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The Impact of Derivatives Collateralization on Liquidity Risk: Evidence From the Investment Fund Sector

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ABSTRACT: Stricter derivative margin requirements have increased the demand for liquid collateral, but euro area investment funds, which use derivatives extensively, have been reducing their liquid asset holdings. Using transaction-by-transaction derivatives data, we assess whether the current levels of funds' holdings of cash and other highly liquid assets would be adequate to meet funds' liquidity needs to cover variation margin calls on derivatives under a range of stress scenarios. The estimates indicate that between 13 percent and 33 percent of euro area funds with sizeable derivatives exposures may not have sufficient liquidity buffers to meet the calls under adverse market shocks. As a result, they are likely to redeem money market fund (MMF) shares, procyclically sell assets, and draw on credit lines, thus amplifying the market dynamics under such stress scenarios. Our findings highlight the importance of further work to assess the potential role of macroprudential policies for nonbanks, particularly regarding liquidity risk in funds.

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WORKING PAPERS

The Impact of Derivatives Collateralization on Liquidity Risk: Evidence from the Investment Fund Sector

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Executive summary

The liquidity risk in investment funds manifested itself in the March 2020 COVID-19-related market turmoil, when market volatility and margin calls rose dramatically. Facing liquidity squeeze from margin calls and redemptions from end-investors, euro area investment funds sold securities worth almost EUR 300 billion in the first quarter of 2020[1], thus amplifying the adverse market dynamics and exceeding by far the asset sales of any other euro area sector.

The existing literature focuses on assessing funds' liquidity risk from redemptions while paying far less attention to the funds' liquidity risk from margin calls on derivatives exposures. This is despite the fact that the derivatives market has undergone a profound structural change, owing to the OTC derivatives reforms enacted as a response to the global financial crisis. These reforms have inter alia introduced the daily exchange of variation and initial margins for the vast majority of derivatives exposures. Whereas the exchange of margins in the form of high-quality collateral reduces counterparty credit risk, the requirements also increase liquidity risk, as counterparties need to hold (or have ready access to) enough high-quality liquid collateral to meet margin calls.

To help fill this gap, our paper assesses whether the current levels of cash and other highly liquid asset holdings would be adequate to meet euro area investment funds' liquidity needs from their derivatives exposures under a range of market stress scenarios and shocks. To do so, we use the complex and voluminous transaction-by-transaction derivatives data collected under the European Market Infrastructure Regulation (EMIR data), which are also often referred to as trade repository data. They can be classified as *big data*, owing to their volume, velocity, and variety. Complemented by a number of commercial data sources, we use EMIR data to calibrate pricing functions for the 10 most prevalent types of derivatives held by funds. This allows us to derive potential variation margin calls under a range of scenarios.

We focus on liquidity risk arising from variation margin calls since the collateralization of funds' portfolios by variation margin currently exceeds that by initial margin. Moreover, variation margin tends to be more procyclical and volatile than initial margin. We compare the potential variation margin calls under a range of scenarios with the actual liquidity buffers held by euro

[1] Rousová 2020b estimated fund margin calls to peak at around EUR 40 billion on March 16, 2020.

area investment funds. We obtain the information on liquidity buffers from Refinitiv Lipper and use several definitions of the buffers to take into account the specificity of the market.

Under extreme stress scenarios, we estimate the liquidity needs of euro area investment funds to be around EUR 30 billion for an extreme one-day market shock and EUR 70 billion under a prolonged market turmoil. These estimates appear realistic in view of the evidence from the recent COVID-19-related market turmoil, when daily variation margin calls on funds likely reached tens of billions of euro.

The paper contributes to the existing literature in several ways. To our knowledge, it is the first paper that analyzes liquidity risk stemming from margin calls faced by euro area investment funds. More importantly, it does so in a comprehensive and forward-looking manner, namely by running simulations for 10 types of contracts from the three largest derivative asset classes held by funds (interest rate, currency, and equity derivatives). Finally, it is a pioneering study that makes use of two large granular data sets: the EMIR and Lipper Refinitiv data.

The results in this paper call for enhanced macroprudential tools to address the liquidity risk in the fund sector, as this risk can have wider systemic implications. Such tools should focus on containing the buildup of vulnerabilities before risks materialize. Regulatory requirements aimed at strengthening funds' ability under stress to meet potential funding needs, including variation margin calls, could be effective in this respect. They could, for instance, aim at aligning funds' liquidity risk with the liquidity of the funds' assets and redemption policies. Limits on synthetic leverage could also reduce funds' exposure to liquidity risk arising from their derivatives exposures. Such tools would make the sector more resilient to future financial turbulence and decrease the need for ex post interventions.

1 Introduction

The regulatory reforms in the OTC derivatives markets[2] have introduced the daily exchange of variation and initial margin for the vast majority of derivatives exposures[3].

[2] As of November 2022 (FSB 2022a), OTC derivatives reforms have been implemented in all G20 jurisdictions, with heterogenous levels of scope.
[3] See BCBS, IOSCO 2020, BCBS, CPMI, IOSCO 2022, FSB 2022, for an overview of margin requirements for the cleared and bilateral trades.

Variation margin represents collateral that is collected to extinguish current exposures resulting from changes in market prices of a portfolio of derivatives contracts: if the market price of a portfolio decreases, a variation margin is called (see also BCBS, CPMI, IOSCO; 2022). Initial margin is an additional collateral buffer that protects a counterparty against a potential future decline in the market value of a portfolio over a short period, should the other counterparty default.

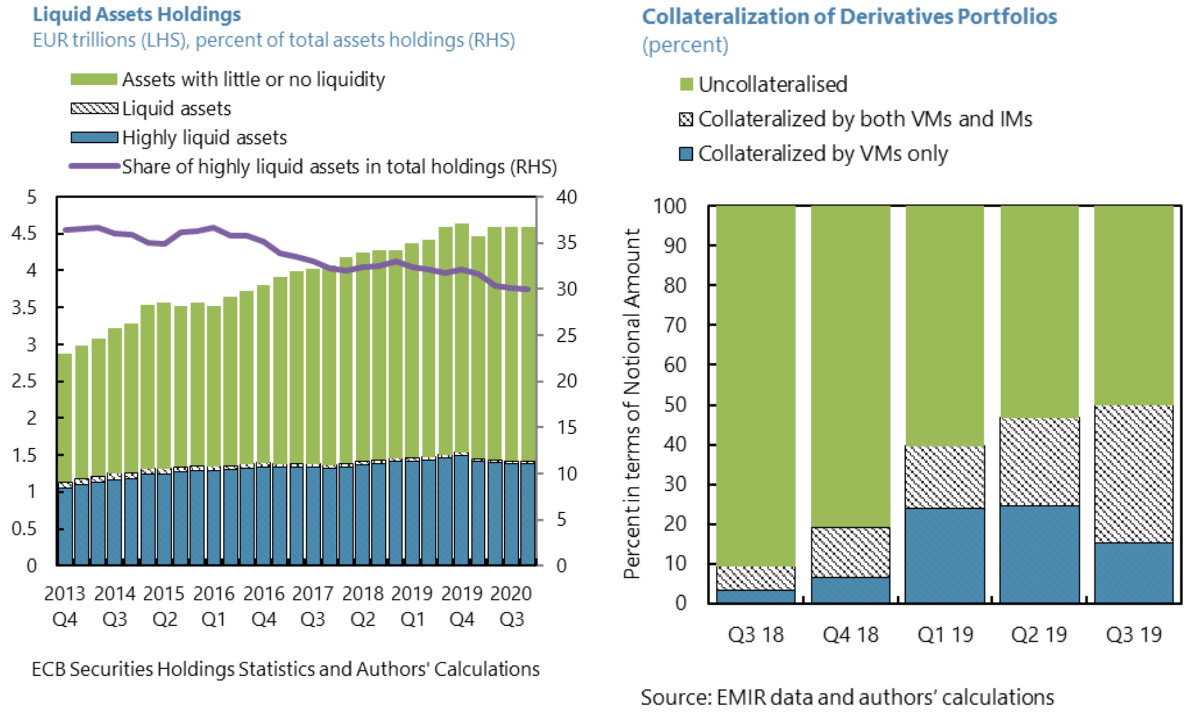
The exchange of margins in the form of high-quality collateral reduces counterparty credit risk but also increases liquidity risk, as counterparties need to hold (or have ready access to) high-quality liquid collateral to meet margin calls[4]. Such liquidity risk manifested itself in the March 2020 COVID-19-related market turmoil, when market volatility and margin calls rose dramatically, including for nonbank financial intermediaries (Bank of England 2020; Fache Rousová et al. 2020a, b; FSB 2020). Facing liquidity squeeze from both margin calls and redemptions, euro area investment funds sold in the first quarter of 2020 securities worth almost EUR 300 billion, which amplified the adverse market dynamics and by far exceeded sales of any other euro area sector (Schnabel 2020). The failure of Archegos, a US family office, in March 2021 (ESMA 2022; SEC 2022) and the heavy sales of gilts by Liability Driven Investment (LDI) funds in September 2022 (Chen and Kemp 2023, ESRB 2023) were further events that highlighted the risks and vulnerabilities in non-banks facing margin and collateral calls including spillovers to the rest of the financial system. Moreover, the LDI episode illustrates that such risks and vulnerabilities might have increased in the recent high interest rate risk environment. Despite these episodes and an increasing collateralization in derivative markets, investment funds' holdings of liquid assets have continued to decline and remain at a historical low (Figure 1, Chart 3 in ECB 2023). Against this background, our paper is the first—to our knowledge—to assess whether the recent levels of cash and other highly liquid asset holdings would be adequate to meet investment funds' liquidity needs from their derivative exposures under a range of market stress scenarios and shocks. The key data set for our analysis is the complex and voluminous transaction-by-transaction derivatives data collected under the European Market Infrastructure Regulation (EMIR data), also often referred to as trade repository data. First of all, these *big data* provide

[4] Unless otherwise specified, liquidity risk refers to funding risk throughout this paper.

us with information on derivative portfolios held by euro area funds. Second, combined with external data sources, they allow us to develop pricing functions for several types of contracts, which fall into the three most prevalent derivative asset classes held by funds: interest rate, currency, and equity derivatives. Third, we use the pricing functions to simulate variation margin on funds' derivatives portfolios under a range of scenarios and different netting assumptions. Finally, having derived the potential variation margin, we compare it with the actual liquidity positions of individual euro area investment funds, which we obtain from Refinitiv Lipper. Our estimates indicate that between 13 percent and 33 percent of euro area funds with sizable derivatives exposures may not have sufficient liquidity buffers to meet the calls under the adverse market scenarios. Overall, we estimate the margin calls to reach up to EUR 140 billion in a scenario of prolonged market turmoil, of which only half would be covered by the (highly) liquid assets of funds (that is, cash and government bonds eligible for the Basel Liquidity Coverage Ratio). Consequently, funds with liquidity shortages would be likely to redeem money market fund (MMF) shares, procyclically sell assets, and draw on credit lines, thus amplifying the market dynamics under the adverse stress scenarios. For instance, the LDI episode in September 2022 in the UK illustrates that fire sales of bonds by investment funds in the current high interest rates environment can amplify sudden increases in yields and disrupt the markets to the extent that central bank intervention is needed (Chen and Kemp 2023). But we also find that our results vary significantly with the type of shock and fund, where some categories of funds have particularly severe liquidity shortages.

Despite the large size and complexity of investment funds' derivative portfolios, the existing literature on liquidity risk from investment funds' derivatives exposures is scarce. To our knowledge, only one study, Bank of England (2018), assesses liquidity risk in funds from derivatives exposures, but the study is limited to funds domiciled in the UK and an interest rate shock only. Furthermore, the analysis in Guagliano et al. (2018) and Braunsteffer et al. (2019) is limited to funds' use of credit default swap (CDS) contracts and does not examine funds' liquidity risk. While Schrimpf et al. (2020) emphasizes the role of variation margin calls on highly leveraged hedge funds in amplifying market dynamics in the US Treasury market in the March 2020 market turmoil, the study is only indicative regarding the level of liquidity stress that these funds faced. Since liquidity and leverage in nonbanks can be interlinked (Aramonte et al. 2021), our paper complements the literature on leverage in funds (Fricke 2021; Molestina Vivar et al. 2020) and nonbanks more generally (Ianiro et al. 2022; Jukonis 2022).

Figure 1. Liquid asset holdings and collateralization of derivative portfolios of euro area investment funds



Note: Assets are classified according to the Basel Liquidity Coverage Ratio requirements for high-quality liquid assets (HQLA). Highly liquid assets correspond to level 1, liquid assets to levels 2A and 2B, and assets with little or no liquidity to non-HQLA.

Note: Based on selected dates close to the end of the respective quarter and the field "collateralization" in EMIR reporting. The extent of collateralization may be underreported in EMIR data, owing to the limited quality of the data (for example, missing values).

In addition to its focus on investment funds, our paper looks at liquidity risk from derivatives exposures comprehensively, covering interest rate, currency, and equity derivatives. This is particularly important for investment funds that are heavy users of derivatives, which they can use for hedging purposes or to amplify their exposures by building synthetic leverage. As result, they hold diverse portfolios depending on their strategy. Similarly, our coverage of EMIR data is comprehensive, as we use data from all seven trade repositories authorized under EMIR at the end of 2018, while other papers typically use only data from a small subset of these trade repositories (for example, Bank of England 2018; Abad et al. 2016).

A few pioneer studies have recently investigated the liquidity risk from derivatives exposures in (parts of) the financial system, but they consider only a limited number of contract types or simplistic market shocks. In addition, none of the studies covers equity derivatives, even if equity markets tend to be often hit by relatively large shocks. Specifically, Paddrik et al. (2020) looks only at credit default swaps, while studies on insurers and/or pension funds consider only interest rate swaps (de Jong et al. 2019; Fache Rousová et al. 2020c; Jensen and Achord 2019). Bank of England (2018) covers two types of interest rate contracts, while Bardoscia et al. (2021) adds to them two types of currency derivatives. Although Bardoscia et al. (2019) covers six contract types in three OTC derivatives markets (interest rate, credit, and currency derivatives), the modeling of market shocks in this study is simplistic and unrealistic for periods of market stress, as shocks are obtained by draws from (uncorrelated) normal distributions of historical prices of these contracts. Other studies, such as Glasserman and Wu (2018), do not look at liquidity risk from actual derivatives portfolios held by market participants, but proxy the risk by considering volatility of certain market indexes (for example, S&P 500).

While it is tempting to focus on interest rate and/or currency derivatives, which are the two largest derivative classes in terms of notional values, these asset classes are not necessarily the most important for liquidity risk. First, the market value of an interest rate and currency derivative is usually only a small fraction of the notional value, while this may not be the case for other asset classes (for example, CDS contracts). Second, other asset classes may be affected by larger and/or more frequent shocks. For instance, during the March 2020 market turmoil, around 53 percent of the variation margin calls faced by euro area investment funds originated from equity derivatives, even though these derivatives account for only around 11 percent of funds' derivative portfolios in terms of notional value (Fache Rousová et al. 2020b, charts B1 and B2). Third, some contracts may have a nonlinear payoff (for example, option). Moreover, a severe shock from one market usually spreads to other markets. For all these reasons, it is paramount to study comprehensively a combination of shocks and derivatives exposures, as done in our paper.

One limitation of our study is that we focus on liquidity risk from variation margin only and not initial margin. This is, however, common for most other studies on this topic (Bank of England 2018; Bardoscia et al. 2021; de Jong et al. 2019; Jensen and Achord 2019), since the modeling and estimates of initial margin are more complex and thus have been investigated mostly theoretically (Ghamami et al. 2022). Furthermore, the collateralization of funds' portfolios by variation margin exceeds that by initial margin (Figure 1)[5] and variation margin also tends to be more procyclical and volatile (see, for example, Bardoscia et al. 2021). In line with this, European Central Bank (ECB) survey data indicate that posting initial margins (as opposed to posting variation margin) had almost no impact on the liquidity situation of investments funds in the March 2020 market turmoil (ECB 2020). In addition, Fache Rousová et al. (2020a), Ghio et al. (2022) and Czech et al. (2021) suggest that the need for nonbanks to meet variation margin can lead to large redemptions from money market funds (MMFs) and heavy selling of government bonds. Finally, it was the large variation margin call that led AIG close to failure in 2008 (McDonald and Paulson 2015).

The rest of the paper is structured as follows. Section 2 describes the data, section 3 explains the methodology, and section 4 presents the results. Section 5 briefly concludes.

2 Data

The results presented in this paper are based on granular data assembled from several sources. These include the transaction-by-transaction EMIR data on derivatives, Lipper data on individual funds from Refinitiv, the ECB's Centralised Securities Database (CSDB) on characteristics of individual securities, and various market data sources.

The key data source is the ECB sample of EMIR data, which we use to retrieve the derivatives portfolios of individual euro area investment funds. We use trades reported by counterparties located in the euro area and paired transactions from EMIR trade state reports (Pérez-Duarte and Skrzypczynski 2019). EMIR data have been reported by counterparties resident in the EU since February 2014 and include more than 120 data fields for each individual derivatives transaction conducted by these counterparties. The data provide information on the type of derivative, underlying, price, notional value, market valuation, collateral, and lifecycle events (FSB 2010).

[5] The initial margin requirements for noncentrally cleared contracts are less widespread, as they were phased in until September 2022 and they only apply to new contracts. Moreover, even after September 2022, some entities with smaller derivatives portfolios are exempted from the requirement.

Owing to their size and complexity, the EMIR data require extensive manipulation and cleaning. Results presented in this paper are based on a cleaned subsample of the data using the reference date December 20, 2018. Despite careful cleaning and processing, the final data are still subject to some data quality limitations, such as missing information on underlying.

Table 1 provides an overview of the cleaning steps. First, in the case of paired trades, we compare the two legs on significant dimensions to harmonize the data and fill potential missing values. Second, we drop trades with no maturity or with maturity prior to the reference date. Similarly, we drop trades that are already terminated or whose "action type" refers to a lifecycle state of no longer active trades. Further, we exclude trades whose notional value is implausibly low (lower than EUR 1,000) or too high (higher than EUR 50 billion for interest rate derivatives, EUR 3 billion for currency derivatives, and EUR 2.5 billion for equity derivatives) or null. Further. we adjust trades with extremely high notional values, which appear in the data due to wrongly reported currency denomination. Specifically, we replace wrongly reported currency (typically US dollars) with local currency (for example, Indian rupees) . To identify trades conducted by euro area funds, we filter the EMIR data using the sector classification developed in Lenoci and Letizia (2021), that also provide information on the type of fund and investment strategy. After data processing, the notional value of euro area investment funds' derivatives exposures amounted to around EUR 17 trillion in December 2018, of which 31 percent was centrally cleared.

Table 1: EMIR data processing - The effect of the cleaning procedure on notional value and the number of rows in our sample

	EUR trillion	Number of rows
Total	48,216	20,190,406
Drop matured	48,216	20,169,707
Drop terminated	44,137	19,708,345
Drop inconsistent action type	44,137	19,700,297
Drop outliers	378	17,013,147
Adjust trades with wrongly reported currency	276	17,013,147
Filter for the euro area investment fund sample	17	1,893,893

Source: EMIR data, and Authors' calculations.

Having cleaned the EMIR data, we enrich them with information on the products underlying the derivatives instruments held by euro area investment funds. This information comes from various market data sources such as ANNA DSB, Bloomberg, and Datastream.

The second important data source in our paper is Lipper data from Refinitiv, from which we obtain the liquidity positions of euro area funds. We retrieve cash (deposit) and security-by-security holdings of bond, equity, and mixed funds at end-2018. For securities, which have an international securities identification number (ISIN) and can thus be matched with information from the ECB's CSDB (ECB 2010), we enrich the holdings with information on the issuer of the security and other characteristics.

Table 2 shows that out of the almost 60,000 euro area investment funds, around 35 percent use derivatives. The use of derivatives clearly increases with funds' size: over 80 percent of funds with net asset value (NAV) over EUR 5 billion use derivatives, but less than 5 percent of funds with NAV below EUR 1 million do so. Derivatives use is more prevalent for bond, hedge, and mixed funds (over 45 percent) than for equity (33 percent) and real estate funds (8 percent).

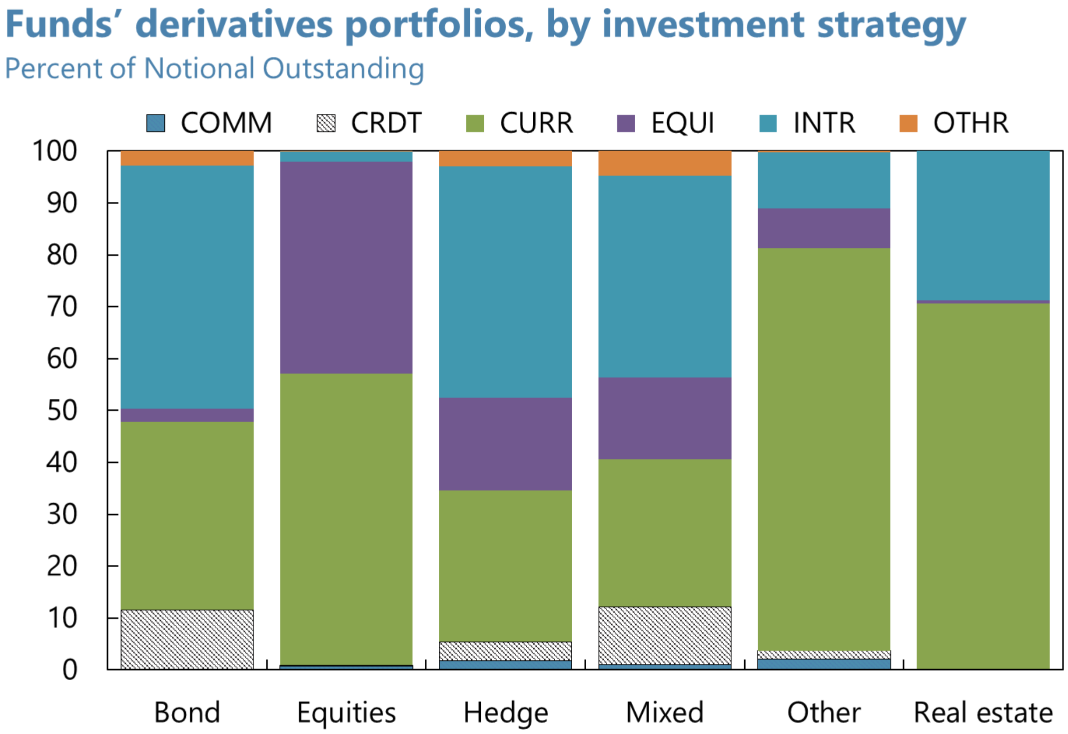
Figure 2 indicates that the composition of funds' derivatives portfolios depends heavily on their mandates. Almost half of the derivatives portfolios of bond, hedge, and mixed funds are interest rate derivatives, followed by currency derivatives. Conversely, equity funds do not use interest rate derivatives, and their derivatives portfolios are built predominantly from currency and equity derivatives.

Table 2: Share of funds using derivatives broken down by NAV and strategy

NAV in EUR million	Bonds	Equities	Hedge	Mixed	Real estate	Other	All types	Number of all euro area funds
0 − 1	6%	2%	6%	7%	3%	3%	4%	7,575
1 − 5	24%	15%	23%	24%	6%	37%	28%	5,274
5 − 50	42%	26%	49%	40%	9%	34%	34%	19,215
50 − 100	53%	34%	55%	50%	13%	31%	42%	6,932
100 − 500	63%	45%	65%	61%	16%	36%	52%	11,696
500 − 1,000	72%	57%	70%	68%	16%	40%	62%	2,364
1,000 − 5,000	78%	68%	76%	73%	26%	40%	69%	2,013
> 5,000	88%	77%	75%	85%	78%	45%	81%	183
Not available	2%	2%	3%	4%	1%	3%	3%	3292
All sizes	50%	33%	46%	45%	8%	23%	35%	58,544
Number of all euro area funds	9,693	12,481	2,089	15,270	5,072	13,939	58,544	

Source: EMIR data, ECB's Investment Fund Statistics, and Authors' calculations.

Figure 2: Euro area funds' derivatives portfolios



EMIR data, ECB's investment funds statistics, and authors' calculations.

3 Methodology

In this section, we describe the various steps we follow to assess whether the fund sector can face liquidity distress from the use of derivatives. We conduct the analysis at the level of a single fund. First, we estimate the margin call on the fund's derivatives portfolio after a market shock. We then compare the margin call to the fund's liquid asset holdings, and if liquid assets are insufficient to cover the margin call, we define the fund as suffering a liquidity shortfall. Finally, to measure the overall liquidity need and the potential spillovers to other markets and sectors, we compute the number of funds with insufficient liquidity and derive the aggregate liquidity shortfall at the sector level.

3.1 Step 1: Identify funds' derivatives and liquidity positions

The first step is to retrieve the positions of each fund in terms of its derivatives portfolio and liquid assets. To do this, we use the granular data available from EMIR and Refinitiv Lipper presented in Section 2.

From EMIR data, we retrieve the legal entity identifiers (LEIs) of funds' counterparties, the collateral portfolio identifiers, and several other attributes, allowing us to reprice the contracts in funds' portfolios. Since derivatives positions of funds tend to be complex and heterogeneous, we consider three asset classes: interest, equity, and currency derivatives, which overall represent 89 percent of the notional value of euro area funds' derivatives portfolios.

Using Lipper Refinitiv data, we estimate the liquidity positions as funds' holdings of cash (deposits) and high-quality government debt securities. Specifically, we consider high-quality government debt securities to be those issued by euro area sovereigns and AAA-rated debt securities issued by other sovereigns, following the Basel definition of level 1 high-quality liquid assets (HQLA-L1) developed for banks[6]. On average, the cash held by funds in our sample is EUR 11.9 million, while the liquidity buffer including both cash and HQLA-L1 instruments amounts on average to EUR 71.6 million (Table 3). When considering only funds that trade derivatives, these figures increase to EUR 15.6 and EUR 91.7 million, respectively.

Table 3: Average, median, and quantiles of the size of liquidity buffers for euro area funds in the sample. Monetary amounts are in EUR millions.

	Cash and equivalents	*Cash and HQLA-L1*	
EA funds			58,544
Of which having asset holdings available in Lipper data			6,634
Average	11.9	71.6	
25th Percentile	0.0	1.4	
Median	1.0	7.2	
75th percentile	5.8	37.8	
Total	78,859.0	475,179.0	
Of which also reporting derivatives in EMIR data			4,305
Average	15.6	91.7	
25th Percentile	0.0	2.5	
Median	1.4	12.3	
75th percentile	8.3	53.6	
Total	67,266.0	394,760.0	

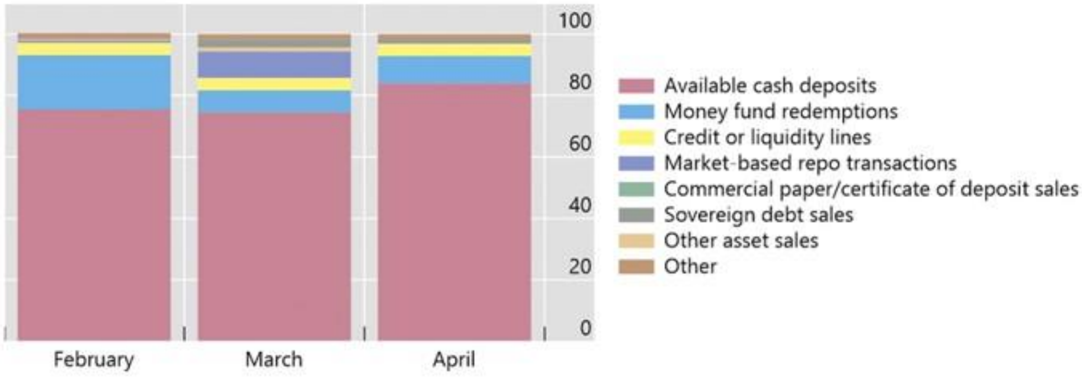
Source: Lipper data, authors' calculations.

The choice of using cash and government bonds as the liquidity buffer is motivated by Figure 3, which is taken from BCBS, CPMI, IOSCO (2022) and indicates that over three quarters of peak margin calls in February to April 2020 paid by "clients," typically nonbank financial intermediaries, came from available cash deposits. Cash is the most favored asset to

[6] See, for example,. www.bis.org/basel framework/chapter/LCR.

cover variation margin calls because it is fungible and can be transferred between counterparties quickly. Moreover, it is the only collateral for variation margin accepted by central clearing counterparties (CCPs)[7].

Figure 3: Funding sources for peak margin payments directly funded by the corresponding source, averaged across reporting clients (in percent).



Source: BCBS, CPMI, IOSCO (2022), Figure 22.

At the peak of the market stress in March 2020, the second most common source of liquidity was market-based repo transactions. We use high-quality government bonds as a proxy for the ability of euro area investment funds to engage in repo transactions during stress market periods. We do so because government bonds are the dominant type of collateral in the euro-denominated repo market, accounting for 85 percent of all transactions (ECB 2021)[8]. Repo markets with high-quality liquid collateral, such as government bonds, also endured the March 2020 market turmoil (ICMA 2020). Moreover, highly liquid government bonds can be accepted to cover variation margin calls under a wide range of bilateral agreements, even though they tend to be far less preferred than cash by the receiving counterparty.

Finally, Figure 3 shows that the third funding source for clients' peak margin calls in March 2020 were redemptions from MMFs. We consider this funding source insufficiently liquid, given the significant outflows and strains that MMFs experienced during the March 2020 market

[7] The clearing of funds' derivatives transactions is typically facilitated by a clearing bank, which collects the collateral to cover the variation margin from the fund and pass it on to the CCP.
[8] Out of these, bonds issued by sovereigns in six euro area countries (Belgium, France, Germany, Italy, the Netherlands, and Spain) account for 92 percent.

turmoil (Boucinha et al. 2020). The findings in Ghio et al. (2022) also suggest that one driver of the strains faced by euro area MMFs was the need for nonbanks (including funds) to pay variation margin on their derivatives portfolios.

3.2 Step 2: Define market shocks

The second step defines the type and size of market shocks, which would trigger significant margin calls. Since developing a fully fledged stress test scenario is beyond the scope of this paper, we consider only stylized shocks, which are defined for each underlying asset class separately. Still, our shocks are motivated by the market moves during the 2008 global financial crisis and the COVID-19-related March 2020 market turmoil. From this historical perspective, and also in light of the recent LDI-related gilt market turmoil[9], the shocks are severe but plausible. Since it is rare in historical data that all market segments experience their largest losses on the same day, we compare our stylized shocks to both (1) the peak shocks for each market segment separately (that is, often occurring on/in different days/periods); and (2) specific days/periods, on/in which all three markets combined performed the worst. Generally, our stylized shocks aid understanding of the direction of funds' positioning in the market while also providing an indicative measure of the overall liquidity shortfall in stressed markets.

We consider two scenarios: a sudden one-day market movement and a prolonged market turmoil over two weeks (Table 4, scenarios 1a and 2a). The first scenario considers an extreme one-day movement, with a 25-basis point parallel downward shift in interest rates, a 5 percent decline in major stock market indexes, and a 2 percent depreciation of the US dollar vis-à-vis the euro. The second scenario reflects prolonged market turmoil, with a 75-basis point parallel downward shift in interest rates, a 15 percent decline in stock markets, and a 5 percent depreciation of the US dollar[10]. The rationale for choosing scenarios over two different time periods is that the collateral used to cover variation margin can be different: while there is no time for collateral transformation in the one-day market movement, such transformation can be undertaken in the prolonged market turmoil (see also Step 5).

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[9] Between September 21 and September 27, 2022 long term gilt yield rose 140 bps, with a peak +70 bps on September 27 (Chen and Kemp 2023).

[10] Only USD depreciation is considered as funds tend to have relatively large holdings denominated in USD but redemptions need to be met in EUR.

Table 4: Stress scenarios compared with extreme market movements in 2008 and 2020

			Interest rate change (bps)		Stock market change (%)		USD depreciation vis-à-vis EUR (%)
			EA	US	EA	US	
One-day movement	Scenario	1a	−25	−25	−5	−5	2.0
		1b	25	25	−5	−5	2.0
	Historical peak	2008	−30	−66	−8	−9	2.9
		2020	−4	−26	−11	−12	1.5
	Specific days	29 Sep 08	−8	−50	−5	−9	1.4
		10 Oct 08	−18	−34	−8	−1	1.2
		12 Mar 20	8	−8	−11	−10	0.9
		18 Mar 20	1	−15	−4	−5	1.3
Two-week movement (prolonged market turmoil)	Scenario	2a	−75	−75	−15	−15	5.0
		2b	75	75	−15	−15	5.0
	Historical peak	2008	−74	−162	−23	−26	8.6
		2020	−13	−118	−28	−23	6.2
	Specific periods	15-29 Sep 08	−17	−46	−7	−7	−1.4
		26 Sep-10 Oct 08	−74	−66	−23	−26	7.8
		27 Feb-12 Mar 20	−4	−110	−24	−17	−1.9
		4-18 Mar 20	4	−71	−28	−23	2.5

Note: EA = euro area. Interest rate declines are measured as the change in the three-month EUR-OIS and US T-bill rates for the euro area and the US, respectively. Stock market declines refer to the percentage change in the EURO STOXX 600 and S&P 500 indexes. Since a substantial part of euro area funds' derivatives portfolios references US markets, US figures are presented in addition to the euro area ones. Historical peak considers only declines, not largest movements in absolute terms.
Source: Bloomberg, Authors' calculations

Although these extreme market moves did not occur as a combined shock on the same day or in the same period, shocks of such magnitudes were seen separately in the three markets during the 2008 or 2020 stress episodes. For instance, the stock market crash on September 29, 2008, has seen 9 percent and 5 percent declines in the US and euro area stock markets, respectively, while the respective interest rate declines were 50 and 8 basis points and the US dollar depreciated by 1.4 percent against the euro. The direction and magnitude of our stylized shocks for the one-day market movement with a decline in interest rates (scenario 1a) are then broadly commensurate with that day, assuming a 5 percent decline in both stock markets, a 25-basis point decline in interest rates, and a 2 percent depreciation of the US dollar against the euro.

As a slight modification of the two scenarios (denoted as scenarios 1b and 2b), we also consider an increase (rather than a decrease) in interest rates to test funds' sensitivity to such a move. This modification is motivated by the March 2020 episode when interest rates reversed their declining trend amid the turmoil and rapidly bounced back within a couple of days.

3.3 Step 3: Reprice derivatives

Having defined the market shocks, we simulate margin calls by repricing single contracts in funds' portfolios. This section describes the main features of the pricing tool EPIC[11] we developed for this purpose. The tool leverages on the granular information reported in EMIR data and commercial data sources as well as the extensive literature on derivatives pricing.

Pricing models' specification in EPIC follows standard industry practices and a general risk-neutral approach, as described in, for example, Filipovic (2009), while also allowing for more complex underlying process representations restricted to affine class (Duffie et al., 2003). The contracts covered by the tool and the pricing models used are reported in Table 5. The contracts covered include interest rate derivatives (plain vanilla interest rate swaps, overnight index swaps (OIS), forward rate agreements, and EURIBOR and LIBOR futures), equity derivatives (call/put European/American options, futures, and contracts for difference), and FX derivatives (EUR/USD forwards). Regarding the models, we always resort to a less complex model specification (indicated by (1) in Table 5). Overall, the choice of the contracts to price and the models used is a result of a tradeoff between market segment size, accuracy, complexity, and data availability. For each asset class, we select the types of contracts and underlying, which are the most traded by funds in our sample.

The pricing of contracts is extremely data intensive and requires several variables that are not reported in EMIR data. Missing contract characteristics (for example, starting dates, frequency of payments, and so on) are set to the most common market practices. For example,

[11] EMIR pricing Infrastructure.

EURIBOR and USD-LIBOR indexed interest rate swaps are assumed to have six-month and three-month payment and reset frequencies for the floating leg and one-year and six-month for the fixed leg, respectively. Current and historical prices of the underlying instruments that are necessary to price plain vanilla contracts are sourced from external data providers such as Bloomberg. Whenever possible, reported market prices (ffor example, fixed interest or exchange rates, futures prices) are matched to the end-of-day midprices, and inconsistent or missing values are transformed, dropped, or replaced.

Further, volatility parameters for contracts that involve optionality are calibrated directly to the EMIR data, as in Jukonis and Thorin (2022), to obtain a smooth volatility surface. Euro area counterparties are also obliged to report their contract valuations based on the end-of-day settlement prices (or closing midprices if settlement is not available). Using this information, we select the end-of-day reports for all outstanding options of interest and invert the Black-Scholes formula to obtain the implied volatility surface. This methodology is also based on a sequential resampling algorithm that exploits the large scale of the data and performs this estimation for samples of various sizes to reject faulty or misreported transactions.

Table 5: Overview of contracts included in EPIC and models used

	Forwards	Futures	Swaps	Options	Contracts for differences
Interest rates	(1)(2)	benchmark rates (1)(2)	plain vanilla, OIS (1)(2)	caps, floor (2)	
Currency	(1)(2)	(1)(2)	(1)(2)	(3)	(1)(2)
Equity	indexes, stocks			indexes European (4) American (5)	, stocks (1)

Note: (1) Standard linear models and relationships derived using nonarbitrage arguments (see, for example, Filipovic 2009). (2) Affine representations (Duffie et al. 2003). (3) Garman and Kohlhagen (1983). (4) Black and Scholes (1973). (5) Binomial tree-type (see, for example, Cox et al. 1979).
Source: authors.

3.4 Step 4: Estimate margin calls

Using the pricing tool, we can generate changes in market values of individual contracts. However, variation margin is paid on a portfolio basis and a portfolio typically contains several contracts, so the variation margin is calculated as the sum of the changes in market value of each trade in the portfolio. The market value of the individual contracts within a portfolio can both increase and decrease over the same period, so the positive and negative contributions from market value movements of the individual trades within a portfolio are offset (are netted).

A pair of counterparties may have several portfolios (also referred to as netting sets), but usually, contracts of a certain type (for example, interest rate derivatives) in the same currency are grouped in one portfolio. The identifier of the collateral portfolio is reported in EMIR data, so in most cases, we know the portfolio to which a trade belongs[12]. We define a reliable and unique collateral portfolio code for each pair of counterparties sharing a portfolio of derivatives by concatenating the LEIs of the two counterparties with the reported collateral portfolio codes. If one of the latter does not exist, then it is replaced by the reported variation margin value.

To estimate the total liquidity need at the level of a single fund under a shock scenario, we aggregate the margin calls from the collateral portfolios the fund holds. Under the one-day market move scenario, the timing of the collateral inflows and outflows among the various portfolios of a fund may not coincide[13] and therefore, we do not net margin inflows and outflows at the fund level in our benchmark results. As a robustness check, we also calculate the results with full netting. In the prolonged market turmoil, we assume the exact timing to be less critical, and the incoming and outgoing margin payments are thus always netted.

Figure 4 shows a stylized example of the two netting assumptions. First, changes in market values of individual trades are netted on a portfolio level to derive margin payments for a portfolio. In the case of partial netting (when the timing of collateral inflows and outflows may not coincide), the total liquidity need of a fund equals the sum of the variation margin that the fund needs to post on all its portfolios, which lost market value since the last margin exchange. In the case of full netting, the total liquidity need of a fund is the sum of all margin inflows and outflows on all funds' portfolios.

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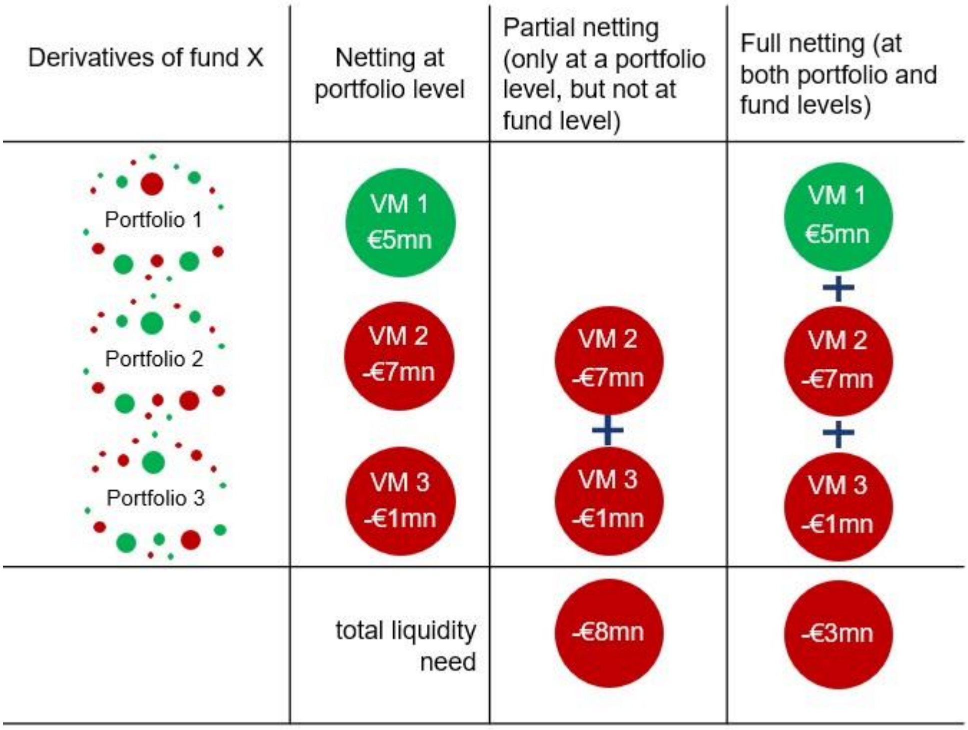
[12] EMIR data also provide information on past values of variation and initial margin posted or received on that portfolio.

[13] For example, if a fund trades with counterparties A and B, counterparty A may require the fund to post margin earlier than counterparty B delivers it to the fund.

Figure 4: Example of netting assumptions to compute the total liquidity needs of a fund.



Source: Authors.

3.5 Step 5: Measure liquidity shortfall

The next step is to measure the liquidity shortfall at the level of a single fund and for the whole sector. For each fund, we compute the liquidity shortfall as the difference between the fund's liquidity buffer and its total liquidity needs arising from margin calls. At the sector level, we report the number of funds with a liquidity shortfall and calculate the aggregate liquidity shortfall to gauge the potential spillovers to other market participants (for example, dealer banks).

Depending on the scenario, we use two different definitions of liquidity buffers in the benchmark specifications: cash under scenario 1 (one-day market movement) and cash and HQLA-L1 assets under scenario 2 (two-week market movement). The rationale for using the two different liquidity buffers is that daily variation margin payments are typically required only in cash and there could be limited possibilities to transform high-quality government bonds into cash under scenario 1. In the prolonged market turmoil (scenario 2), funds should instead have sufficient time to engage in collateral transformation, which is why we consider the liquidity buffer as consisting of both cash and HQLA-L1 assets under this scenario (see also Step 2). To check the sensitivity of the results to these assumptions, we relax the (relatively strict) assumption on the use of the cash buffer in the one-day market movement scenario with a negative interest rate shock and calculate the results for this scenario using the broader liquidity buffer.

Table 6 provides an overview of the specifications for the benchmark and robustness simulations presented in Section 4. The specifications show the signs and amplitude of the shocks, netting assumptions, and the assumptions on the use of collateral.

Table 6: Overview of the benchmark and robustness simulation specifications

		Shock				
Scenario	Duration	Interest rates	FX	Equities	Netting	Collateral
1a - benchmark	1 day	−25bps	2%	−5%	partial	cash
1b - benchmark	1 day	+25bps	2%	−5%	partial	cash
2a - benchmark	2 weeks	−75bps	5%	−15%	full	cash + HQLA-L1
2b - benchmark	2 weeks	+75bps	5%	−15%	full	cash + HQLA-L1
1a - robustness 1	1 day	−25bps	2%	−5%	full	cash
1a - robustness 2	1 day	−25bps	2%	−5%	partial	cash + HQLA-L1
1a - robustness 3	1 day	−25bps	2%	−5%	Full	cash + HQLA-L1

Source: Authors

3.6 Step 6: Rescale liquidity shortfalls to the full sample

From the perspective of the full euro area investment fund sector, the measurement of the size of an aggregate liquidity shortfall is severely limited by the (un)availability of the data. First, information on the liquidity position is available for only around 4,300 funds (Table 3), while after filtering for funds for which we can apply our methodology we are left with 3500 funds, with NAV of around EUR 1.7 trillion. But the sample of funds, for which EMIR data indicate a holding of a derivatives portfolio and for which our pricing functions allow us to calculate the variation margin, includes around 14,000 funds (representing around 68 percent of funds using derivatives). Given the limited representativeness of our sample and to account for this discrepancy, we rescale the liquidity shortfalls calculated from the small sample to the larger sample. The rescaling assumes that the ratio of the liquidity shortfall to the size of the variation margin call is the same in the two samples[14].

4 Results

We present the results in three steps. First, in section 4.1, we calculate elasticities of margin payments to single (independent) market shocks, before moving on to combinations of stylized shocks. We report these results only for the small sample of funds where we have information on liquidity positions. In section 4.2, we elaborate on the benchmark results for the combined stress scenario in all three markets, focusing on the version with interest rate declines while also rescaling the shortfalls to the full sample of euro area funds. Finally, in section 4.3, we analyze the robustness of the results for the benchmark one-day market move scenario in relation to the choice of assumptions on netting and the liquidity buffer.

4.1 Sensitivity analysis: Simple and combined shocks

As a first step, we estimate the elasticities of margin payments to interest rate, equity, and FX shocks independently and report the results in Table 7. The elasticities are calculated as changes in the value of the contracts held by funds in the sample, where information on liquidity positions is available for marginal changes in the underlying variables. Such elasticities are also known as PV01 for interest rate products and Delta for equities.

Table 7: Elasticity of margin calls to independent shocks

Type of market/ asset class	Type of shock	Variation margin call (EUR billion)
Interest rates	1bp parallel downward shift	0.065
FX/currency	1% USD depreciation vis-à-vis EUR	0.750
Equities	1% decline	0.630

Source: Authors’ calculations

The results suggest that a 1 basis point parallel downward shift in the yield curves, all else equal, would yield a margin call of EUR 0.065 billion on the funds in our small sample (in the case of a 1 basis point upward shift, the result would be symmetrical, and funds would receive variation margin payments). This reveals that euro area investment funds’ derivatives portfolios

[14] Alternative rescaling could be considered, for example by considering fund-strategy- specific rescaling factor to account for heterogeneity within the funds’ sector.

are exposed, on aggregate, to declines rather than increases in interest rates[15]. Further, a 1 percent depreciation in the US dollar vis-à-vis the euro is estimated to result in a margin call of EUR 0.75 billion in our small sample of funds. Finally, we calculate that a 1 percent decline in all equity indexes or stocks underlying the derivatives held by our small sample of funds would trigger a margin call of EUR 0.63 billion on them.

While these elasticities can provide a relatively good approximation of the funds' margin calls for small shocks in the underlying markets, they become less reliable for both larger shocks and the combinations of shocks, owing to nonlinearities in the pricing models and potential netting within portfolios in the case of shock combinations. Therefore, we proceed with simulations of margin calls for combinations of the stylized shocks defined in 3.2 and report the results in Table 8.

Table 8: Results for simple and combined market shocks

		Shock			*Margin calls (EUR billion)*				*Shortfall (EUR billion)*
Scenario	Duration	Interest rates	FX	Equities	Interest rates	FX	Equities	ALL	ALL
Interest rates	1 day	+25 bps			1.7		0.1	0.1	0.5
		−25 bps					0.1	1.8	
	2 weeks	+75 bps			5.3		0.1	0.1	0.8
		−75 bps					0.1	5.4	
Interest rates & FX	1 day	+25 bps	2%		1.7	1.4	0.1	1.4	0.6
		−25 bps	2%			1.4	0.1	3.2	1.1
	2 weeks	+75 bps	5%		5.3	0.5	0.1	0.5	0.1
		−75 bps	5%				0.1	5.4	0.8
Interest rates & equities	1 day	+25 bps		−5%	1.7		3.5	3.5	3.4
		−25 bps		−5%			3.5	5.2	3.9
	2 weeks	+75 bps		−15%	5.3		10.7	10.6	8.6
		−75 bps		−15%			10.8	16.0	9.4
ALL	**1 day**	+25 bps	2%	−5%	**1.7**	1.4	3.5	4.9	4
		−25 bps	**2%**	**−5%**		**1.4**	**3.5**	**6.6**	**4.5**
	2 weeks	+75 bps	5%	−15%	**5.3**	0.5	10.7	10.9	8.7
		−75 bps	**5%**	**−15%**			**10.8**	**16.0**	**9.4**

Note: The results for the two benchmark stress scenarios (scenarios 1a and 2a) introduced in section 3.2 are in bold. Cells in which the shortfall, shocks, and margin calls are 0 are left blank.
Source: Authors' calculations

Starting with interest rate shocks, we estimate that a 25 (75) basis point parallel downward shift in the yield curves would trigger a margin call of EUR 1.7 billion (EUR 5.3 billion) and a

[15] Since euro area insurers and pension funds tend to hedge through derivatives against declines in interest rates, funds could be "on the other side" of (some of) these trades. At the same time, a (bank) dealer would typically intermediate such a trade and thus stand "in the middle," so that the economic link may not be easily identified by using granular transaction-by-transaction data and aggregation at the sector level—such as done here—would be needed.

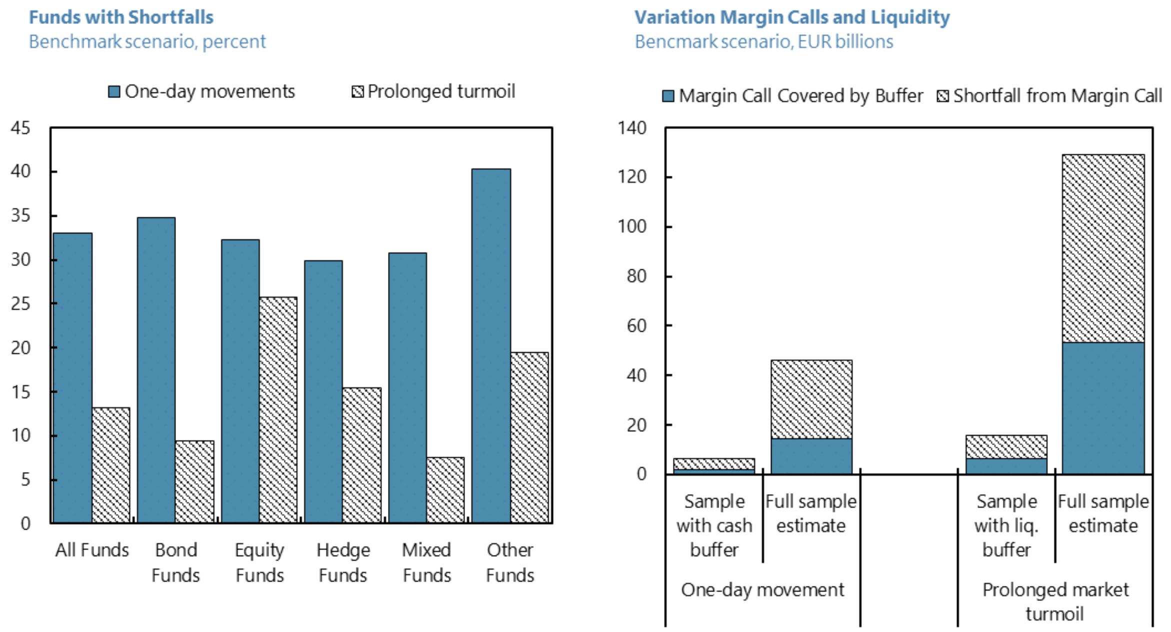
liquidity shortfall of EUR 0.5 billion (EUR 0.8 billion). Despite the broader liquidity buffer under the prolonged market stress scenario, the shortfalls are larger for this scenario compared with the one-day shock scenario. Although the shocks apply to only interest rates, a small shortfall also arises from margin payments on equity derivatives, owing to the repricing of some equity contracts due to the change in the discount curves. Margin calls triggered by changes in the FX rate and declines in equity prices (in addition to interest rate changes) increase the liquidity shortfalls substantially, highlighting the importance of analyzing shocks in these two markets in addition to those in interest rates. Adding the equity shocks to the interest rate shocks increases the shortfalls under the prolonged market turmoil scenario more than 10-fold (from EUR 0.8 billion to EUR 9.4 billion). The largest shortfalls are then associated with the combination of shocks in all three markets, reaching EUR 4 billion and EUR 4.5 billion for our benchmark one-day market move scenarios and EUR 8.7 billion and EUR 9.4 billion for our benchmark prolonged market turmoil scenarios.

4.2 Scenario analysis: Combined shocks rescaled to the full sample

Focusing on the one-day scenario of combined shocks across all three markets with interest rate declines (scenario 1a), we estimate that 33 percent of funds with derivatives exposures may not have sufficient cash buffers to absorb variation margin calls. The share is found to be even higher for bond and "other" funds, at 35 percent and 40 percent, respectively (Figure 5, left panel). The estimated cash shortfalls amount to EUR 4.5 billion for a sample of around 3,500 funds, for which data on both derivatives and liquidity buffers are available (Figure 5, left panel). By rescaling the cash shortfalls to the full sample of 14,000 funds, for which variation margin calls can be calculated (typically funds with sizable derivatives exposures), the overall cash shortfall from the simulated aggregate variation margin of EUR 46 billion is estimated to reach EUR 31 billion (Figure 5, right panel). Around 53 percent of the variation margin calls originate from equity derivatives, followed by interest rate (26 percent) and currency (21 percent) derivatives.

Under the prolonged market turmoil scenario with interest rate declines (scenario 2a), we calculate that 13 percent of funds with derivatives exposures do not have sufficient liquidity buffers to fully absorb the simulated margin call. Particularly affected are equity funds, where the share of funds with an insufficient buffer reaches 25 percent (Figure 5, left panel). This result relates to the sizable margin calls on equity derivatives simulated in this scenario (68 percent of the overall calls) and the relatively low holdings of high-rated government bonds by equity funds. The estimated liquidity shortfall for the limited sample of around 3,500 funds is EUR 9.4 billion, which—after rescaling to the full sample—results in an estimated broader liquidity shortfall of around EUR 76 billion from the simulated aggregate variation margin of EUR 129 billion (Figure 5, right panel)[16].

Figure 5: Results for the two benchmark stress scenarios split by type of fund (left panel) and rescaled to the full sample of funds (right panel)



Source: Authors' Calculations

4.3 Robustness analysis: Netting and liquidity buffer assumptions

In Table 9, we present the results for the benchmark one-day market move scenario with a negative interest rate shock (scenario 1a) but vary the assumptions on netting and the liquidity buffer. The results suggest that the assumption on netting plays a relatively minor role, as it alters the size of the simulated variation margin by around 5 percent only. The assumption on the liquidity buffer is, however, substantial: the estimated shortfall declines by around one-third if the assumption is relaxed and a broader liquidity buffer including high-quality government

[16] We run linear regressions by type of fund as robustness check, which gave comparable results, so for simplicity we kept the simple rescaling.

bonds is used. Similarly, the number of funds with a shortfall is halved but remains substantial, close to 15 percent. This result is not surprising, considering the size of the broader liquidity buffer for our sample of funds is on average around six times larger than that of the narrow cash buffer (Table 3).

Table 9: Robustness with respect to the assumptions on netting and type of liquidity buffer

Netting	Liquidity buffer	Variation margin (EUR billion)	Shortfall (EUR billion)	Share of funds with shortfall (percent)
Partial	cash only	6.61	4.50	33
Full	cash only	6.27	4.41	28
Partial	cash + HQLA-L1	6.61	2.93	16
Full	cash + HQLA-L1	6.27	2.90	13

Note: Based on the small sample of 3,523 euro-area funds, for which liquidity buffers are available. The first line corresponds to the results for the benchmark one-day market move scenario with a negative interest rate shock (scenario 1a).
Source: Authors

5 Conclusions

This paper assesses the liquidity risk faced by euro area investment funds from variation margin calls on their derivative exposures. According to the simulations of extreme stress scenarios, additional liquidity needs are estimated to be around EUR 30 billion for an extreme one-day market shock, when aggregate variation margin is simulated to reach around EUR 45 billion, and EUR 70 billion under prolonged market turmoil with simulated aggreate variation margin of around EUR 130 billion. The estimates appear realistic in view of the evidence from both the COVID-19-related market turmoil and the recent LDI episode. In mid-March 2020, daily variation margin calls on funds likely reached tens of billions of euro (Fache Rousová et al. 2020b), while in the Autumn 2022 turmoil, UK pension funds raised GBP 40 bn in cash to cover margin and collateral calls on their LDIs. Considering the large derivative exposures of euro area funds (around EUR 17 trillion of notional value), the estimates covering three derivatives classes are also sensible when compared with the same type of simulations run on interest rate swap portfolios of European insurers and pension funds (Fache Rousová et al. 2020c; Jensen and Achord 2019).

At the same time, the simulation results rely on several assumptions and, as such, must be interpreted with caution. For example, after a shock, funds may rebalance their portfolios, but the analysis assumes that portfolios are static. Similarly, the margin calls can happen concurrently to an improved market valuation of the fund's portfolio but still bring about a liquidity distress if the fund is not able to quickly monetize the valuation gain, due to their illiquidity. In addition, the actual cash/liquidity buffers available to funds to cover margin calls might differ from those considered by us: funds may have the option to use less liquid assets, while some of the assets currently considered can be already encumbered[17]. Moreover, investment funds' liquidity needs would also be aggravated if margin calls were combined with redemption requests and/or falls in prices of assets used as collateral, such as in the recent March 2020 market turmoil. Similarly, variation margin calls would likely be accompanied by initial margin calls in a period of market stress. Expansion of our simulation tool to incorporate other types of potential liquidity shocks faced by funds and simulations of the results for a wider range of stress scenarios, including the effect of a sharp yield increase, are left for future research.

Despite its limitations, the results of our paper call for enhanced prudential tools – in particular the development of a macroprudential approach – to address the liquidity risk in the fund sector, as this risk can have wider systemic implications. To be effective, such tools should aim at strengthening funds' ability under stress to meet potential funding needs, including variation margin calls, thereby containing the buildup of vulnerabilities before risks materialize.

In particular, our methodology could feed into the development of both system-wide and fund-level liquidity stress testing exercises that would incorporate the assessment of liquidity risk arising from margin calls. In line with FSB recommendation (FSB 2017), authorities conduct system-wide exercises for risk identification but such exercises typically do not cover liquidity risk arising from margin calls. Similarly, the results of our paper could be used to inform potential regulatory requirements related to robust liquidity stress tests at individual fund level. This in turn could help strengthen the assessment of liquidity risk arising from margin calls in funds' liquidity risk management frameworks.

[17] The data available at the time of the analysis did not allow for such distinction.

Limits on synthetic leverage[18] could also reduce funds' exposure to liquidity risk arising from their derivatives exposures. Such tools would make the sector more resilient to future financial turbulence and decrease the need for ex post interventions.

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[18] In EU, UCITS funds "shall ensure that its global exposure relating to derivative instruments does not exceed the total net asset value of its portfolio" (Directive 2001/108/EC), i.e. a 100 percent leverage limit, while other funds do not have such requirements, See also Chapter 1 of the April 2018 IMF GFSR for a discussion on funds leverage, and Vivat et al. (2019) for an overview of UCITS leverage restriction s in the EU.

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