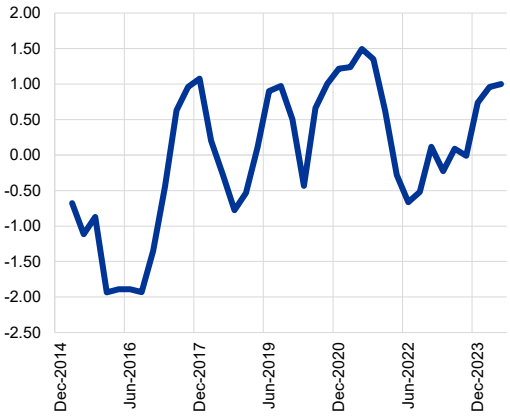
- Definition: Average z-score of the probability of default of two or more systemically important banks:

  RDF.D.D0.Z0Z.4F.EC.DFTLB.PR

  See **ECB (2012)**, Box 8.

- Dimension covered: Interconnectedness
- Scope: Banks
- Frequency: Daily
- Data source: SDW
- Type of data source: Market data
- Transformation into z-score: Relative to historical average
- Reason for inclusion: The spread indicator gives an indication of systemic risk in the banking sector.

Chart C.2.2
Change in z-score, June 2015-June 2024

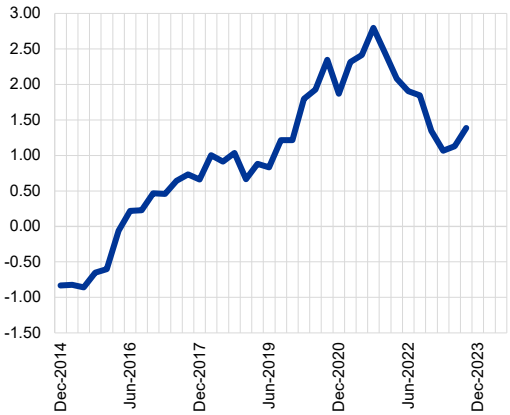


Source: SDW.

Portfolio similarity with the banking sector (all)

- Definition: Average z-score of the portfolio similarity indicator comparing portfolio weights (at individual ISIN levels) between institutional sectors. The indicator equals zero if the compared portfolios are identical (similar exposures to individual ISINs) and one if there are no common elements in them.
- Dimension of funding liquidity covered: Interconnectedness
- Scope: NBFIs and banks
- Frequency: Quarterly
- Data source: ESRB calculations
- Type of data source: Reporting
- Transformation into z-score: Relative to historical average
- Reason for inclusion: The indicator shows amplification potential across portfolio holdings.

Chart C.2.3
Change in portfolio similarity with the banking sector (all), z-score, Dec. 2014-June 2023



Source: ESRB calculations.

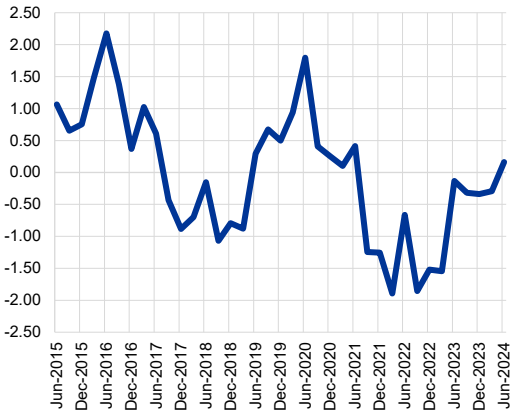
Collateral reuse ratio (Banks)

- Definition: z-score based on:

  (F32.02, R130, C010)/(F32.02,R130,C010 + F32.02, R130, C040)

- Dimension of funding liquidity covered: interconnectedness
- Scope: Banks
- Frequency: Monthly
- Data source: FINREP
- Type of data source: Regulatory
- Transformation in z-score: Relative to historic average
- Reason for inclusion: High levels of collateral re-use may pose systemic risks in at least three ways: Collateral re-use may (1) contribute to interconnectedness and higher risks of contagion; (2) contribute to the build-up of leverage; and (3) increase procyclicality in the financial sector.

Chart C.2.4
Change in collateral-reuse ratio, z-score, Jun 2015 – Jun 2024

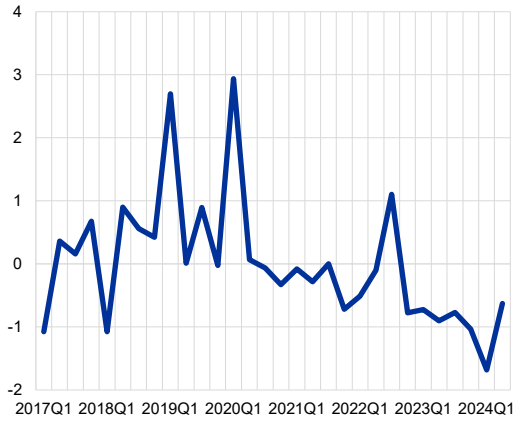


Source: FINREP.

Leverage (Alternative Investment Funds)

- Definition: Z-score based on gross leverage defined as the ratio of Assets under Management to NAV. See ESMA (2024) for further details.
- Dimension of contagion covered: Leverage risk.
- Scope: Investment funds
- Frequency: Quarterly
- Data source: AIFMD
- Type of data source: Regulatory reporting
- Transformation into z-score: Relative to historic average.
- Reason for inclusion: The use of leverage amplifies market movements and can lead to procyclical effects.

Chart C.2.5
Change in leverage risk (Alternative Investment funds), z-score, Mar 2017 – June 2024



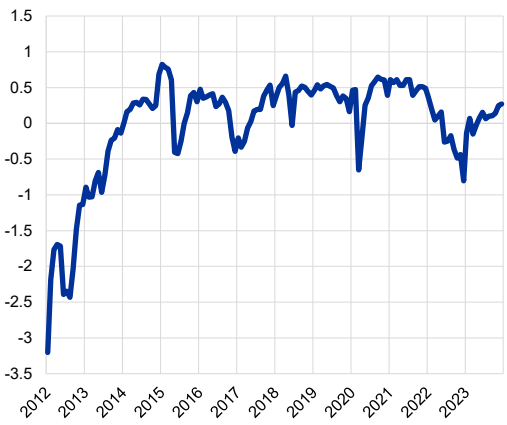
Source: AIFMD.

3. Market liquidity indicators

Bid-ask spread

- Definition: Difference between bid and ask prices as a percentage of mid-price. For sovereign/corporate bonds, a market value-weighted average on indicative bid and ask prices across all euro area sovereign/corporate bonds. For FX, a traded volume-weighted average of EUR/USD, EUR/JPY and EUR/GBP pairs (source for traded volume: BIS). For interest rate derivatives, based on the ten-year €STR swap and based on the EURIBOR swap using Roll's estimator.[49] For covered bonds, based on a simple average of bid-ask spreads on the three largest euro area covered bond ETFs (LSEG tickers: IUS6.DE, COVR.DE, R1JKEX.DE).
- Dimension of market liquidity covered: Tightness
- Scope: Sovereign bonds, FX, interest rate derivatives, corporate bonds, covered bonds
- Frequency: Up to tick basis on central limit order book markets; aggregated to daily market-weighted averages for some asset classes
- Data source: S&P iBoxx indices (sovereign bonds, corporate bonds), Bloomberg Finance L.P. (FX, interest rate derivatives), LSEG (covered bonds)
- Type of data source: Commercial
- Transformation into z-score: Relative to daily average since 2012; inverted
- Reason for inclusion: Bid-ask spreads are the most commonly used indicator for market liquidity and capture a price-based measure of how tight markets are. They are available across asset classes, but are not readily comparable across different types of securities due to different market structures (e.g. central limit order book vs over the counter).

Chart C.3.1
Change in bid-ask spread for sovereign bonds, z-score, Jan. 2012-Dec. 2023

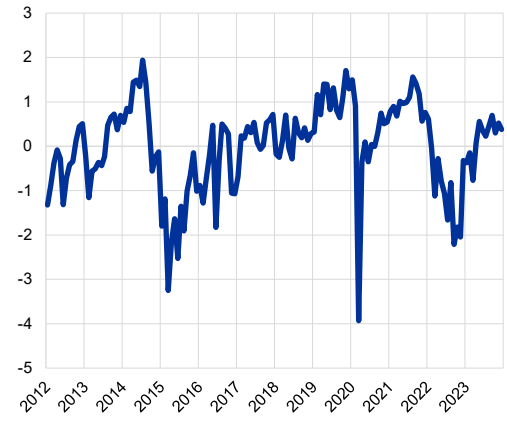


Sources: S&P Down Jones Indices LLC and/or its affiliates and ECB calculations.

High-low spread

- Definition: Difference between daily high and low prices as a percentage of mid-price. For sovereign/corporate bonds, a market value-weighted average on indicative bid and ask prices across all euro area sovereign/corporate bonds. For FX, a traded volume-weighted average of EUR/USD, EUR/JPY and EUR/GBP pairs (source for traded volume: BIS). For unsecured money market, based on €STR. For interest rate derivatives, based on the ten-year €STR swap.
- Dimension of market liquidity covered: Tightness
- Scope: Sovereign bonds, FX, unsecured money market, interest rate derivatives, corporate bonds
- Frequency: Daily; aggregated to monthly frequency with a simple average of daily observations
- Data source: S&P Down Jones Indices LLC and/or its affiliates (sovereign bonds, corporate bonds), Bloomberg Finance L.P. (FX, interest rate derivatives), ECB MMSR (unsecured money market)
- Type of data source: Commercial and public
- Transformation into z-score: Relative to daily average since 2012; inverted

Chart C.3.2
Change in high-low spreads in FX markets, z-score, Jan. 2012-Dec. 2023



[49] The methodology is described in Boudiaf et al. (2024).

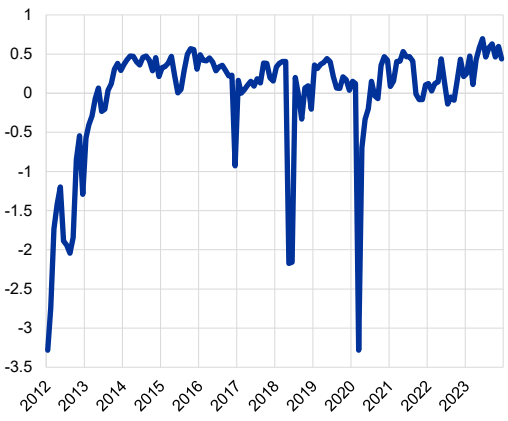
- Reason for inclusion: High-low spreads capture the tightness of a market on a given day and therefore measure one aspect of market liquidity. However, they also capture market volatility. High and low prices are often readily available and are therefore an alternative to bid-ask spreads when these are not available.

Sources: Bloomberg Finance L.P and ECB calculations.

Quote slope

- Definition: The ratio between the market value-weighted bid-ask spread and the sum of quoted quantities (on both bid and ask side)
- Dimension of market liquidity covered: Tightness and depth
- Scope: Sovereign bonds
- Frequency: Daily; aggregated to monthly frequency with a simple average of daily observations
- Data source: MTS
- Type of data source: Commercial
- Transformation into z-score: Relative to daily average since 2012; high value indicates low liquidity
- Reason for inclusion: Offers a richer way to look at bid-ask spreads, taking into account the relationship with quantities. However, only available for central limit order book markets.

Chart C.3.3
Change in quote slope of sovereign bonds, z-score, Jan. 2012-Dec. 2023



Sources: MTS and ECB calculations.

Number of market-makers/counterparties

- Definition: The number of official market-makers (sovereign and corporate bonds), the number of active banks (unsecured money market), and the number of active counterparties (interest rate derivatives)
- Dimension of market liquidity covered: Immediacy
- Scope: Sovereign bonds, unsecured money market, interest rate derivatives, corporate bonds
- Frequency: Daily; aggregated to monthly frequency with a simple average of daily observations
- Data source: Trax (sovereign bonds, corporate bonds), ECB MMSR (unsecured money market), EMIR (interest rate derivatives)
- Type of data source: Commercial and regulatory
- Transformation into z-score: Relative to daily average since 2013 (sovereign, corporate bonds), 2019 (unsecured money market) and 2018 (interest rate derivatives)
- Reason for inclusion: Market-makers provide two-way pricing and therefore offer immediacy to investors. The larger the number of market-makers, the more likely an investor is to be able to execute a trade immediately. More generally, the number of active banks/counterparties indicates the amount of potential buyers/sellers and therefore measures potential market liquidity.

Chart C.3.4
Change in number of market-makers for sovereign bonds, z-score, Sep. 2013-Dec. 2023

Sources: Trax and ECB calculations.

Trade frequency

- Definition: Number of trades
- Dimension of market liquidity covered: Immediacy
- Scope: Sovereign bonds, unsecured money market, interest rate derivatives, corporate bonds, covered bonds
- Frequency: Daily; aggregated to monthly frequency with a simple average of daily observations
- Data source: MTS (sovereign bonds), ECB MMSR (unsecured money market), Trax (corporate bonds), Bloomberg Finance L.P. (covered bonds)
- Type of data source: Commercial and regulatory
- Transformation into z-score: Relative to daily average since 2012 (sovereign and corporate bonds), since 2019 (unsecured money market), since 2018 (interest rate derivatives), and since 2015 (covered bonds)
- Reason for inclusion: The trade frequency indicates the level of activity in a given market, with a higher trade frequency generally indicating a more liquid market.

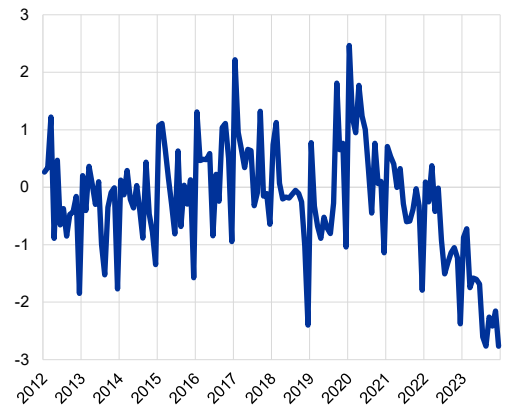
Chart C.3.5
Change in trade frequency in the €STR market, z-score, Oct. 2019-Dec. 2023

Source: S&P Down Jones Indices LLC and/or its affiliates and ECB calculations.

Trade size

- Definition: The average size of a trade over a given period
- Dimension of market liquidity covered: Immediacy
- Scope: Sovereign bonds, interest rate derivatives, corporate bonds
- Frequency: Daily; aggregated to monthly frequency with a simple average of daily observations
- Data source: Trax (sovereign bonds, corporate bonds), EMIR (interest rate derivatives)
- Type of data source: Commercial or regulatory
- Transformation into z-score: Relative to daily average since 2012 (sovereign and corporate bonds) and since 2018 (interest rate derivatives)
- Reason for inclusion: All else being equal, large trade sizes indicate a higher level of immediacy available to investors and therefore higher market liquidity. Trade sizes may also vary due to structural changes, e.g. electronification of markets.

Chart C.3.6
Change in trade size for corporate bonds, z-score, Jan. 2012-Dec. 2023

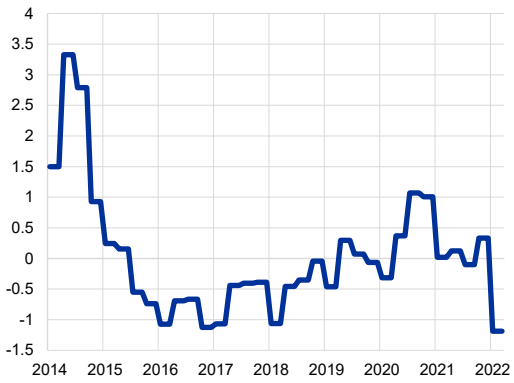


Sources: Trax and ECB calculations.

Dealer inventory

- Definition: Amount of securities (in EUR) held for trading by market-makers
- Dimension of market liquidity covered: Immediacy
- Scope: Sovereign bonds, corporate bonds
- Frequency: Quarterly
- Data source: ECB FINREP
- Type of data source: Regulatory
- Transformation into z-score: Relative to quarterly average since 2014
- Reason for inclusion: Measures the capacity of market-makers to accommodate temporary changes in market demand.

Chart C.3.7
Change in dealer inventory of corporate bonds, z-score, Oct. 2014-Dec. 2022

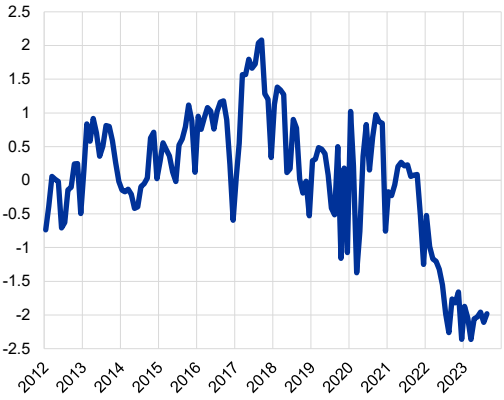


Source: ECB.

Quoted volume

- Definition: Sum of volumes quoted in an order book over a given period (first five levels on bid and ask side)
- Dimension of market liquidity covered: Depth
- Scope: Sovereign bonds
- Frequency: Up to tick basis; aggregated to daily sum
- Data source: MTS
- Type of data source: Commercial
- Transformation into z-score: Relative to daily average since 2012
- Reason for inclusion: Represents the amount that is transactable between buyers and sellers. This frequently used measure is often referred to as market depth.

Chart C.3.8
Change in quoted volume of sovereign bonds, z-score, Jan. 2012-Aug. 2023

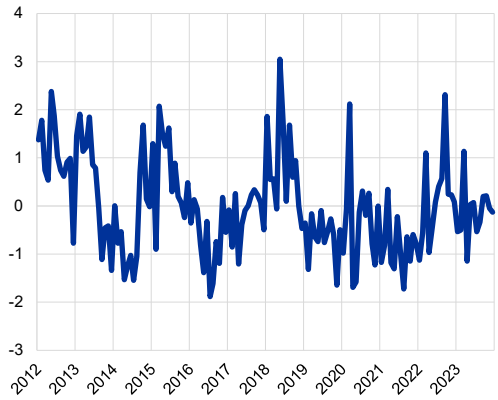


Sources: MTS and ECB calculations.

Traded volume

- Definition: Amount of securities (in EUR) traded over a given period
- Dimension of market liquidity covered: Depth
- Scope: Sovereign bonds, FX, unsecured money market, interest rate derivatives, corporate bonds, covered bonds
- Frequency: Up to tick basis on central limit order book markets; aggregated to daily sums
- Data source: Trax (sovereign bonds, corporate bonds), Bloomberg Finance L.P. (FX futures, unsecured money market, EURIBOR futures), MMSR (unsecured money market), EMIR (EURIBOR swaps), LSEG (covered bond ETFs)
- Type of data source: Commercial or regulatory
- Transformation into z-score: Relative to daily average
- Reason for inclusion: Commonly used and readily available measure of depth across asset classes. Measures trading activity. However, in some cases trading activity is high when market liquidity is low.

Chart C.3.9
Change in traded volume of EUR/USD futures, z-score, Jan. 2012-Dec. 2023

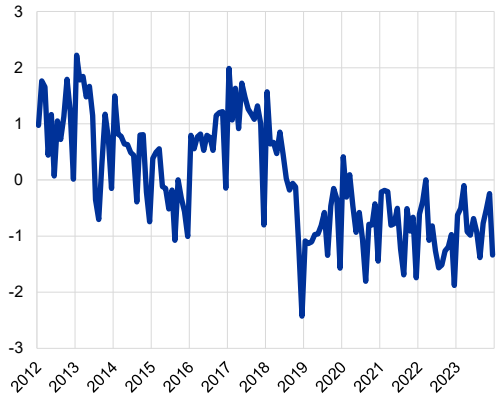


Sources: S&P Down Jones Indices LLC and/or its affiliates and ECB calculations.

Turnover ratio

- Definition: Traded volume as a share of total amount outstanding
- Dimension of market liquidity covered: Depth
- Scope: Sovereign bonds, corporate bonds
- Frequency: Daily
- Data source: Trax, ECB SHS
- Type of data source: Commercial and regulatory
- Transformation into z-score: Relative to monthly average since 2012
- Reason for inclusion: Measures how much of the outstanding is traded. Provides an indicator of depth for a particular security or the market as a whole.

Chart C.3.10
Change in turnover ratio of corporate bonds, z-score, Jan. 2012-Dec. 2023

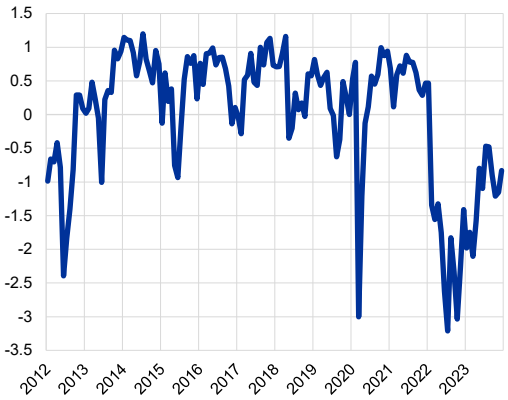


Sources: Trax and ECB calculations.

Effective spread

- Definition: Absolute value of the difference between the median transaction price and last mid-quote, as a percentage of the last quote
- Dimension of market liquidity covered: Depth
- Scope: Sovereign bonds
- Frequency: Intraday; aggregated to daily average
- Data source: MTS
- Type of data source: Commercial
- Transformation into z-score: Relative to daily average since 2012; inverted
- Reason for inclusion: Indicates the price impact of a trade with a larger spread, reflecting lower market liquidity. However, effective spreads also increase naturally with trade size.

Chart C.3.11
Change in effective spreads of sovereign bonds, z-score, Jan. 2012-Dec. 2023

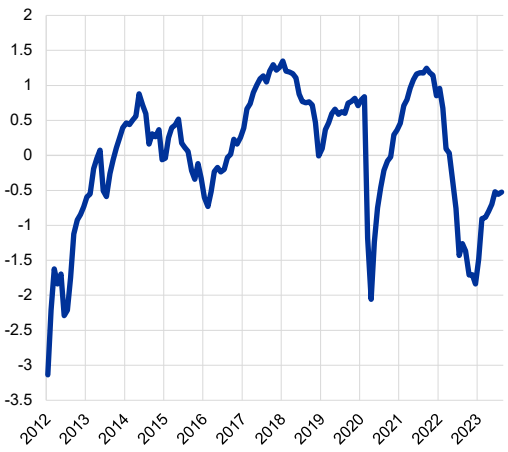


Sources: MTS and ECB calculations.

Bid-ask spread dispersion

- Definition: Difference between the 75th and 25th percentiles (interquartile range) of bid-ask spreads over a given period
- Dimension of market liquidity covered: Breadth
- Scope: Sovereign bonds, corporate bonds
- Frequency: Daily
- Data source: MTS (sovereign bonds), S&P Down Jones Indices LLC and/or its affiliates (corporate bonds)
- Type of data source: Commercial
- Transformation into z-score: Relative to daily average since 2012; inverted
- Reason for inclusion: Indicates differences in tightness across securities in a given asset class.

Chart C.3.12
Change in bid-ask spread dispersion of corporate bonds, z-score, Jan. 2012-Aug. 2023

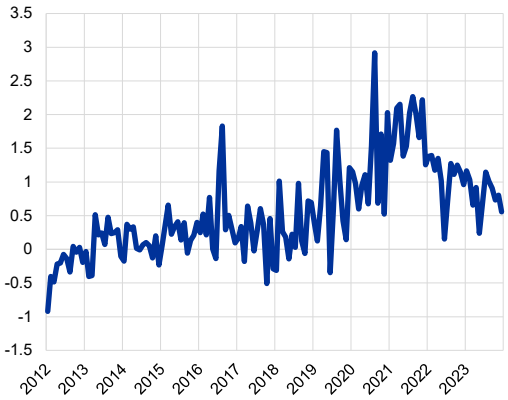


Sources: S&P Down Jones Indices LLC and/or its affiliates and ECB calculations.

Volume concentration

- Definition: Number of bonds accounting for 90% of total traded volume divided by total number of bonds (sovereign and corporate); share of five largest active banks in total volume (unsecured money market)
- Dimension of market liquidity covered: Breadth
- Scope: Sovereign bonds, unsecured money market, corporate bonds
- Frequency: Daily
- Data source: MTS (sovereign bonds), MMSR (unsecured money market), Trax (corporate bonds)
- Type of data source: Commercial or regulatory
- Transformation into z-score: Relative to daily average since 2012; inverted
- Reason for inclusion: Measures whether liquidity is concentrated in the most traded bonds or is distributed more broadly. It thus measures market breadth.

Chart C.3.13
Change in volume concentration of sovereign bonds, z-score, Jan. 2012-Dec. 2023

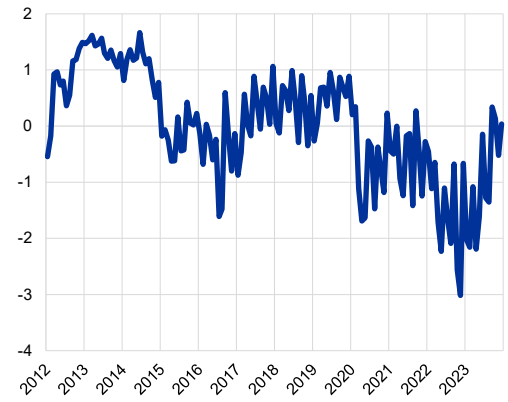


Sources: Euro MTS Ltd and ECB calculations.

Hui-Heubel ratio

- Definition: Daily range divided by traded volume
- Dimension of market liquidity covered: Breadth
- Scope: FX
- Frequency: Daily
- Data source: Bloomberg Finance L.P.
- Type of data source: Commercial
- Transformation into z-score: Relative to daily average since 2012; inverted
- Reason for inclusion: Provides a measure of price impact, with a low ratio indicating high market liquidity.

Chart C.3.14
Change in Hui-Heubel ratio of EUR/USD futures, z-score, Jan. 2012-Dec. 2023



Sources: Bloomberg Finance L.P. and ECB calculations.

Share of non-quoted securities

- Definition: Number of non-quoted securities divided by total number of securities
- Dimension of market liquidity covered: Breadth
- Scope: Sovereign bonds, corporate bonds
- Frequency: Daily
- Data source: Trax
- Type of data source: Commercial
- Transformation into z-score: Relative to daily average since 2013; inverted
- Reason for inclusion: Measures the breadth of a market by focusing on non-quotes in a given universe of securities.

Chart C.3.15

Change in share of non-quoted sovereign bonds, z-score, Sep. 2013-Dec. 2023

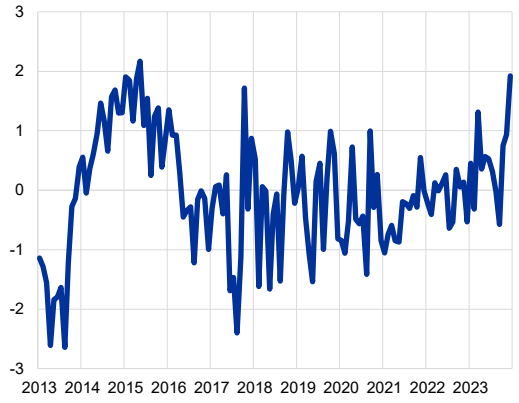
Sources: Trax and ECB calculations.

Share of non-traded securities

- Definition: Number of non-traded securities divided by total number of securities
- Dimension of market liquidity covered: Breadth
- Scope: Sovereign bonds, corporate bonds
- Frequency: Daily
- Data source: Trax
- Type of data source: Commercial
- Transformation into z-score: Relative to daily average since 2013; inverted
- Reason for inclusion: Measures the breadth of a market by focusing on non-trades in a given universe of securities.

Chart C.3.16

Change in share of non-traded sovereign bonds, z-score, Jan. 2013-Dec. 2023

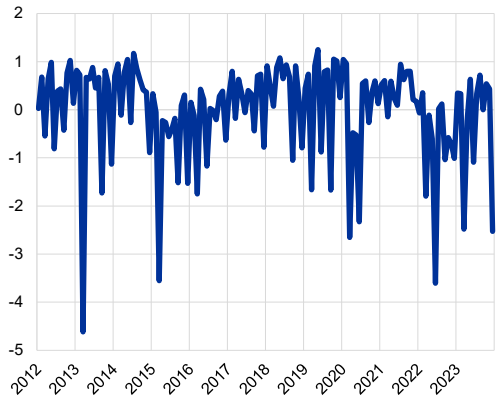


Sources: Trax and ECB calculations.

Amihud ratio

- Definition: Absolute return divided by traded volume over a given period
- Dimension of market liquidity covered: Depth and resilience
- Scope: Sovereign bonds, FX, interest rate derivatives
- Frequency: Daily
- Data source: MTS (sovereign bonds), Bloomberg Finance L.P. (FX, EURIBOR futures), EMIR (EURIBOR swaps)
- Type of data source: Commercial or regulatory
- Transformation into z-score: Relative to daily average since 2012; inverted
- Reason for inclusion: Measures price impact of trades with a high ratio, reflecting the fact that small volumes result in large price changes and therefore market illiquidity.

Chart C.3.17
Change in Amihud ratio of EUR/USD futures, z-score, Jan. 2012-Dec. 2023

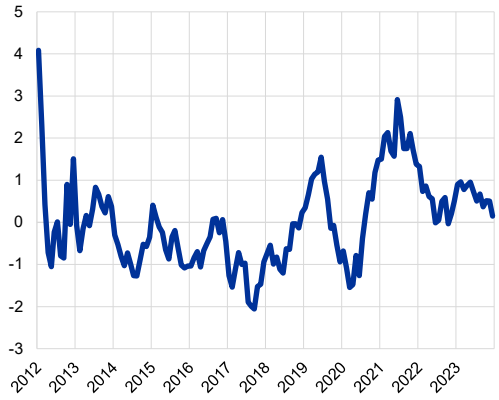


Sources: Bloomberg Finance L.P. and ECB calculations.

Market efficiency coefficient

- Definition: 30-day variance of five-day returns as a share of scaled variance of one-day returns, transformed into deviation from 1
- Dimension of market liquidity covered: Resilience
- Scope: Sovereign bonds, corporate bonds
- Frequency: Daily
- Data source: S&P Down Jones Indices LLC and/or its affiliates
- Type of data source: Commercial
- Transformation into z-score: Relative to daily average since 2012
- Reason for inclusion: In liquid markets price movements are more continuous, even when new information affects the equilibrium price. As a result, when new information becomes available, transitory price changes to a new equilibrium price should be minimal in liquid markets.

Chart C.3.18
Change in market efficiency coefficient of sovereign bonds, z-score, Jan. 2012-Dec. 2023



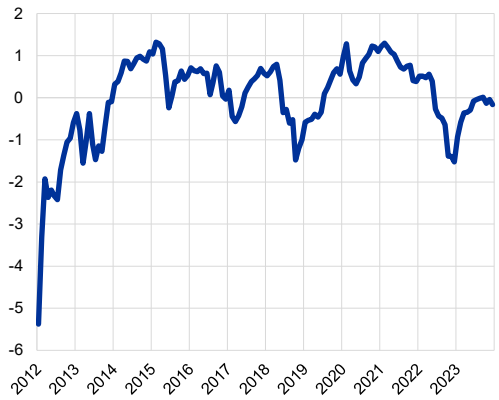
Sources: S&P Down Jones Indices LLC and/or its affiliates and ECB calculations.

Spline spread

- Definition: Average yield error based on the intraday Bloomberg Finance L.P. relative value curve filter
- Dimension of market liquidity covered: Resilience
- Scope: Sovereign bonds
- Frequency: Daily
- Data source: Bloomberg Finance L.P.
- Type of data source: Commercial
- Transformation into z-score: Relative to daily average since 2012; inverted
- Reason for inclusion: When liquidity conditions are favourable, average yield errors are small as any dislocations from fair value are normalised within a short time frame. Under stressed liquidity conditions, dislocations from fair value implied by the curve filter may persist, resulting in large average yield errors.

Chart C.3.19

Change in spline spread of sovereign bonds, z-score, Jan. 2012-Dec. 2023



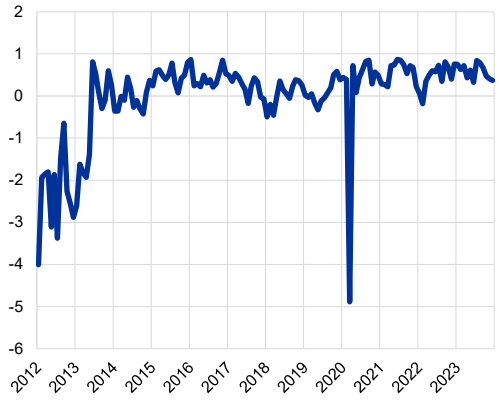
Sources: Bloomberg Finance L.P. and ECB calculations.

NAV spread

- Definition: Absolute value of the difference between the ETF share price and the NAV of the underlying basket of securities, often referred to as ETF premium/discount. Uses a simple average of the three largest ETFs per asset class.
- Dimension of market liquidity covered: Resilience
- Scope: Sovereign bonds, unsecured money market, corporate bonds, covered bonds
- Frequency: Daily
- Data source: Bloomberg Finance L.P., LSEG
- Type of data source: Commercial
- Transformation into z-score: Relative to daily average since 2012; inverted
- Reason for inclusion: NAV spreads may rise temporarily due to illiquidity of the underlying assets, among other factors. Data are readily available across asset classes and countries.

Chart C.3.20

Change in NAV spreads of covered bond ETFs, z-score, Jan. 2012-Dec. 2023



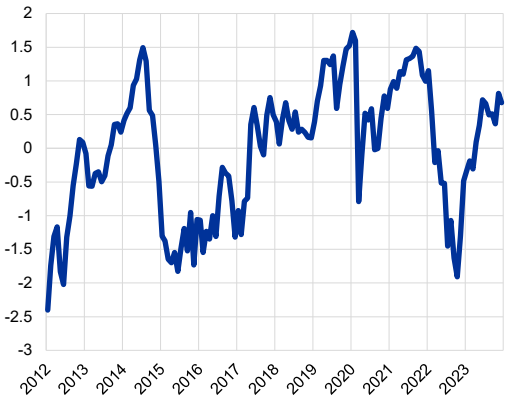
Sources: Bloomberg Finance L.P. and ECB calculations.

Implied volatility

- Definition: Three-month volatility implied by options. For FX markets, a volume-weighted average of EUR/USD, EUR/JPY and EUR/GBP implied volatility
- Dimension of market liquidity covered: Resilience
- Scope: FX, interest rate derivatives
- Frequency: Daily
- Data source: Bloomberg Finance L.P.
- Type of data source: Commercial
- Transformation into z-score: Relative to daily average since 2012; inverted
- Reason for inclusion: Implied volatility is a typically a key factor for liquidity providers and therefore indirectly reflects market liquidity conditions.

Chart C.3.21

Change in implied volatility of FX markets, z-score, Jan. 2012-Dec. 2023



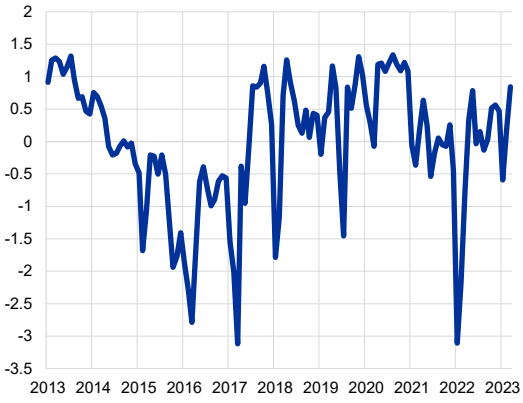
Sources: Bloomberg Finance L.P. and ECB calculations.

Cross-currency basis swap spreads

- Definition: Difference between the interest rates of two currencies in a cross-currency swap.
- Dimension of market liquidity covered: Resilience
- Scope: FX
- Frequency: Daily
- Data source: Bloomberg Finance L.P.
- Type of data source: Commercial
- Transformation into z-score: Relative to daily average since 2012; inverted
- Reason for inclusion: These spreads may increase due to lower market liquidity for the relevant currency pair, among other factors.

Chart C.3.22

Change in cross-currency basis swap spreads, z-score, Oct. 2013-Dec. 2023



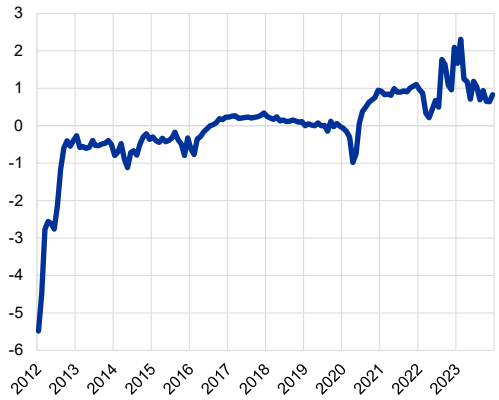
Sources: Bloomberg Finance L.P. and ECB calculations.

EURIBOR-OIS spread

- Definition: Difference between the three-month EURIBOR and three-month OIS
- Dimension of market liquidity covered: Tightness
- Scope: Unsecured money market
- Frequency: Daily
- Data source: Bloomberg Finance L.P.
- Type of data source: Commercial
- Transformation into z-score: Relative to daily average since 2012; inverted
- Reason for inclusion: The spread may increase due to either credit risk or liquidity conditions.

Chart C.3.23

Change in EURIBOR-OIS spread, z-score, Jan. 2012-Dec. 2023



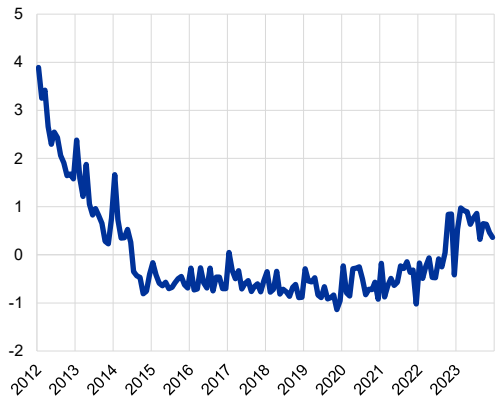
Sources: Bloomberg Finance L.P. and ECB calculations.

STEP issuance volumes

- Definition: Gross issues of short-term European paper (STEP) instruments denominated in all currencies
- Dimension of market liquidity covered: Depth
- Scope: Unsecured money market
- Frequency: Daily
- Data source: SDW
- Type of data source: Regulatory
- Transformation into z-score: Relative to daily average since 2012
- Reason for inclusion: Indicates the availability of new issues in part of the commercial paper market. This reflects, and may affect, liquidity in the secondary market.

Chart C.3.24

Change in STEP issuance, z-score, Jan. 2012-Dec. 2023



Sources: SDW and ECB calculations.

Average time between trades

- Definition: Average time in minutes between two consecutive trades
- Dimension of market liquidity covered: Immediacy
- Scope: Interest rate derivatives
- Frequency: Daily
- Data source: EMIR
- Type of data source: Regulatory
- Transformation into z-score: Relative to daily average since 2018; inverted
- Reason for inclusion: Closely related to other indicators of trading activity, but a more direct way to measure immediacy

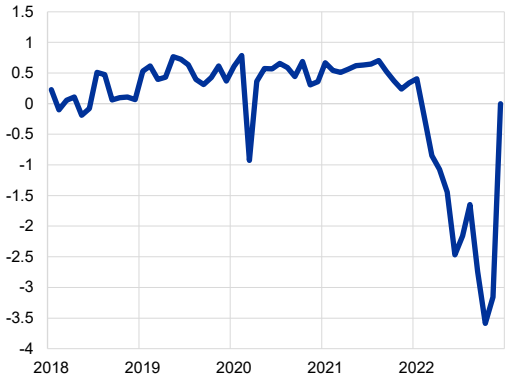
Chart C.3.25
Change in average time between trades of interest rate swaps, z-score, Jan. 2018-Dec. 2022

Sources: EMIR and ECB calculations.

Price dispersion

- Definition: Volume-weighted deviation from average trade price
- Dimension of market liquidity covered: Breadth
- Scope: Interest rate derivatives
- Frequency: Daily
- Data source: EMIR
- Type of data source: Regulatory
- Transformation into z-score: Relative to daily average since 2018; inverted
- Reason for inclusion: One factor contributing to price dispersion is the varying market liquidity of the assets. Price dispersion thus indirectly measures how market liquidity is distributed across securities.

Chart C.3.26
Change in price dispersion of interest rate swaps, z-score, Jan. 2018-Dec. 2022



Sources: EMIR and ECB calculations.

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This report has been prepared by the Agile Team on Systemic Liquidity, led by Desislava Andreeva (ECB) and Antoine Bouveret (ESMA). The report was approved for publication by the ESRB General Board.

<table>
<tr><td colspan="2">Co-chairs of the MPAG-AWG Agile Team</td></tr>
<tr><td>Desislava Andreeva (ECB)</td><td>Antoine Bouveret (ESMA)</td></tr>
<tr><td colspan="2">Secretary of the Agile Team</td></tr>
<tr><td colspan="2">Petya Radulova (ECB)</td></tr>
<tr><td colspan="2">Team members (in alphabetical order)</td></tr>
<tr><td>Funding liquidity workstream
Nander de Vette (workstream lead, De Nederlandsche Bank)
Katja Ahoniemi (Suomen Pankki – Finlands Bank)
Michael Böhl (CSSF)
Esther Cáceres García (Banco de España)
Dimitrios Chalamandaris (Bank of Greece)
Lizette Eistrup Jensen (Danmarks Nationalbank)
George Kaoudis (Bank of Greece)
Kimmo Koskinen (Suomen Pankki – Finlands Bank)
Magnus Stenfeldt Madsen (Danmarks Nationalbank)
Petya Radulova (ECB)
Georgios Vasiladiotis (Bank of Greece)
Elias Veloudos (Bank of Greece)</td><td>Market liquidity workstream
Gibran Watfe (workstream lead, De Nederlandsche Bank)
Paweł Fiedor (Central Bank of Ireland)
Jonas Heipertz (Banque de France)
Argyris Kahros (European Commission)
Simon Kördel (ECB)
Samantha Meyers (Sveriges Riksbank)
Alessio Ruggieri (Banca d’Italia)
Michael Schmidt (Deutsche Bundesbank)</td></tr>
<tr><td colspan="2">Additional support</td></tr>
<tr><td colspan="2">Filippo Bucchi (ESRB Secretariat), Sylvain Canto (ESMA), Massimo Ferrari (ESMA), Laurent Goergen (CSSF), Emilio Hellmers (Danish Financial Supervisory Authority), Arianna Santone (ESRB Secretariat)</td></tr>
</table>

Postal address 60640 Frankfurt am Main, Germany
Telephone +49 69 1344 0
Website **www.esrb.europa.eu**

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