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The impact of derivatives collateralisation 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 suggest that between 13% and 33% of euro area funds with sizeable derivatives exposures may not have sufficient liquidity buffers to meet the calls. As a result, they are likely to redeem 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 non-banks, particularly regarding liquidity risk in funds.

Keywords: variation margin, EMIR data, market stress, big data, non-bank financial intermediaries.

JEL Codes: C60, G23, G13, G17.

Non-technical summary

The liquidity risk in investment funds manifested itself in the March 2020 coronavirus-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, 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 much less attention to the funds' liquidity risk from margin calls on derivative exposures. This is despite the fact that the derivative market has undergone a profound structural change, owing to the OTC derivatives reform enacted as a response to the Great Financial Crisis. This reform has *inter-alia* introduced the daily exchange of variation and initial margin for the vast majority of derivative exposures. On the one hand, the exchange of margins in the form of high-quality collateral reduces counterparty credit risk. But the requirements also increase liquidity risk as counterparties need to hold (or have fast access to) sufficient amount of 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 derivative 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 hereafter), which are also often referred to as trade repository (or TR) 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 the EMIR data to calibrate pricing functions for the ten 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 collateralisation 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 to the actual liquidity buffers held by euro 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 coronavirus-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 analyses 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 ten types of contracts from the three largest derivative asset classes held by funds (interest rate, currency and equity derivatives). Last but not least, it is a pioneering study that makes use of two large granular datasets: 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 build-up of vulnerabilities before risks materialise. 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 derivative exposures. Such tools would make the sector more resilient to future financial turbulence and decrease the need for ex-post interventions.

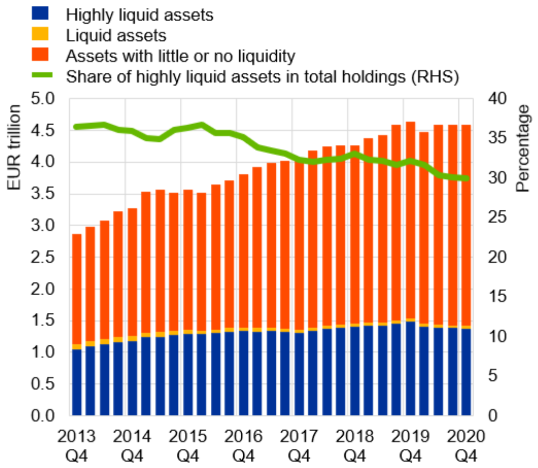
1 Introduction

The regulatory reform in the OTC derivative markets has introduced the daily exchange of variation and initial margin for the vast majority of derivative exposures. 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 fast access to) high-quality liquid collateral to meet margin calls.[1] Such liquidity risk manifested itself in the March 2020 coronavirus-related market turmoil, when market volatility and margin calls rose dramatically, including for non-bank 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 securities worth almost EUR 300 billion in the first quarter of 2020, which amplified the adverse market dynamics and by far exceeded sales of any other euro area sector (Schnabel, 2020). Despite this episode and an increasing collateralisation in derivative markets, investment funds' holdings of liquid assets continued to decline after March 2020 and reached the lowest level since 2013 at the end of 2020 (see Figure 1).

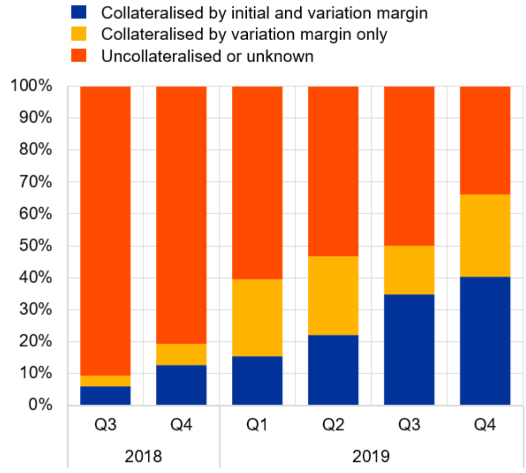
Against this background, our paper is the first – to our knowledge – to asses whether the recent levels of cash and other highly liquid asset holdings would be adequate to meet investment funds' liquidity needs from their derivative exposures under a range of market stress scenarios and shocks. The key dataset for our analysis is the complex and voluminous transaction-by-transaction derivatives data collected under the European Market Infrastructure Regulation (EMIR data hereafter), also often referred to as trade repository data. First of all, these *big data* provide 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 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' derivative portfolios under a range of scenarios. Finally, having derived the potential variation margin, we compare it to the actual liquidity positions of individual euro area investment funds, which we obtain from Refinitiv Lipper.

Our estimates suggest that between 13% and 33% of euro area funds with sizeable derivatives exposures may not have sufficient liquidity buffers to meet the calls. Overall, we estimate the

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



(a) Liquid asset holdings. Sources: ECB Securities Holdings Statistics and authors' calculations. Notes: 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.



(b) Collateralisation of derivative portfolios (lower bound). Source: EMIR data and authors' calculations. Notes: Based on selected dates close to the end of the respective quarter and the field "collateralisation" in EMIR reporting. The extent of collateralisation may be under-reported in EMIR data, owing to the limited quality of the data (e.g. missing values).

Figure 1: Liquid asset holdings and collateralisation of derivative portfolios of euro area investment funds

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 (very) liquid assets of funds (i.e., cash and government bonds eligible for the Basel Liquidity Coverage Ratio). Consequently, funds with liquidity shortages would be likely to redeem MMF shares, procyclically sell assets and draw on credit lines, thus amplifying the market dynamics under the adverse stress scenarios. But we also find that the 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 derivative 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 CDS contracts and does not examine funds' liquidity risk. While Schrimpf et al. (2020) emphasises 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 non-banks can be interlinked (Aramonte et al., 2021), our paper complements the literature on leverage in funds (Fricke, 2021, Molestina Vivar et al., 2020) and non-banks more generally (Ianiro et al., 2022, Jukonis, 2022). The topic of highly leveraged non-banks has recently gained traction, owing to the failure of Archegos, a US family office, in March 2021 (ESMA, 2022, SEC, 2022).

In addition to the focus on investment funds, the key novelty of our paper is that it looks at liquidity risk from derivatives exposures in a comprehensive way, 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 exposure to risks by building synthetic leverage. As result, they hold very diverse portfolios depending on the strategy they pursue. Similarly, our coverage of EMIR data is also very comprehensive as we use data from all seven trade repositories authorised under EMIR at the end of 2018, while other papers typically only use data from a small subset of these trade repositories (see e.g. Bank of England (2018), Abad et al. (2016)).

A few pioneer studies have recently investigated the liquidity risk from derivative exposures in (parts of) the financial system, but they only consider a very 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 only consider 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 derivative markets (interest rate, credit and currency derivatives), the modelling of market shocks in this study is very 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 derivative portfolios held by market participants but proxy the risk by considering volatility of certain market indices (e.g. S&P 500).

While it is tempting to focus on interest rate and/or currency derivatives that 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 (e.g. 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% of the variation margin calls faced by euro area investment funds originated from equity derivatives, even if these derivatives only account for around 11% of funds' derivative portfolios in terms of notional value (see Charts B1 and B2 in Fache Rousová et al. (2020b)). Third, some contracts may have a non-linear pay-off (e.g. option). Moreover, a severe shock from one market usually spreads to other markets. For all these reasons, it is paramount to study a combination of shocks and derivatives exposures in a comprehensive manner as done in our paper.

One limitation of our study is that we focus on liquidity risk from variation margin only, leaving the analysis of initial margin aside. This approach is however common to 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 modelling and estimates of initial margin are more complex and thus have been investigated mostly theoretically (Ghamami et al., 2022). Furthermore, the collateralisation of funds' portfolios by variation margin exceeds that by initial margin (see Figure 1)[2] and variation margin also tends to be more procyclical and volatile (see e.g. Bardoscia et al. (2021)). In addition, Fache Rousová et al. (2020a), Ghio et al. (2022) and Czech et al. (2021) suggest that the need of non-banks to meet variation margin can pass stress on to other markets. 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]The initial margin requirements for non-centrally 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 derivative portfolios are exempted from the requirement.

2 Data

The results presented in this paper are based on very granular data assembled from several sources. These include the transaction-by-transaction EMIR data on derivatives, Lipper data on individual funds from Refinitiv, 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. In particular, 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 derivative transaction conducted by these counterparties. The data provide information on the type of derivative, underlying, price, notional value, market valuation, collateral and life-cycle events (FSB, 2010).

Owing to their size and complexity, the EMIR data require extensive data manipulation and cleaning. Results presented in this paper are based on a cleaned sub-sample of the data using the reference date of 20 December 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 case of paired trades, we compare the two legs on significant dimensions to harmonise 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 which are already terminated or whose "action type" refers to a life-cycle state of no longer active trades. Furthermore, 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 drop trades with extremely high notional values, which appear in the data due to wrongly reported currency denomination (e.g. wrongly reported as denominated in US dollar instead of Indian rupee). To identify trades conducted by euro area funds, we filter the EMIR data using the sector classification developed in Lenoci and Letizia (2021), which also provides information on the type of fund and investment strategy. Overall, the results suggest that the notional value of euro area investment funds' derivative exposures amounted to around EUR 17 trillion in December 2018.

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
drop trades with wrongly reported currency	276	17,013,147
filter for the euro area investment fund sample	17	1,893,893

Having cleaned the EMIR data, we enrich them with information on the products underlying the derivative 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. In particular, we retrieve cash (deposit) and security-by-security holdings of bond, equity and mixed funds. 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% use derivatives. The use of derivatives clearly increases with funds' size: over 80% of funds with net asset value (NAV) over EUR 5 billion use derivatives but it is the case for less than 5% of funds with NAV below EUR 1 million. The derivative usage is found to be more prevalent for bond, hedge and mixed funds (over 45%) than for equity (33%) and real estate funds (8%).

Figure 2 indicates that the composition of funds' derivative portfolios depends heavily on their mandates. Almost half of the derivative portfolios of bond, hedge and mixed funds are interest rate derivatives, followed by currency derivatives. On the other hand, equity funds do not use interest rate derivatives and their derivative portfolios are predominantly built 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%	3,292
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	

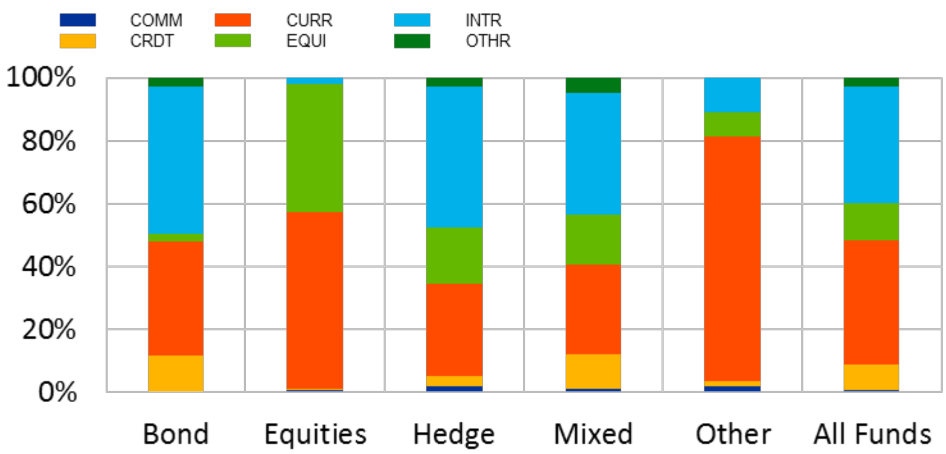


Figure 2: Notional values of euro area funds' derivative portfolios broken down by asset class and funds' investment strategy.

3 Methodology

In this section we describe the various steps we follow to assess if the fund sector can face liquidity distress from the use of derivatives. We conduct the analysis at the level of a single fund. In a nutshell, we first estimate the margin call on fund's derivative 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 that the fund suffers a liquidity shortfall. Finally, to measure the overall liquidity need and the potential spillovers to other markets and sectors, we compute the the number of funds with insufficient liquidity and derive the aggregate liquidity shortfall at a sector level.

3.1 Step 1: identifying funds' derivatives and liquidity positions

The first step consists of retrieving the positions of each fund in terms of its derivatives portfolio and liquid assets. For this, we use the granular data available from EMIR and Refinitiv Lipper presented in the previous section (Section 2).

From EMIR data, we retrieve the Legal Entity Identifiers (LEIs) of fund's counterparties, the collateral portfolio identifiers and several other attributes, which allows us to reprice the contracts in fund's portfolios. Since derivatives positions of funds tend to be complex and very heterogeneous, we consider three asset classes: interest, equity and currency derivatives, which overall represent 89% of the notional value of euro area funds' derivative 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[3]. 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 (see Table 3). When considering only funds that trade derivatives, these figures increase to EUR 15.6 and EUR 91.7 million, respectively.

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 suggests that over three quarters

[3] See e.g. www.bis.org/basel_framework/chapter/LCR

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	47,5179	
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	39,4760	

of peak margin calls in February to April 2020 paid by 'clients', typically non-bank financial intermediaries, came from available cash deposits. Cash is the most favoured asset to cover variation margin calls because it is fungible and can be transferred between counterparties very quickly. Moreover, it is the only collateral for variation margin accepted by CCPs.[4]

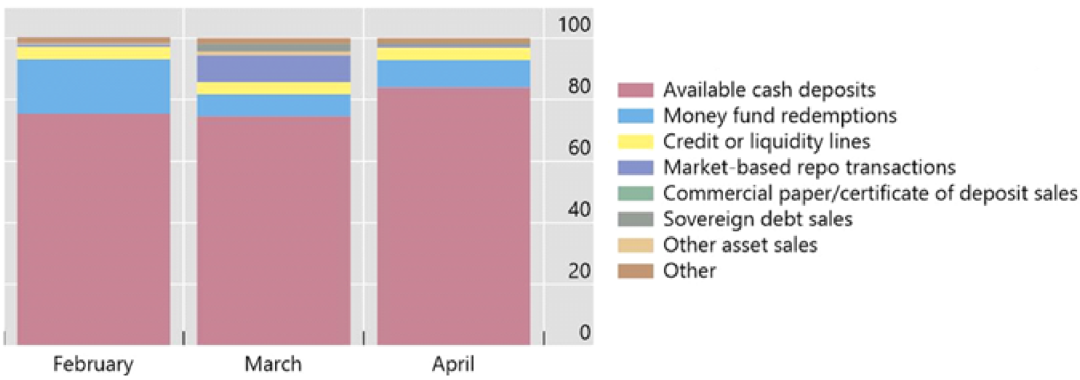


Figure 3: Funding sources for peak margin payments directly funded by the corresponding source, averaged across reporting clients (in percent). Source: Figure 22 from BCBS, CPMI, IOSCO (2022).

At the peak of the market stress in March 2020, the second most common source of liquidity were 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

[4]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.

because government bonds are the dominant type of collateral in the euro-denominated repo market, accounting for 85% of all transactions (ECB, 2021).[5] Repo market with high-quality liquid collateral such as government bonds also 'held up well' during 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 much 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 money market funds (MMFs). We do not consider this funding source as sufficiently liquid, given the significant outflows and strains that MMFs experienced during the March 2020 market 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 of non-banks (including funds) to pay variation margin on their derivative portfolios.

3.2 Step 2: defining 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 would go beyond the scope of this paper, we only consider *stylised* shocks, which are defined for each underlying asset class separately. Still, our shocks are motivated by the market moves during the 2008 financial crisis and the coronavirus-related March 2020 market turmoil. From this historical perspective, they are severe but plausible. Since it is rarely the case in historical data that all market segments experience their largest losses on the same day, we compare our stylised shocks to both (i) the peak shocks for each market segment separately (i.e. often occurring on different days/periods) and (ii) specific days/periods, on which all three markets combined performed the worst. Generally, our stylised shocks help to understand 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 (see Table 4, Scenarios 1a and 2a). Specifically, the first scenario considers an extreme one-day movement, with a 25 basis point parallel downward shift in interest rates,

[5] Out of these, bonds issued by sovereigns in six euro area countries (Germany, France, Italy, Spain, the Netherlands and Belgium) account for 92%.

a 5% decline in major stock market indices and a 2% 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% decline in stock markets and a 5% depreciation of the US dollar. 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).

Table 4: Two 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	−2	−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-weeks 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

Notes: EA indicates 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 indices. Since a substantial part of euro area funds' derivative portfolios references US markets, US figures are presented in addition to the euro area ones.

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 29 September 2008 has seen 9% and 5% declines in the US and euro area stock markets respectively, while the respective interest rate declines were 50 and 8 basis points and the USD depreciated by 1.4% against EUR. The direction and magnitude of our stylised 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% decline in both stock markets, a 25 basis points decline in interest rates and a 2% depreciation of 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 rate reversed their declining trend in the midst of the turmoil and rapidly bounced back within a couple of days.

3.3 Step 3: repricing 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[6] we developed for this purpose. The tool leverages on the granular information reported in EMIR data and commercial data sources as well as the wide 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. Specifically, 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 trade off between market segment size, accuracy, complexity and data availability. For each asset class we select the types of contracts and underlyings, which are the most commonly 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 (e.g. starting dates, frequency of payments, etc.) are set to the most common market practices. For example, EURIBOR and

[6] Emir Pricing InfrastruCture

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	indices, stocks			indices, stocks European (4) American (5)	(1)

Note. (1) Standard linear models and relationships derived using non-arbitrage arguments, see e.g. Filipovic (2009). (2) Affine representations, see Duffie et al. (2003). (3) Garman and Kohlhagen (1983). (4) Black and Scholes (1973). (5) Binomial tree-type, see e.g. Cox et al. (1979).

USD-LIBOR indexed interest rate swaps are assumed to have 6 month and 3 month payment and reset frequencies for the floating leg and 1 year and 6 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 (e.g. fixed interest or exchange rates, futures prices) are matched to the end of day mid-prices and inconsistent or missing values are either transformed, dropped or replaced.

Furthermore, 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. In particular, euro area counterparties are also obliged to report their contract valuations based on the end-of-day settlement prices (or closing mid-prices if settlement is not available). Using this information, we select the end of the 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 in order to reject faulty or misreported transactions.

3.4 Step 4: estimating 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 that the variation margin is calculated as the sum of the changes in market value of each trade in the portfolio. The market values of the individual contracts within a portfolio can both increase and decrease over the same period, so that the positive and negative contributions from market value movements of the individual trades within a portfolio offset (are netted).

A pair of counterparties may have several portfolios (also referred to as netting sets) but usually contracts of a certain type (e.g. 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 to.[7] 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[8] and, therefore, we do not net margin inflows and outflows at the fund level in our baseline results. As a robustness check, we however 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 stylised 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 to the sum of the variation margin that the fund needs to post on all of its portfolios, which lost in 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 fund's portfolios.

3.5 Step 5: measuring 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

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

[8]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.

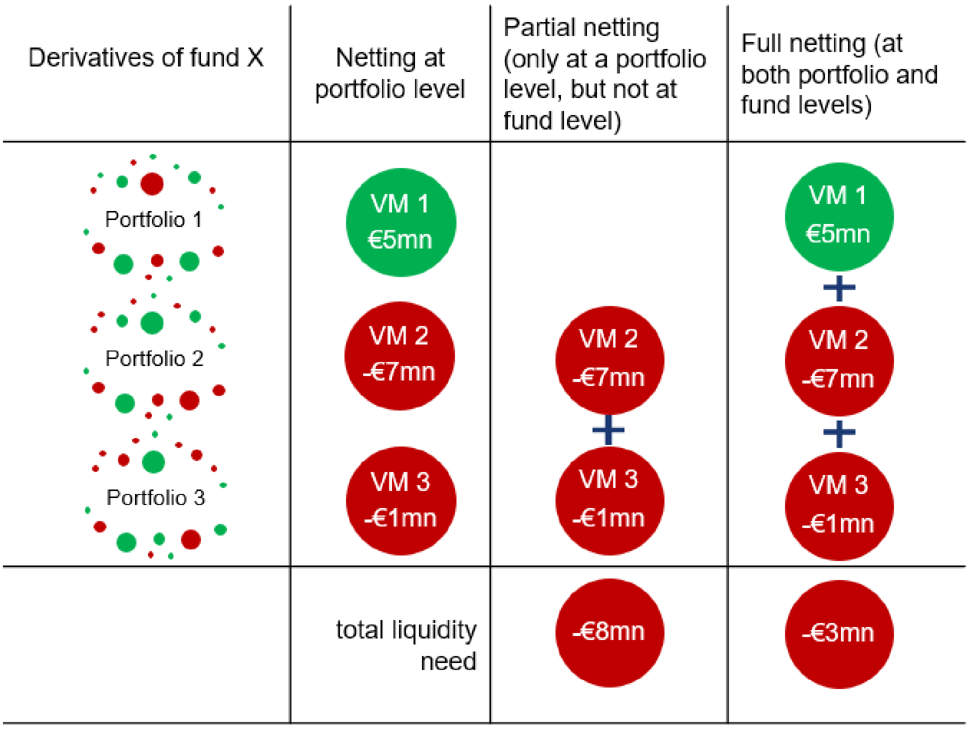


Figure 4: Example of netting assumptions to compute the total liquidity needs of a fund.

liquidity buffer and its total liquidity needs arising from margin calls. At a 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 (e.g. dealer banks).

Depending on the scenario we use two different definitions of liquidity buffers in the baseline specifications: cash under scenario 1 (1-day market movement) and cash and HQLA-L1 assets under scenario 2 (2-weeks 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 (1-day market movement). In the prolonged market turmoil (2-weeks market movement), funds should instead have sufficient time to engage in collateral transformation, which is why we consider the liquidity buffer to consist 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 also calculate the results for this scenario using the broader liquidity buffer.

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

Table 6: Overview of the baseline and robustness simulation specifications

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

3.6 Step 6: rescaling 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 liquidity position is only available for around 4,300 funds (see Table 3). But the sample of funds, for which EMIR data indicate a holding of a derivative portfolio and for which our pricing functions allow to calculate the variation margin, includes around 14,000 funds. 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.

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 stylised 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 in more detail on the baseline 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 analyse the robustness of the results for the baseline 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 with respect to 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

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 be receiving variation margin payments). This reveals that euro area investment funds' derivative portfolios are exposed, on aggregate, to declines rather than increases in interest rates.[9] Furthermore, a 1% depreciation in US dollar vis-à-vis the euro is estimated to result in a margin call of EUR

[9] 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 sector level – such as done here – would be needed.

0.75 billion in our small sample of funds. Finally, we calculate that a 1% decline in all equity indices 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 non-linearities in the pricing models and potential netting within portfolios in case of shock combinations. Therefore, we proceed with simulations of margin calls for combinations of the stylised 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					0.1	0.1	
		−25 bps			1.7		0.1	1.8	0.5
	2-weeks	+75 bps					0.1	0.1	
		−75 bps			5.3		0.1	5.4	0.8
Interest rates & FX	1-day	+25 bps	2%			1.4	0.1	1.4	0.6
		−25 bps	2%		1.7	1.4	0.1	3.2	1.1
	2-weeks	+75 bps	5%			0.5	0.1	0.5	0.1
		−75 bps	5%		5.3		0.1	5.4	0.8
Interest rates & Equities	1-day	+25 bps		−5%			3.5	3.5	3.4
		−25 bps		−5%	1.7		3.5	5.2	3.9
	2-weeks	+75 bps		−15%			10.7	10.6	8.6
		−75 bps		−15%	5.3		10.8	16.0	9.4
ALL	**1-day**	+25 bps	2%	−5%		1.4	3.5	4.9	4
		−25 bps	**2%**	**−5%**	**1.7**	**1.4**	**3.5**	**6.6**	**4.5**
	2-weeks	+75 bps	5%	−15%		0.5	10.7	10.9	8.7
		−75 bps	**5%**	**−15%**	**5.3**		**10.8**	**16.0**	**9.4**

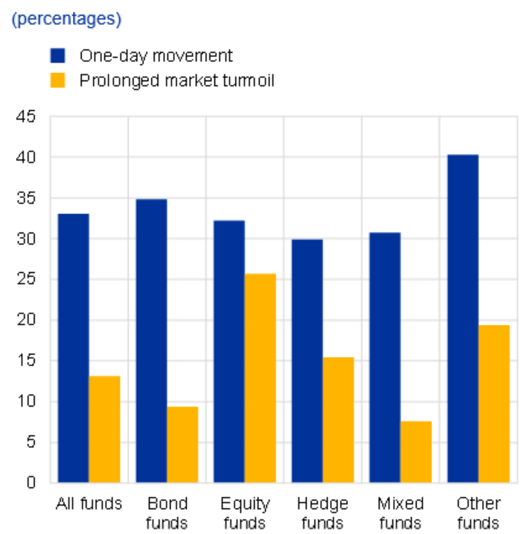
Notes: The results for the two baseline stress scenarios (Scenarios 1a and 2a) introduced in Section 3.2 are in bold. Simulations for which the shortfall is 0 are left blank.

Starting with interest rate shocks, we estimate that a 25 (75) basis points parallel downward shift in the yield curves would trigger a margin call of EUR 1.7 billion (EUR 5.3 billion) and a 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 to the one-day shock scenario. Although the shocks only apply to 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 analysing shocks in these two markets in addition to those in interest rates. In particular, adding the equity shocks to the interest rate shocks increases the shortfalls under the prolonged market turmoil scenario more than tenfold (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 baseline one-day market move scenarios and EUR 8.7 billion and EUR 9.4 billion for our baseline prolong market turmoil scenarios.

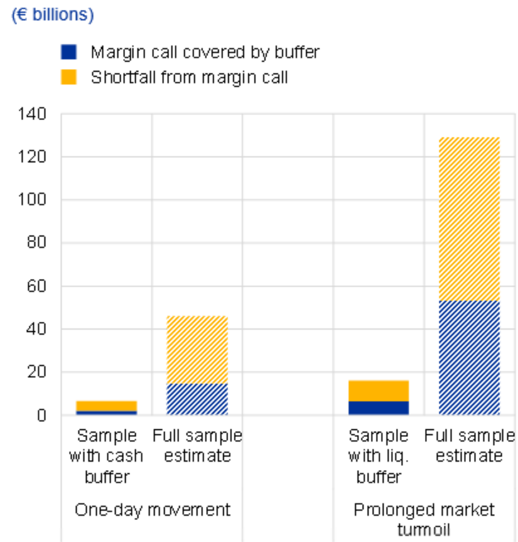
4.2 Scenario analysis: combined shocks rescaled to the full sample

Focusing on the one-day scenario of combined shocks across all three markets with interest rate declines (Scenario 1a), we estimate that 33% of funds with derivative 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, standing at 35% and 40% respectively (see 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 sizeable derivative exposures), the overall cash shortfall is estimated to reach EUR 31 billion (Figure 5, right panel). Around 53% of the variation margin calls originate from equity derivatives, followed by interest rate (26%) and currency (21%) derivatives.

Under the prolonged market turmoil scenario with interest rate declines (Scenario 2a), we calculate that 13% of funds with derivative 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% (see Figure 5, left panel). This result relates to the sizeable margin calls on equity derivatives simulated in this scenario (68% 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 (see Figure 5, right panel).



(a) Estimated share of funds with shortfalls under baseline scenarios by type of fund



(b) Variable margin calls and liquidity shortfalls under baseline scenarios rescaled to the full sample

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

4.3 Robustness analysis: netting and liquidity buffer assumptions

In Table 9, we present the results for the baseline one-day market move scenario with a negative interest rate shock (Scenario 1a) but vary the assumptions on netting and 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% 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 bonds is used. Similarly, the number of funds with a shortfall halves but still remains substantial, close to 15%. This result is not surprising taking into consideration that 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 (see 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 (%)
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%

Notes: 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 baseline one-day market move scenario with a negative interest rate shock (Scenario 1a).

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 and EUR 70 billion under prolonged market turmoil. The estimates appear realistic in view of the evidence from the recent coronavirus-related market turmoil, when daily variation margin calls on funds likely reached tens of billions of euro (Fache Rousová et al., 2020b). Considering the fairly large derivative exposures of euro area funds (around EUR 14 trillion of notional value), the estimates covering three derivative 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, have to be interpreted with caution. For example, after a shock, funds may rebalance their portfolios, but the analysis assumes that portfolios are static. In addition, the cash/liquidity buffers considered are relatively narrow as funds may have the option to use less liquid assets to cover margin calls, while our robustness analysis suggests that the choice of a liquidity buffer can influence the results substantially. On the other hand, investment funds' liquidity needs would 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 simulation of the results for a wider range of stress scenarios are left for future research.

Despite their limitations, our results call for the development of 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 build-up of vulnerabilities before risks materialise. 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 derivative 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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