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Containing risks posed by leverage in alternative investment funds

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ESRB
European Systemic Risk Board
European System of Financial Supervision

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Abstract

This paper proposes a framework for monitoring risks arising from the build-up of leverage in EU-domiciled alternative investment funds (AIFs) and examines policy tools that could be effective in mitigating these risks in line with international recommendations. We develop a novel framework that combines confidential fund-level and transaction-level data on derivatives and repurchase agreements to present a comprehensive overview of the sources of leverage in highly leveraged AIFs. Using a range of risk metrics, our analysis identifies hedge funds and funds pursuing liability-driven investment (LDI) strategies as the most vulnerable to leverage-related risks. If interest rates rise, LDI funds may face significant mark-to-market losses and liquidity needs due to margin and collateral calls. Hedge funds appear to be more resilient against this type of shock but are sensitive to credit risk, especially hedge funds with relative value strategies. To mitigate these risks, we evaluate the impact of a range of policy tools such as leverage limits and minimum haircuts on collateral used for repo. Our analysis shows that the impact of the tools depends on the types of funds considered. Imposing a direct limit on net leverage of ten times the net asset value would lead to a sizeable reduction in the net exposures of hedge funds, but would barely affect other leveraged AIFs. Minimum haircuts on collateral would most likely affect only hedge funds with relative value strategies, as LDI funds, which already operate under a leverage limit, appear to have enough unencumbered assets to meet any additional collateral requirements. Overall, our findings suggest a need for tailored policy designs and highlight the complex interplay between different regulatory measures.

Keywords: Leverage, leverage limit, yield buffer, initial margin, alternative investment funds, AIFMD, SFTR, EMIR, haircut, repo, derivatives, synthetic

JEL codes: G15, G23, G28

Executive summary

Leverage may pose significant risks to financial stability by magnifying exposures and the resulting profits and losses. Recent market disruptions, such as the 2020 US Treasury market stress episode, the 2021 Archegos Capital collapse, and the 2022 UK gilt market crisis, underscore the vulnerabilities associated with the build-up of high leverage levels in non-bank financial institutions. These events highlight the critical need for robust monitoring and containment of risks stemming from leverage in non-bank financial intermediation (NBFI) to safeguard financial stability and prevent systemic spillovers. In the EU, alternative investment funds (AIFs), including hedge funds and liability-driven investment (LDI) funds, are among the non-bank entities with the highest levels of leverage. This paper assesses the risks posed by leverage in the EU AIF sector and examines policy measures to contain these risks. We present a comprehensive framework for EU authorities to regularly monitor financial stability risks related to the build-up of leverage in AIFs. Our work is linked to recent recommendations from the Financial Stability Board (FSB) regarding leverage in non-bank financial intermediation. These recommendations call, among other actions, for a new risk monitoring framework and for the assessment of various policy measures, including both entity-based and activity-based approaches.[1]

We illustrate how combining entity- and transaction-level data allows for an in-depth risk assessment using a comprehensive set of risk metrics and a stress scenario. We merge fund-level data reported under the AIFM Directive[2] with transaction-level data on derivatives and repurchase agreements under EMIR[3] and SFTR[4]. The dataset includes information on the net asset value (NAV) of each fund, holdings of highly liquid assets, and leverage metrics, alongside detailed information on synthetic exposures[5] and repo borrowing positions. This integration facilitates a thorough analysis of financial and synthetic leverage by considering risk metrics as well as the effects of an interest rate shock, and is crucial for the proposed risk monitoring framework. Building such a robust monitoring and policy evaluation framework is a critical step towards identifying and addressing leverage-related risks in the NBFI sector.

Our analysis shows that leverage in AIFs may carry significant risks, particularly for hedge funds and LDI funds. Hedge funds exhibit the highest leverage ratios due to their extensive use of financial and synthetic leverage. LDI funds, while operating with lower leverage than hedge funds, face risks due to their reliance on interest rate swaps and repo borrowing, which exposes them to interest rate risk: a parallel upward shift in the yield curve can create substantial liquidity needs and losses for such funds. Hedge funds appear to be more resilient to this type of shock, but are

1 Financial Stability Board (2025), *Leverage in Non-Bank Financial Intermediation: Final report*, July.

2 Alternative Investment Fund Managers Directive (AIFM): **Directive 2011/61/EU** of the European Parliament and of the Council of 8 June 2011 on Alternative Investment Fund Managers and amending Directives 2003/41/EC and 2009/65/EC and Regulations (EC) No 1060/2009 and (EU) No 1095/2010.

3 European Market Infrastructure Regulation (EMIR): **Regulation (EU) No 648/2012** of the European Parliament and of the Council of 4 July 2012 on OTC derivatives, central counterparties and trade repositories.

4 Securities Financing Transactions Regulation (SFTR): **Regulation (EU) 2015/2365** of the European Parliament and of the Council of 25 November 2015 on transparency of securities financing transactions and of reuse and amending Regulation (EU) No 648/2012.

5 Synthetic exposures are financial positions that replicate the economic characteristics of holding an underlying asset without directly owning it, typically created through derivatives such as swaps, futures or options.

potentially sensitive to other types of market risk. For instance, we document that hedge funds with relative value strategies are vulnerable to credit risk.

Our policy assessment offers important lessons for the design and calibration of measures to contain leverage-related risks. We show that the impact of measures such as direct leverage limits and minimum haircuts on repo collateral varies significantly across fund types. Hedge funds are notably affected by even moderate leverage limits, while LDI funds require stricter limits for an impact to be seen. Minimum haircuts also tend to constrain hedge funds given their limited holdings of unpledged collateral. LDI funds, by contrast, hold plenty of additional collateral, and would not need to deleverage if haircut floors were introduced. Our findings suggest a need for tailored policy designs and highlight the complex interplay between different regulatory measures. Future research could focus on the development of risk-sensitive direct leverage limits for complex hedge fund strategies.

1 Introduction

Leverage in investment funds can pose significant risks to financial stability by amplifying exposures and the resulting profits and losses. Funds can increase their exposures through financial leverage, such as outright bank borrowing or collateralised borrowing in the repo market, or through synthetic leverage by using derivatives. In adverse market conditions, mark-to-market losses can be amplified by leverage, and the net asset value of these funds can be reduced more than proportionally, leading to investor losses and heightened credit risk for counterparties. Synthetic leverage also introduces liquidity risk, as funds may need to meet margin calls on derivatives due to mark-to-market losses (variation margin) or changing market conditions (initial margin). Furthermore, a decline in the value of collateral used for repo borrowing may necessitate additional collateral or cash to cover valuation losses. This can create a feedback loop where declining asset values trigger forced sales to raise cash, thereby exacerbating market stress.

Recent episodes of market stress have illustrated the vulnerabilities associated with leverage among non-bank financial institutions (NBFIs). In March 2020, elevated leverage in NBFIs, including hedge funds, strained the US Treasury markets during the “dash for cash” episode, due to inadequate supervisory guidance and minimal haircuts for funding transactions (Kruttli et al., 2021). The March 2021 collapse of Archegos Capital revealed significant leverage and mispriced counterparty credit risk, emphasising the need for enhanced risk management and regulatory oversight for family offices (Bouveret and Haferkorn, 2022). In 2022, the commodities market faced stress from position liquidations driven by rising margins and counterparty credit risk, compounded by insufficient disclosure and transparency in synthetic exposures. Subsequently, in September 2022, leverage in liability-driven investment (LDI) strategies intensified the sell-off in the UK gilt market, causing forced asset sales and market disruption, prompting the Bank of England to step in with a large purchase programme (see Dunne et al., 2023).

In the EU investment fund sector, high leverage is predominantly associated with alternative investment funds (AIFs).[6] These funds are covered by the Alternative Investment Fund Managers Directive (AIFMD) and include hedge funds, real estate funds and private equity funds. AIFs are typically marketed to institutional investors and generally operate with limited regulatory restrictions on leverage levels or sources.[7] AIFMD facilitates comprehensive data collection on fund leverage, liquidity and exposures to asset classes, enabling national competent authorities (NCAs) to annually assess leverage-related risks (Haquin and Proietti, 2024). Article 25 of AIFMD provides NCAs with the authority to impose leverage limits or other restrictions in cases where leveraged AIFs contribute to the build-up of systemic risk or disorderly markets. To date, such powers have

6 Unlike AIFs, UCITS are subject to leverage limits. Under the commitment approach – used by most UCITS – the global exposure, including positions acquired through derivatives, is limited to 100% of the fund’s net asset value (NAV) after netting and hedging. UCITS using the Value-at Risk (VaR) approach are subject to indirect limits on leverage through caps on market risk, and therefore some of them may exhibit high leverage. ESMA (2025) provides evidence of VaR UCITS with very high gross leverage, including some funds with gross leverage levels above those of AIF hedge funds. See also European Systemic Risk Board (2024) and Molestina Vivar et al. (2023). In some countries, national law and regulation can also cap leverage for certain types of AIFs.

7 AIFMD prescribes maximum leverage limits for loan-originating AIFs: 175% for open-ended funds and 300% for closed-ended funds, calculated as the ratio of the AIF’s exposure (using the commitment method) and its NAV. In addition, AIF managers set internal leverage limits which they may apply on behalf of each AIF they manage.

been used on two occasions; once in 2022 following concerns over Irish property funds[8] and then again in 2024 to address leverage risk among Irish and Luxembourg GBP-denominated LDI funds following the 2022 “mini-budget” crisis. The indirect leverage limit on GBP LDI funds is referred to as the “yield buffer”, as AIFMs must maintain a level of liquid assets to withstand a minimum increase of 300 basis points in UK yields before their NAV turns negative (see CSSF, 2024 and CBI, 2024).

In this analysis, we explore the risks posed by leverage among EU-domiciled alternative investment funds and evaluate policy options to contain these risks. We focus on highly leveraged funds with gross leverage above three times their net asset value (NAV).[9] Our sample of 655 funds can be subdivided into hedge funds, LDI funds and other leveraged funds. Their total NAV is €170 billion, while their total gross exposures exceed €1 trillion, reflecting the high level of leverage among this particular group of funds.

We combine entity-level data with transaction-level data on repos and derivatives to obtain a comprehensive picture of the leverage employed by AIFs. Entity-level data reported under AIFMD include information on fund characteristics, measures of resilience such as holdings of liquid assets and NAV, and portfolio exposures. However, the information on asset exposures, including derivative contracts and repo transactions reported under AIFMD, is not sufficiently granular to allow for a comprehensive risk assessment and evaluation of policy options. By contrast, transaction-level data reported under EMIR and SFTR provides up-to-date and granular information on the exposures of funds, but fails to provide information on fund characteristics and measures of their resilience. Therefore, merging these three different data sources is crucial to gain a thorough understanding of leverage in AIFs and to provide policy suggestions to address related risks.

Panel a) of Figure 1 below illustrates how transaction-level data enrich the information on funds’ balance sheets available in AIFMD data. On the assets side, EMIR and SFTR data can be used to identify encumbered assets arising from derivative positions (collateral posted as initial margins) or from repo borrowing (pledged bonds). This, in turn, allows an estimate to be made of the amount of unencumbered cash and unpledged bonds that could be mobilised to meet further liquidity demands related to margin calls or collateral calls. On the liabilities side, SFTR reporting provides information on the maturity and types of repo borrowing used by funds. Position-level EMIR and SFTR data can also be used to estimate mark-to-market losses and potential margin and collateral calls in the event of adverse market developments.

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[8] All new Irish property funds will need to comply with a 60% leverage limit, while existing funds are granted up to five years to comply (see Central Bank of Ireland, 2022).

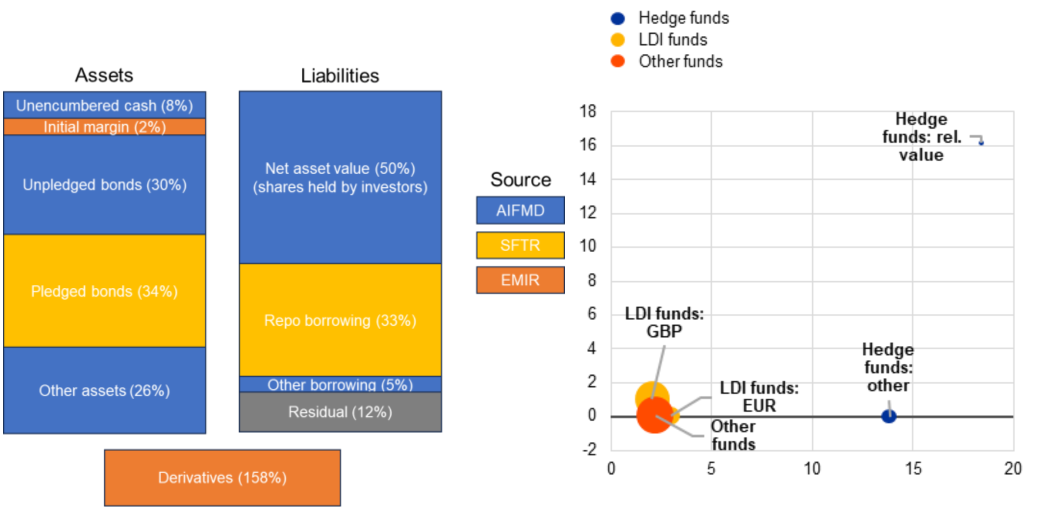
[9] AIFMD defines “substantially leveraged” funds as those with commitment leverage greater than 300%. The threshold used here relates to gross leverage, as there are data quality concerns with the values reported for net leverage according to the commitment method.

Figure 1

Synthetic leverage, financial leverage and data sources

a) Stylised balance sheet of an AIF and data sources | *b) Synthetic and financial leverage*

(x-axis: synthetic leverage; y-axis: leverage through repo, both expressed as multiples of NAV)



Sources: AIFMD, SFTR and EMIR data.

Notes: Panel a): the different colours indicate the different sources of the data. Percentages refer to the value of the positions (cash, initial margin, etc.) of all leveraged AIFs compared with the sum of all assets held by these AIFs. For derivatives, the gross notional exposure over total assets is displayed. SFTR and EMIR data provide transaction-level information, whereas AIFMD data include only information on exposures at the level of asset classes. Owing to discrepancies across the three datasets, the sum of assets is not equal to the sum of liabilities. Since we average across all funds in our sample, this figure does not reflect the high degree of heterogeneity within and across fund types. Panel b): synthetic leverage is measured as gross synthetic exposure (EMIR) divided by NAV (AIFMD). Leverage through repos is measured as gross repo borrowing (SFTR) divided by NAV (AIFMD). The size of the circles is proportional to the NAV of the AIF groups. Leverage through repos for other hedge funds is very low and is set to zero in the figure to comply with data confidentiality guidelines. Other funds refer to leveraged funds from the “other” fund category.

Leverage metrics point to risks in the hedge fund sector and for LDI funds. Within our sample of highly leveraged funds, hedge funds have much higher levels of leverage than LDI funds and other leveraged funds. Looking at sources of leverage, all types of highly leveraged funds have synthetic exposures through derivatives, but only hedge funds pursuing relative value strategies and GBP-denominated LDI funds rely on financial leverage from repo borrowing (see Figure 1, panel b). Other forms of financial leverage are not commonly employed by the funds in our sample. In addition to leverage metrics based on notional exposures, we consider the ratio of the initial margin posted by the AIF relative to its NAV. Such a metric based on initial margin incorporates the netting of exposures and captures the derivatives portfolio’s sensitivity to market risk, making it a valuable complement to standard leverage metrics.

We also examine liquidity risks from margin and collateral calls, as well as the interconnectedness with banks that act as leverage providers. We construct measures of leverage-related liquidity risk as the ratio of repo borrowing or synthetic exposures to unencumbered cash. Based on these metrics, hedge funds – especially those with relative value strategies – appear to be most vulnerable to leverage-related liquidity risks. Our analysis of the counterparties of highly leveraged AIFs reveals that GBP-denominated LDI funds trade primarily with UK banks, in both the repo and derivatives market. For hedge funds, most financial leverage through repo is provided by EU commercial banks, whereas their counterparties in the derivatives market are both US and EU investment banks.

We estimate the resilience of highly leveraged AIFs to adverse changes in certain risk factors. Since both LDI funds and relative value hedge funds are exposed to interest rate risk, we compute the impact of a parallel upward shift in interest rate curves on the NAV and available liquidity of funds using granular transaction-level data. LDI funds are most vulnerable to this shock because of their concentrated exposures to long-dated government bonds. In contrast, relative value hedge funds appear more exposed to adverse changes in credit spreads, given their concentrated exposures to credit assets such as corporate bonds.

We evaluate the potential of direct leverage limits and minimum haircuts to mitigate the risks posed by leverage, focusing on their effects on permissible leverage among AIFs. In our assessment, we consider both the extensive margin, i.e. the fraction of affected funds or transactions, and the intensive margin, i.e. the reduction in exposures. Leverage limits are expressed as a ratio of gross or net exposure to NAV. A relatively loose gross leverage limit of 10 would already affect more than half of the EU hedge fund sector, while a relatively strict limit of 5 or below would be needed to significantly reduce leverage among LDI funds and other leveraged funds. Looking at minimum haircuts, we observe that current haircuts tend to be very low or even zero. However, since LDI funds typically hold significant amounts of unpledged bonds that are available as additional collateral, they would not need to reduce their repo borrowing should minimum haircuts be introduced. This stands in contrast to relative value hedge funds, which would need to reduce their repo borrowing by around one-half in this scenario because they cannot pledge additional bonds. A full assessment of other options to contain leverage, such as indirect leverage limits (e.g. minimum yield buffer requirement for LDI funds) and required margins, as well as an analysis of potential unintended consequences (e.g. the adaptation of fund strategies and regulatory leakage), goes beyond the scope of this paper.

Our analysis is closely related to work on non-bank leverage by the Financial Stability Board (FSB). In a recent report (FSB, 2025), the FSB makes recommendations on how to address leverage-related risks among NBFIs. One key recommendation is that authorities should establish a framework for monitoring and identifying risks posed by NBFI leverage. Our analysis can form the basis for implementing this recommendation for EU-domiciled AIFs, as we follow the list of metrics suggested by the FSB for this purpose. Notably, the consultation report also recommends assessing a broad spectrum of policy measures, including both activity-based and entity-based approaches, to identify the most suitable policies when financial stability risks stemming from NBFI leverage arise. By exploring the impacts of various policy options, we are putting this recommendation into practice.

Compared with earlier research on risks arising from leverage among alternative investment funds, we provide a more detailed analysis by complementing entity-level data collected under AIFMD with transaction-level data. Haquin and Proietti (2024) assess risks from leverage among EU AIFs by using AIFMD data to illustrate the application of the Guidelines on Article 25 of AIFMD. Similarly, van der Veer et al. (2017) analyse leverage-related risks in Dutch AIFs using AIFMD data only. Data reported under EMIR and SFTR allow us to provide information on counterparties, haircuts and initial margins as well. Moreover, thanks to transaction-level data, we can compute sensitivity to interest rate risk and corroborate the aggregate borrowing positions and synthetic exposures reported under AIFMD. To the best of our knowledge, the only prior publication that combines AIFMD data with transaction-level data is the special feature on LDI funds in ESRB (2023). Our focus is broader, since we consider hedge funds and leveraged funds in the "other funds" category in addition to LDI funds, and we also engage in a more detailed discussion on policy measures.

In contrast to earlier research on the effects of minimum haircuts, our analysis considers information on unpledged bonds. Grill et al. (2025) assess the impact of the introduction of the FSB minimum haircut framework on the euro area repo market, focusing in particular on (i) the increase in pledged capital necessary to maintain repo borrowing levels, and (ii) the decrease in repo borrowing if pledged capital is held constant. Since they rely on transaction-level data only, they do not know whether entities have suitable unpledged collateral in their portfolio that they could pledge to maintain repo borrowing. By combining entity-level AIFMD data with transaction-level SFTR data, we overcome this problem and show how heterogeneity in the portfolio composition of AIFs can lead to very different effects of minimum haircuts on levels of financial leverage. Moreover, we focus on the Eurosystem minimum haircut framework, which includes sovereign bonds, while the existing FSB minimum haircut framework does not apply to this important type of repo collateral.

2 Building a comprehensive dataset of leveraged AIFs in the EU

Monitoring systemic risks requires detailed and timely information on the resilience and exposures of leveraged funds, which can be achieved by merging entity- and transaction-level data. Entity-level data, such as data reported under AIFMD, provide information on NAV, available liquidity, asset class exposures and the use of leverage by AIFs. However, the low frequency and lack of granularity of such data make them insufficient for monitoring risks in a comprehensive manner. Meanwhile, transaction-level data, such as data reported under EMIR and SFTR, provide detailed and timely information on derivatives and repo positions but fail to provide information on the resilience of counterparties, such as their NAV and available liquidity.

This chapter describes how we construct a dataset of highly leveraged AIFs based on AIFMD, SFTR and EMIR data. Section 2.1 describes the three datasets used, Section 2.2 explains the selection of highly leveraged funds, and Section 2.3 describes how we enrich the AIFMD sample of funds with information reported under EMIR and SFTR.

2.1 Data reported under AIFMD, EMIR and SFTR

Under AIFMD[10], fund managers that are active in the EU are required to provide information on the funds they manage. AIF managers domiciled in the EU or with funds domiciled or marketed in the EU fall within the scope of AIFMD. The reporting frequency (quarterly, semi-annually or annually) and other variables depend on domicile, size, leverage and other factors. Important AIFMD variables that are crucial for our analysis relate to (i) size, measured by NAV and (regulatory) assets under management (AuM)[11]; (ii) leverage, which is computed using the gross method and the commitment method[12]; (iii) fund type and primary strategy; and (iv) available liquidity. Moreover, AIFMD data contain information on the total amount borrowed (including borrowing through repos), total notional exposures to various types of derivatives, and securities exposures aggregated by security type (corporate bonds, sovereign bonds, etc.).

Under SFTR[13], EU entities are required to report repurchase agreements and other types of securities financing transactions. In this analysis, we focus on repos, as the most important type of security financing transaction for AIFs. SFTR data contain daily information on the counterparties, the principal amount, the maturity date, the collateral posted, the haircut, and further contract details for each outstanding repo transaction. If both counterparties are located in the EU, SFTR data contain two reports on the transaction, one from the perspective of each counterparty.

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[10] For further details, see *ESMA Guidelines on reporting obligations under Articles 3(3)(d) and 24(1), (2) and (4) of the AIFMD*.

[11] Under AIFMD, assets under management are defined as the sum of all exposures, including those acquired through the use of leverage.

[12] See Section 3 or ESMA (2019, p. 40--44) for a definition of these leverage metrics.

[13] For further details, see **SFTR reporting**.

Under EMIR[14], EU entities are required to report derivative transactions. EMIR data contain daily information on the counterparties, the notional amount, the maturity date, the underlying asset, the contract type, and further contract details for each outstanding derivative transaction. Moreover, EMIR data on the initial margin and variation margin posted and received are available at the portfolio level. Similar to SFTR data, EMIR data contain two reports on the transaction (one from the perspective of each counterparty) if both counterparties are located in the EU.

2.2 Sample of highly leveraged funds

Our analysis focuses on investment funds with a legal entity identifier (LEI)[15] that are domiciled in the EU, based on end-2023 data. We link AIFMD observations to SFTR and EMIR data using the LEI. We discard observations with duplicate LEIs, which can arise if a fund manager uses the same LEI to execute transactions for several funds, as in such case we are unable to assign repo and derivative transactions to individual funds. We also discard below-threshold funds, which are subject to less comprehensive reporting obligations under the AIFMD, as well as feeder funds[16]. We focus on end-2023 data, since end-of-year data is available for all AIFs.[17]

Panel a) of Figure 2 further below shows the various types of investment funds featured in our sample of EU-domiciled AIFs with a unique LEI. Our sample includes funds of funds, hedge funds, private equity funds and real estate funds. The largest category of investment funds is “other” funds (see ESMA, 2020, p. 35-41 for a discussion of this category). The primary strategy reported under AIFMD can be used to further divide “other” funds into commodity funds, equity funds, fixed income funds, infrastructure funds and “other-other” funds (i.e. funds with a strategy that cannot be described by any of the labels just mentioned). A predominant AIF type of “None” refers to cases in which a fund is best described as a mix of several types.

We focus on highly leveraged alternative investment funds and include only those with an AuM/NAV leverage ratio above 3 in our sample. Article 111(1) of Commission Delegated Regulation (EU) No 231/2013, which supplements AIFMD, defines AIFs that employ leverage on a substantial basis as AIFs with commitment leverage above 3. However, the commitment leverage variable presents certain data quality issues. Therefore, we proxy AIFs using high leverage as those with an AuM/NAV ratio above 3 (see also ESMA, 2023). Regulatory AuM, as reported under the AIFMD, includes exposures to derivatives, and therefore the AuM/NAV leverage metric captures both financial and synthetic leverage. The AuM/NAV ratio is very close to a gross leverage

14 For further details, see **EMIR reporting.**

15 For further details, see the **Global Legal Entity Identifier Foundation (GLEIF)**.

16 Feeder funds are funds that invest only in another fund known as the “master fund”. Failing to discard feeder funds would result in the investment being counted twice .

17 For the transaction-level datasets, the reference date is the 29 December, because the 30 and 31 December were not trading days. Due to concerns over window dressing (the practice of funds temporarily adjusting their portfolios before reporting dates to present a more favourable risk profile), we check whether our results are robust to the use of transaction-level data from 15 November, the middle of the fourth quarter. Panel a) of Figure 17 in the appendix shows no evidence of window dressing for repo borrowing among the AIFs in our sample. Panel b) of Figure 17 shows that gross synthetic exposures are 13% lower on 29 December compared with 15 November, which could reflect either a modest window-dressing effect or other market developments. We also test the robustness of our interest rate shock analysis and find that deviations from using mid-quarter data remain within ±15% and do not meaningfully alter our conclusions.

ratio and, as such, might overestimate the size of leveraged AIFs compared with commitment leverage, suggesting a more conservative approach in our analysis.

Leveraged AIFs with an AuM/NAV above 3 are most common among hedge funds and "other" funds. Highly leveraged funds of other types (such as funds of funds, private equity funds and real estate funds) make up less than 10% of AuM combined.[18] Moreover, leveraged funds of these types often do not obtain leverage through derivatives or repo borrowing, but rely on other leverage sources, such as loans. For this reason, we focus only on highly leveraged hedge funds and "other" funds in our analysis.

We identify liability-driven investment (LDI) funds among "other" funds using a list of LEIs compiled for the EU NBFI Risk Monitor 2023 (ESRB, 2023, p. 24). LDI funds were identified by searching for AIF names and descriptions of investment strategies that include "LDI", "liability-driven", "liability matching", "liability solution", "liability aware" or "overlay". While the list of funds was corroborated by supervisors in Ireland, Luxembourg and the Netherlands, it might not include all LDI funds.

Panel b) of Figure 2 below shows the resulting sample of highly leveraged hedge funds, LDI funds, and remaining "other" funds. The sample contains 96 hedge funds, 222 LDI funds and 337 other leveraged funds, such as leveraged fixed income and mixed funds. Compared with the whole universe of AIFs, the highly leveraged hedge funds included in our sample make up 16% of all EU hedge funds in terms of NAV (68% in terms of AuM). Meanwhile, the LDI funds featured in our sample account for 49% of all LDI funds (72% of AuM) and the highly leveraged other funds account for 3% of all "other" funds (10% of AuM). AIFMD provides a granular classification of hedge fund strategies, although we confine ourselves to the distinction between relative value strategies and other strategies throughout our analysis. Hedge funds with a relative value strategy stand out because they reach the highest levels of leverage and rely heavily on repo borrowing. Moreover, we categorise LDI funds according to their base currency, which reveals the geographic focus of their investments and the origin of their owners. GBP-denominated LDI funds make up roughly 75% of total LDI funds in terms of their number, NAV and AuM, while EUR-denominated LDI funds account for the remaining 25%.

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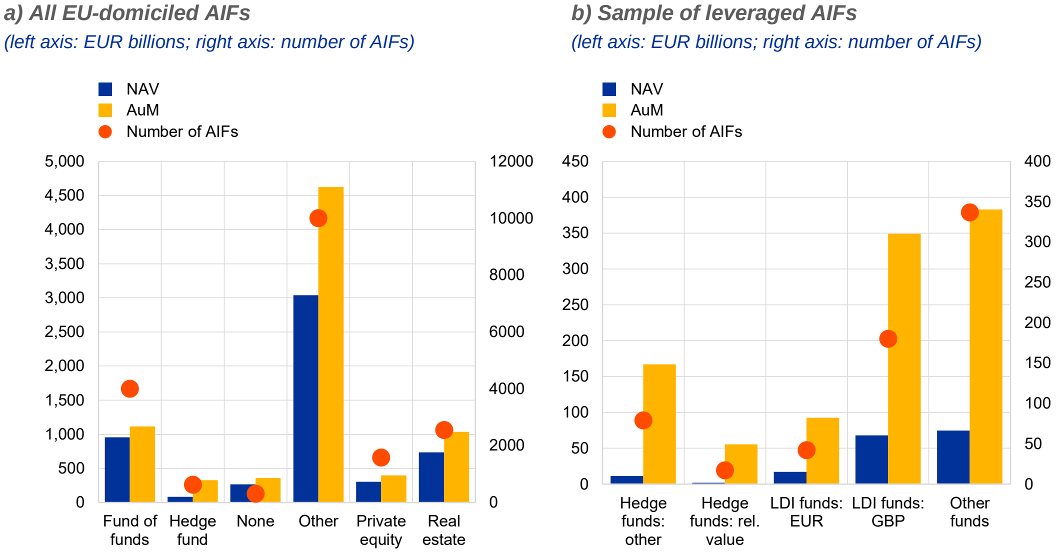
[18] Note, however, that private equity funds benefit from a carve-out under AIFMD: unlike other AIF types, they do not have to report the leverage embedded in their investments (with a look-through approach) and therefore artificially appear almost entirely unleveraged. Indeed, ESRB (2024) noted that "there is little visibility on the use of leverage by private equity funds since they do not report exposures at the portfolio company level" (p.14).

Figure 2
Sample selection



Source: AIFMD data.
Notes: Panel a): end-2023 sample of EU-domiciled AIFs that report a unique LEI under AIFMD. Feeder funds, below-threshold funds and two AIFs that report the wrong LEIs are excluded. Panel b): subsample of leveraged hedge funds, LDI funds and other funds with an AuM/NAV above 3. See the main text on how we identify LDI funds from among the AIFMD data.

2.3 Merging AIFMD data with transaction-level data

We remove invalid transaction reports from SFTR and EMIR using standard filters. For SFTR data, we follow data-cleaning steps that have been used previously in ECB publications such as Bassi et al. (2025). We remove transactions with a settlement date after the reference date (29 December 2023), transactions with a maturity date before or on the reference date, and transactions with implausibly large principal amounts (larger than €100 billion). We also remove reports relating to repo transactions that have been repriced in the meantime but not removed. For EMIR data, we follow data-cleaning steps that have been previously used in ECB publications, such as Cominetta et al. (2019) and Rousová and Letizia (2018). We remove transactions with a termination date or maturity date before the reference date, transactions with implausibly large notional amounts (the thresholds here depend on the type of derivative) and transactions with outdated contract valuations (older than 10 days). We also construct clean asset class and contract type variables that combine the information from the CFI code[19], the self-reported asset class and contract type, and the set of specific fields for each asset class. For EMIR, we use a deduplicated dataset as a starting point, whereas we use only the information reported by AIFs for SFTR because deduplication has not been implemented for the ESRB version of the SFTR data.

We use LEIs to link transaction-level variables in SFTR and EMIR to observations in AIFMD data. Some variables are available in AIFMD data and can also be computed using transaction-

[19] CFI stands for Classification of Financial Instruments and corresponds to the ISO norm 10962:2021.

level data, such as gross repo borrowing or gross notional exposures to derivative types. In these cases, we report both versions of the same metric and are transparent about discrepancies across the datasets.

3 Exploring the risks posed by leveraged AIFs

We explore the risks posed by highly leveraged AIFs using metrics suggested in the final report on leverage among NBFIs published by the Financial Stability Board (FSB, 2025). Variables such as repo borrowing or the total notional of derivatives measure the exposure of an entity, whereas other variables, such as NAV or available liquid assets, measure its resilience. Many useful metrics can be constructed as the ratio between an exposure metric and a resilience metric, including financial leverage (borrowing/NAV) or liquidity risk from margin calls (synthetic exposure/liquidity). We first report overall leverage metrics (Section 3.1), followed by metrics on financial leverage (Section 3.2) and then synthetic leverage (Section 3.3). For synthetic leverage, we consider metrics based on initial margins posted in addition to metrics based on notional amounts, because such metrics are more informative about sensitivity to market risk.

We supplement these metrics with stress scenarios that shed light on the sensitivity to interest rates in Section 3.4. Our analysis focuses primarily on how higher risk-free rates affect NAV and available liquidity. For this purpose, we approximate instrument-level mark-to-market gains and losses in response to interest rate shocks using data on repo collateral and interest rate swaps, aggregate them at the fund-level, and then compare them with the self-reported interest rate sensitivities under the AIFMD. To illustrate the vulnerabilities of relative value hedge funds exposed to credit risk, we also consider their resilience to a shock to credit spreads. Other sources of market risk, such as changes in stock prices, the yield curve slope and exchange rates are omitted because self-reported risk sensitivities are too unreliable, and because we lack the appropriate tools to compute valuation changes ourselves.

3.1 Overall leverage

The overall leverage metrics in AIFMD data that measure both financial leverage and synthetic leverage include AuM/NAV, leverage according to the gross method, and leverage according to the commitment method. To compute leverage metrics, derivative positions are converted into the equivalent position in their underlying assets and security financing positions are included as well as exposure gained from reinvesting cash borrowing. The main difference between leverage computed according to the gross and the commitment method is that the latter takes netting and hedging arrangements into account, whereas the gross method simply adds up the absolute values of positions. It also excludes the value of cash and cash equivalents in the base currency, whereas the commitment method includes this information. Despite the improvements made in the last few years, leverage according to the commitment method can be frequently misreported under AIFMD (see ESMA, 2019, p. 40-44). AuM/NAV is an alternative leverage measure that is less error-prone and closely aligned with leverage according to the gross method.

In our sample, hedge funds with relative value strategies show the highest levels of leverage according to all three leverage metrics (see Figure 3, panel a). Among other leveraged hedge funds, these leverage metrics take substantially lower values. As expected, LDI funds and other leveraged funds show lower levels of leverage than hedge funds. Taking netting and hedging into account reduces the measured leverage, especially for hedge funds pursuing a relative value strategy. The leverage levels found for hedge funds are consistent with earlier results in ESMA (2019, p. 48-51) and leverage measures reported by hedge funds in the United States.[20]

Figure 3

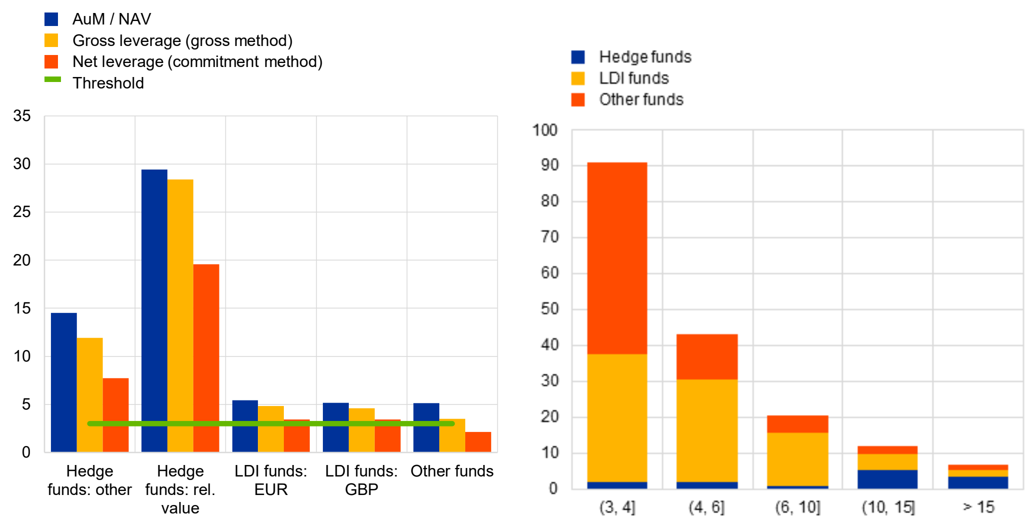
Overall leverage

a) Leverage metrics

(y-axis: multiples of NAV)

b) Distribution of gross leverage (AuM/NAV)

(x-axis: multiples of NAV;
y-axis: aggregate NAV in EUR billions)



Source: AIFMD.

Notes: Panel a): the values reported for each type of leveraged AIF are averages weighted by NAV. The green threshold refers to the condition of gross leverage (AuM/NAV) being greater than 3 to select highly leveraged funds.

3.2 Financial leverage

Repo borrowing is an important source of leverage mainly among hedge funds pursuing a relative value strategy and among GBP-denominated LDI funds (see Figure 4, panels a and b). About 80% of the AIFs in these categories borrow in the repo market, whereas only around 10% of leveraged funds in other categories do so. Relative value hedge funds and GBP-denominated LDI funds also dominate the AIF segment of the repo market in terms of borrowing volumes, with a borrowing volume of €70 billion among GBP-denominated LDI funds and €31 billion (according to SFTR data) or €14 billion (according to AIFMD data) among relative value hedge funds.[21] In contrast to GBP-denominated LDI funds, LDI funds with EUR as their base currency are barely active in the repo market.

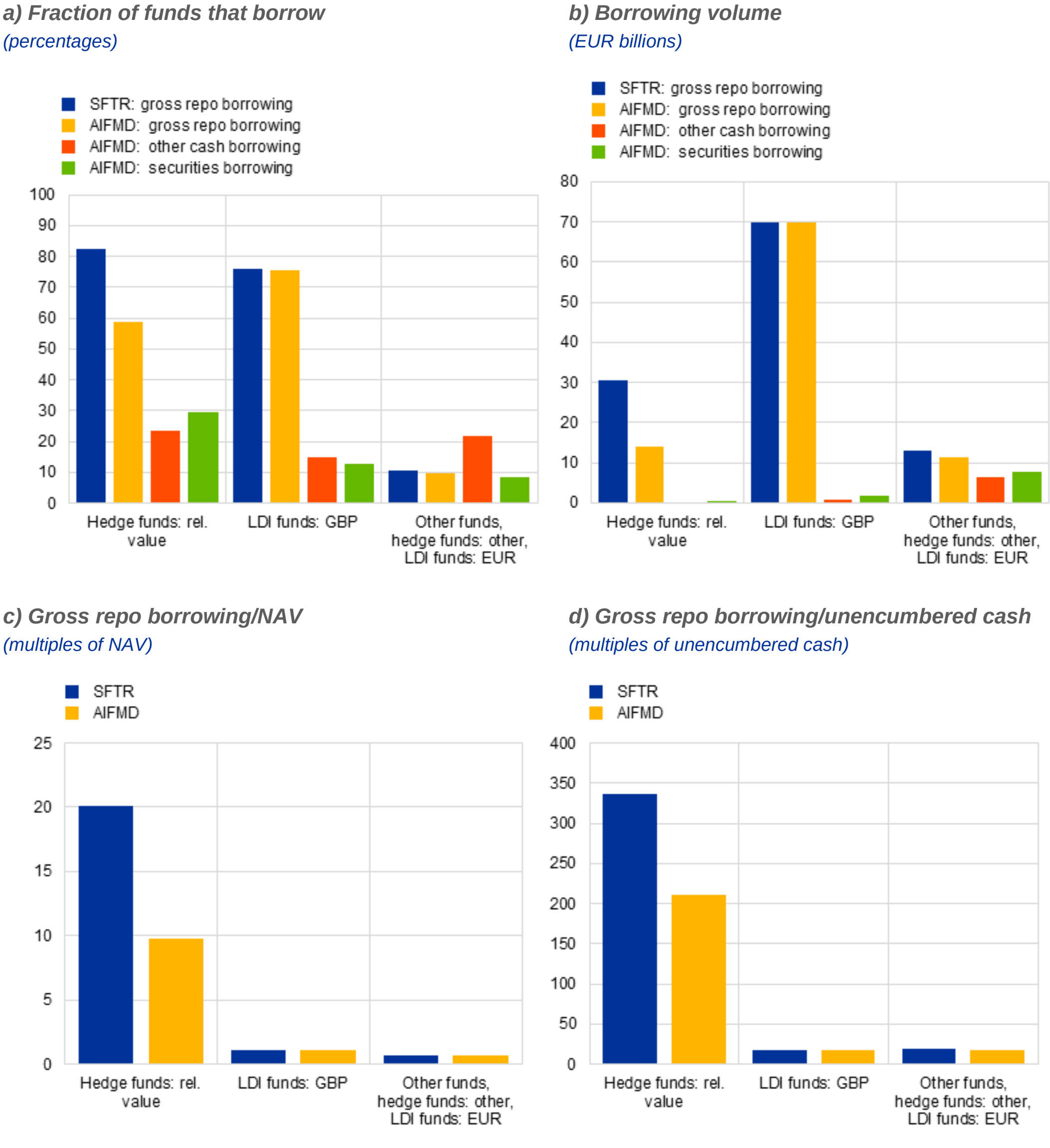
[20] The **Hedge Fund Monitor** published by the Office of Financial Research reports an average gross leverage ratio of 28.2 at the end of 2023 for relative value hedge funds subject to SEC reporting requirements.

[21] Such discrepancies between AIFMD and SFTR data will be discussed in more detail below,

Securities borrowing and non-repo cash borrowing are not an important source of leverage for highly leveraged EU-domiciled AIFs. The vast majority of funds in our sample do not use these types of borrowing. Moreover, both the total value of borrowed securities and the cash borrowed not through repo account for less than 10% of aggregate repo borrowing. For these reasons, we do not consider these types of borrowing in the remainder of our analysis.

Figure 4

Financial leverage: basic metrics



Sources: AIFMD and SFTR data.

Notes: Panel b): "AIFMD: other cash borrowing" is set to zero for relative value hedge funds for data confidentiality reasons. Panels c) and d): NAV and unencumbered cash of AIFs that do not borrow in the repo market are not considered. The legend indicates the source of the repo borrowing data. NAV and unencumbered cash are taken from AIFMD data. Panel d): observations are discarded if unencumbered cash is missing, zero, or larger than the NAV or long position in cash.

We show both the self-reported gross repo borrowing in AIFMD data and the aggregate amount borrowed according to individual positions in SFTR data. At the level of fund categories, discrepancies between the two measures are typically quite low, which points to the overall reliability of the variables. However, gross repo borrowing among relative value hedge funds is about twice as large in SFTR than it is in AIFMD, which is due a very small number of funds. The most likely reason for this discrepancy is invalid reports in SFTR that cannot be identified as invalid using our set of filters. While a few funds appear to report net instead of gross repo borrowing in the relevant field of AIFMD reporting, this does not explain most of the differences at the fund level and fund category level.

Financial leverage through repo borrowing and roll-over risk are highest among hedge funds pursuing a relative value strategy (see Figures 4, panels c and d). Financial leverage through repo is measured as the ratio of gross repo borrowing to NAV. For relative value hedge funds active in the repo market, this ratio averages 20 (according to SFTR data) or ten (according to AIFMD data), but falls to around one for LDI funds with GBP as their base currency. We proxy roll-over risk using the ratio of gross repo borrowing to unencumbered cash. It takes a value of about 340 (SFTR) or 210 (AIFMD) for relative value hedge funds active in the repo market, and falls to below 20 for other types of leveraged funds.[22]

For GBP-denominated LDI funds, the average haircut is below 0.5%, whereas it is about 1% for relative value hedge funds (see Figure 5, panel a). Haircuts are relevant in this context because they determine the theoretically possible level of financial leverage through repos. The lower the haircuts, the higher the potential financial leverage. In an extreme scenario, zero haircuts would allow infinite leverage. The differences in average haircuts are mostly driven by the credit risk of the collateral used. While LDI funds use almost exclusively high-quality government bonds as collateral, hedge funds tend to use a wider range of riskier securities, including corporate bonds and securitised products. See Section 4.2 for a more detailed analysis of the determinants of haircuts in the AIF sector.

[22] Panel c) of Figure16 in the appendix presents an alternative proxy using a broader measure of unencumbered assets that includes unpledged bonds. This alternative metric supports the finding that relative value hedge funds are most prone to roll-over risk. However, the numerical values are naturally lower because including unpledged bonds in the liquidity measure increases the denominator.

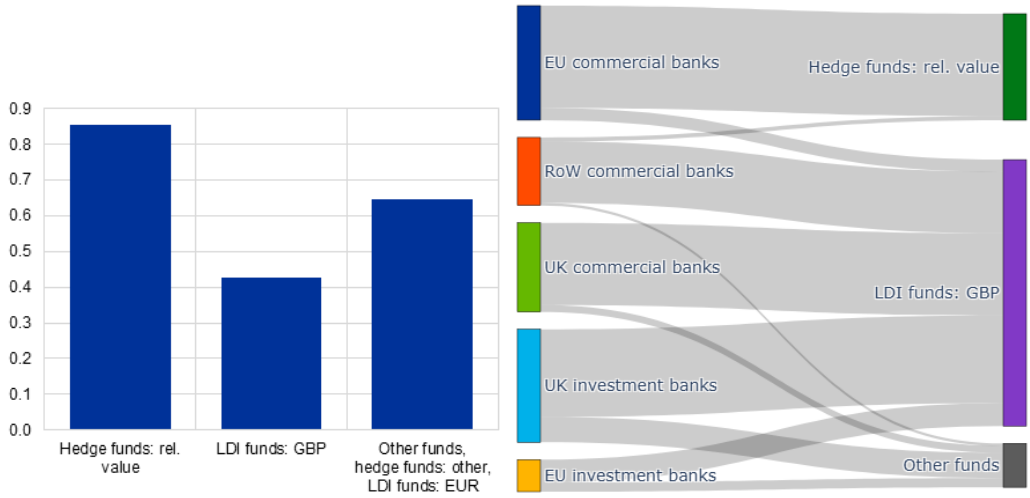
Figure 5

Financial leverage through repos: haircuts and counterparties

a) Average haircut

(percentage points)

b) AIF counterparties



Source: SFTR data.

Notes: Panel a): average haircut on repo transactions with AIFs as cash borrowers, weighted by borrowing volumes. Panel b): cash borrowing AIFs are depicted on the right, and cash lending counterparties on the left. The counterparty sector classification is based on Lenoci and Letizia (2021). The width of the links is proportional to the amount borrowed in EUR. Counterparty sectors that lend less than 2% of the total volume are removed, and some links are removed for data confidentiality reasons. RoW: Rest of the world.

EU commercial banks are the primary cash lenders to relative value hedge funds, while UK banks are the most common counterparties for GBP LDI funds (see Figure 5, panel b). By contrast, EU investment banks and US banks play only a minor role in lending to highly leveraged AIFs. Interestingly, Canadian and Australian banks are also significant lenders to GBP LDI funds according to end-2023 SFTR data.

3.3 Synthetic leverage

Derivatives are an important source of leverage across all types of leveraged AIFs in our sample (see Figure 6, panels a and b). Almost all highly leveraged AIFs hold derivatives. The proportion of funds using derivatives across individual fund categories ranges from nearly 100% for EUR-denominated LDI funds to around 70% for other fund types. Hedge funds, LDI funds and other funds each have aggregated synthetic exposures of roughly €200 billion. According to the AIFMD reporting guidelines, exposures correspond to notional values in the case of swaps and futures, and to delta-adjusted notional values[23] for options. In pre-Refit[24] EMIR data, the delta of options is not reported, which is why we report unadjusted notional values for EMIR data instead. When aggregated at the fund category level, relative deviations between AIFMD and EMIR exposures vary from 5% to 40%. Some of these differences may be explained by the different treatment of options.

Hedge funds have particularly large synthetic exposures relative to their NAV and available liquid assets (see Figure 6, panels c and d). Synthetic leverage, measured as the ratio of exposures to NAV, is above 15 for hedge funds pursuing relative value strategies and stands at 12 (according to AIFMD data) or 15 (according to EMIR data) for hedge funds pursuing other strategies. The synthetic exposures of LDI funds and other highly leveraged funds in our sample are on average about three times their NAV. Similarly, when considering the ratio of exposures to unencumbered cash as a crude measure of the liquidity risks related to synthetic leverage, relative value hedge funds stand out with a ratio above 200. For other hedge funds, synthetic exposures are 75 (AIFMD) or 100 (EMIR) times larger than their available liquidity. For LDI funds and other leveraged funds, the ratio ranges from 35 to 65, depending on the fund category and the data source.[25]

However, metrics based on gross notional values do not provide an accurate characterisation of the risks posed by synthetic leverage. Gross notional values do not account for netting and hedging exposures, which can substantially reduce the effective synthetic exposure. Moreover, sensitivity to market risk depends on the contract type and the underlying of the derivative. The measure of exposure reported under AIFMD addresses this issue partially by asking fund managers to report the delta-adjusted notional for options. However, even the AIFMD measure of exposure should be interpreted with caution since there is no one-to-one relationship between (delta-adjusted) notional values and typical variations in contract values.

Instead, metrics based on initial margins posted by the AIFs could provide a more risk-sensitive measure of synthetic leverage. The main purpose of the initial margin posted by an AIF for a derivatives portfolio is to protect the counterparty against potential losses in the event of the AIF's default. For this reason, the initial margin posted to the counterparty could be viewed as a proxy for the risk associated with the derivatives portfolio. Initial margins are typically calculated according to the ISDA-SIMM model, or a similar model developed internally by the counterparty. These models take into account portfolio-level netting of positions, as well as the sensitivity of individual positions to market risk. A key assumption when interpreting initial margins as proxies for risk is that the calibration of models used to determine these margins does not differ significantly across counterparties.

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[23] The delta-adjusted notional adjusts a derivative's notional amount by its delta (price sensitivity) to reflect the position's actual exposure to changes in the underlying asset's price.

[24] In April 2024, EMIR reporting underwent a substantial change known as as EMIR Refit. Since we are working with end-2023 data, we do not benefit from the additional variables that are reported under the new requirements.

[25] Panel a) of Figure 16 in the appendix presents an alternative proxy for liquidity risks arising from synthetic leverage, using a broader measure of unencumbered assets that includes unpledged bonds. This alternative metric supports the finding that hedge funds tend to have the highest ratio of synthetic exposures to liquidity, although it indicates higher risks for other hedge funds than for relative value hedge funds, thus illustrating the value of considering a range of complementary risk metrics.

Our risk assessment based on initial margins underscores the potential usefulness of these metrics (see Figure 7, panels a and b). Most of the qualitative conclusions from the assessment based on notional values remain unchanged, such as hedge funds being particularly vulnerable to risks arising from synthetic leverage. However, the ratio of initial margin posted to NAV provides additional valuable information: ratios of 56% and 38% for hedge funds with relative value strategies and other strategies, respectively, indicate that counterparties estimate that about half of the NAV could be wiped out upon the occurrence of an adverse market event owing to changes in the value of derivative contracts.[26] Moreover, the metrics based on initial margins posted suggest that risks arising from synthetic leverage in EUR-denominated LDI funds are much larger compared with their GBP-denominated counterparts. This stands in contrast to our risk assessment based on notional amounts, which suggested similar levels of leverage-related risks. Initial margin can be helpful in determining potential liquidity needs in the event of adverse market movements, with higher initial margins suggesting higher exposures and therefore higher potential variation margins. The ratio of initial margin to unencumbered cash captures an entity's ability to meet margin calls on its derivative exposures by using unencumbered cash. Ratios above one for all groups of leveraged funds indicate that assets might need to be liquidated to cover margins calls in the event of large adverse market movements (Giuzio et al., 2024).[27]

Low data quality impedes the use of initial margins as a proxy for the risk of a derivatives portfolio. In pre-Refit EMIR data, the initial margins posted are missing for about half of the derivative portfolios of AIFs in terms of their gross notional values. The availability of initial margin data improves only slightly if we also consider the information reported by counterparties on the initial margins received. We impute initial margins in these cases based on the assumption that the ratio of initial margins posted to synthetic exposures is constant across portfolios held by the same group of AIFs.

Interest rate derivatives represent the largest share of gross synthetic exposures for most leveraged AIFs (see Figure 7, panel c), although gross notional values may overstate their importance. LDI funds focus narrowly on interest rate derivatives and do not typically hold any other types of derivatives. Hedge funds and other leveraged funds are exposed to a more diverse range of derivatives, including currency, equity and credit derivatives. However, gross notional values might overstate the importance of interest rate derivatives, since partial netting of interest rate swap positions is very common. Moreover, interest rate swaps – especially those with a short time to maturity – are typically not very sensitive to changes in interest rates.[28]

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26 Notably, initial margins are typically calculated so that it is highly unlikely that they can be wiped out overnight, even though such a scenario cannot be entirely ruled out, for instance if the fund has concentrated exposures. However, if the fund suffers heavy losses either from the start of the day or progressively during the day, the fund will inevitably have to unwind positions at some point and deleverage as the losses mount. This can occur even if the fund is able to post additional margin; for instance to reduce the default risk if markets continue to move unfavourably or if the leverage, which mechanically increases as losses rise, breaches some internal or contractual limit. Such procyclical behaviour tends to reinforce market movements that are unfavourable for the manager and other managers pursuing similar strategies.

27 Panel b) of Figure 16 in the appendix presents the results for an alternative proxy for risks from margin calls on derivatives that includes unpledged bonds in the measure of available liquid assets.

28 Panel d) of Figure 16 in the appendix disaggregates notional exposures to interest rate derivatives by contract type and shows that interest rate swaps are the most common type of interest rate derivatives among AIFs in our sample. Notional exposures to other types of interest rate derivatives are negligible for hedge funds pursuing relative value strategies and LDI funds, while hedge funds pursuing other strategies and other leveraged funds tend to maintain substantial exposures to interest rate/bond futures and options.

UK and US investment banks are counterparties for almost half of the derivative contracts of leveraged EU-domiciled AIFs in terms of notional values (see Figure 7, panel d). EU-domiciled hedge funds have a diverse range of counterparties in the derivatives market, including US, EU and UK investment banks. The most common counterparties of GBP-denominated LDI funds are UK investment banks, whereas the other leveraged funds predominantly hold contracts with EU banks as their counterparties.

Figure 6

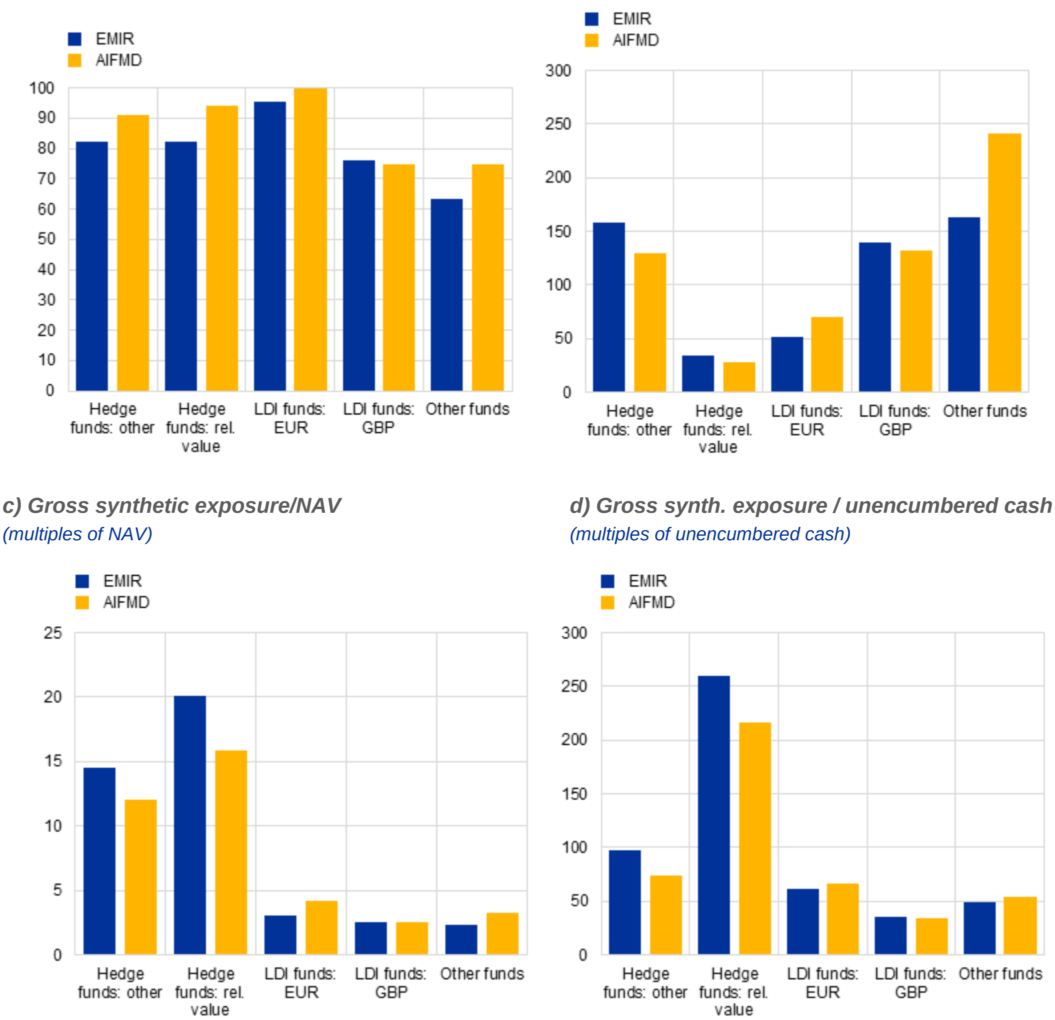
Synthetic leverage: basic metrics

a) Fraction of funds with derivatives
(percentages)

b) Gross synthetic exposure
(EUR billions)

c) Gross synthetic exposure/NAV
(multiples of NAV)

d) Gross synth. exposure / unencumbered cash
(multiples of unencumbered cash)



Sources: AIFMD and EMIR data.
Notes: Panels b), c) and d): a possible reason for the discrepancy between AIFMD and EMIR is that under AIFMD the delta-adjusted notional is reported, whereas under EMIR it is not. Panels c) and d): NAV and unencumbered cash of AIFs that do not trade derivatives are not taken into account. The legend indicates the source of the gross synthetic exposures data. NAV and

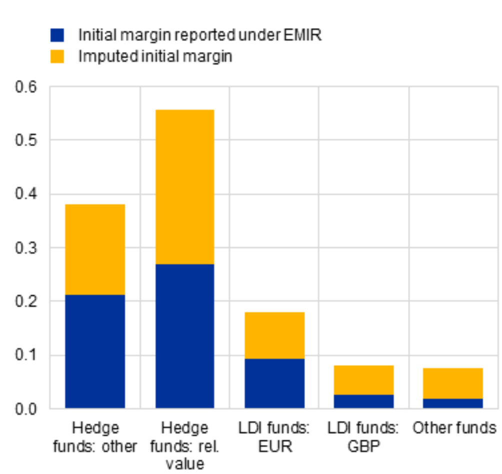
unencumbered cash are taken from AIFMD data. Panel d): observations are discarded if unencumbered cash is missing, zero or larger than the NAV or long position in cash.

Figure 7

Synthetic leverage: initial margin, asset classes and counterparties

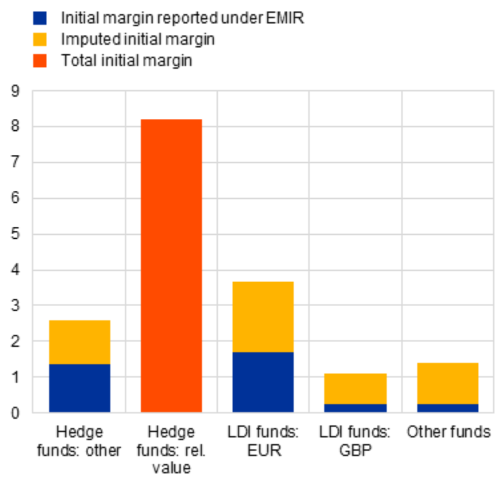
a) Initial margin posted/NAV

(multiples of NAV)



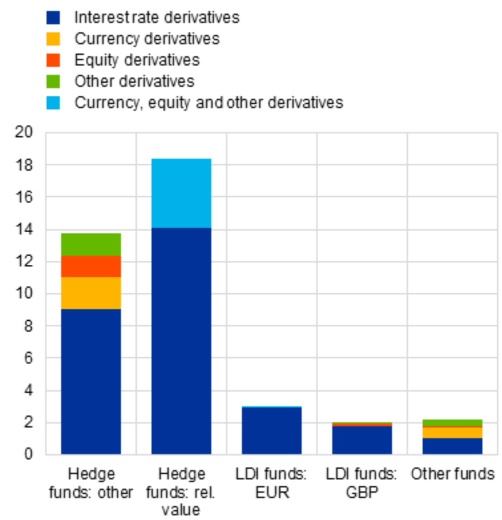
b) Initial margin posted/unencumbered cash

(multiples of unencumbered cash)

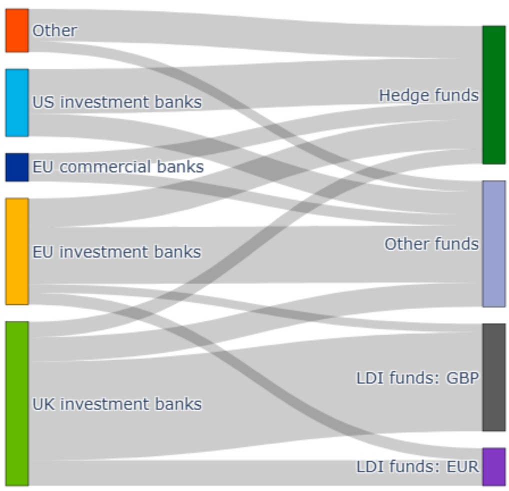


c) Synthetic leverage by asset class

(multiples of NAV)



d) AIF counterparties



Sources: AIFMD and EMIR data.

Notes: Panels a) and b): we impute missing initial margins based on the assumption that the ratio of initial margins posted to synthetic exposures is constant across portfolios held by the same group of AIFs. Panel b): observations are discarded if unencumbered cash is missing, zero or larger than the NAV or long position in cash. Reported and imputed initial margins are combined for relative value hedge funds to preserve data confidentiality. Panel c): the NAV of AIFs that do not trade derivatives *are taken into account here, which explains the different leverage levels compared witho panel c) of Figure 6. Currency, equity and other derivatives are grouped together for relative value hedge funds and EUR LDI funds to preserve data confidentiality. Panel d): AIFs are depicted on the right and counterparties on the left. The width of the links is proportional to the notional amount in EUR. Counterparty sectors responsible for less than 2% of the aggregate amount are removed, and some links are removed for data confidentiality reasons.*

3.4 Sensitivity to interest rate changes

As the next step of our risk assessment, we estimate the impact of interest rate shocks on the mark-to-market value of fixed income securities and interest rate swaps held by AIFs. We focus on interest rate changes as a source of market risk because all categories of highly leveraged AIFs hold sizeable interest rate derivative positions, as described in Section 3.3, and some also use repos to build leveraged bond positions, as demonstrated in Section 3.2. Similar to Jukonis et al. (2022), we consider a parallel upward shift of all interest rate curves, regardless of currency and collateralisation. We focus on the impact on NAV and possible liquidity shortfalls as the main outcome variables.

We approximate the change in the valuation of a bond with a fixed coupon by shifting its yield to maturity. A more precise computation of the valuation change could be achieved by shifting the relevant interest rate curve instead of the yield to maturity. Our approximation method avoids the need to construct the relevant interest rate curves for the large variety of interest rates that matter for the instruments in our sample (EUR, US, UK, inflation-indexed etc.), because the yield to maturity can be computed directly based on the reported price of a bond. As this approximation does not rely on the shock being small, the relative approximation error does not increase when we consider bigger shocks. Appendix A explains the theoretical foundation for our approach. We have confirmed that the approximation error is sufficiently small, based on both simulations and checks using Refinitiv Eikon.

We view vanilla interest rate swaps with a fixed and a floating leg as a position in a fixed coupon bond combined with an opposite position in a bond with a variable coupon rate. We also assume that the effect of an interest rate change on a floating rate note is approximately zero. Consequently, the interest rate sensitivity of an interest rate swap is approximately equal to the sensitivity of the equivalent fixed coupon bond if the AIF receives fixed coupons and pays the variable rate coupons. In the opposite case, we need to multiply the sign of the sensitivity by minus one.

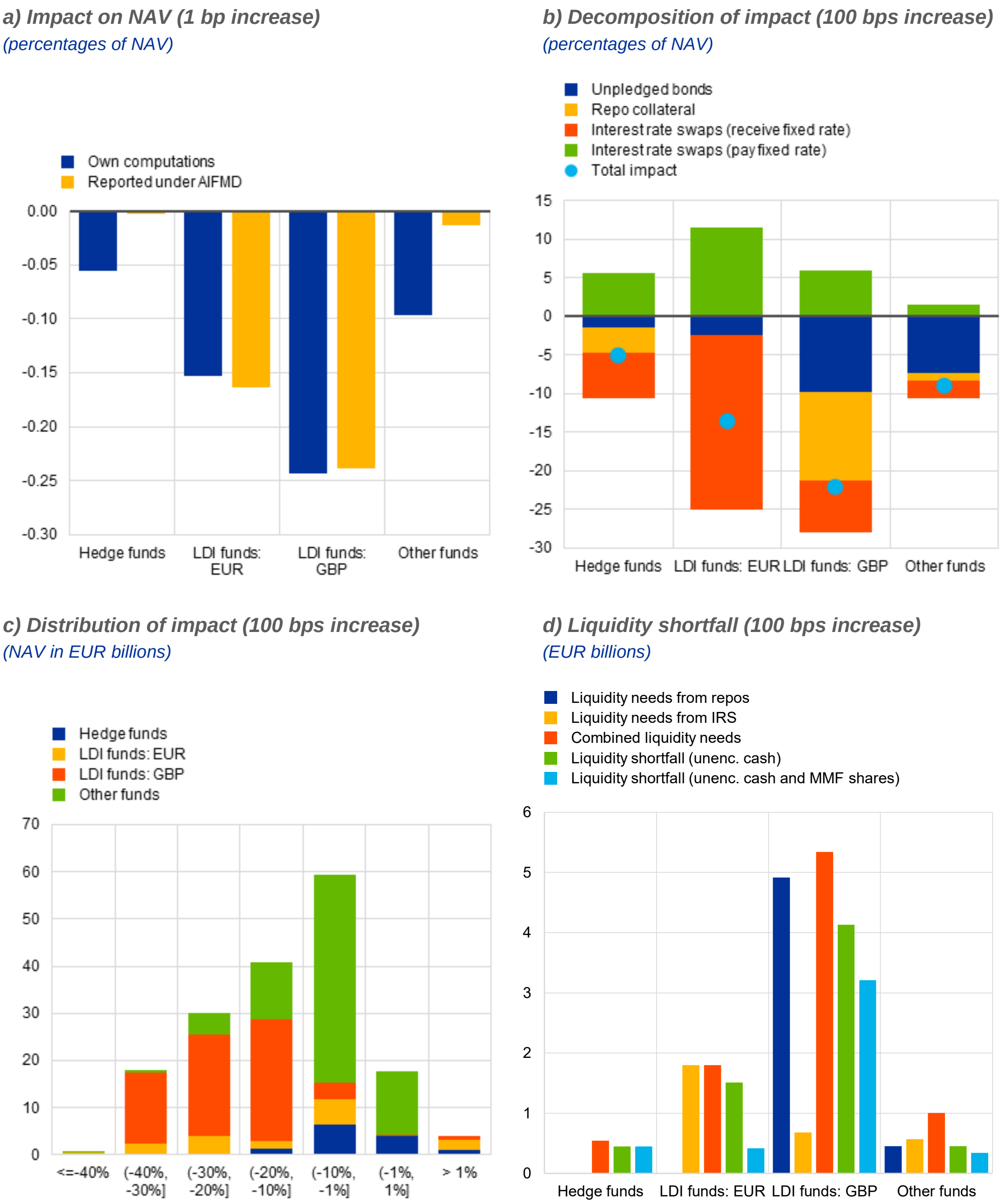
Computing the interest rate sensitivity of other types of interest rate derivatives goes beyond the scope of this paper. Panel d) of Figure 16 in the appendix shows that interest rate swaps are the most relevant type of interest rate derivative in terms of notional exposures, accounting for 98% among LDI funds and 86% among hedge funds with relative value strategies. Other leveraged funds and hedge funds with different strategies have substantial exposures to other types of interest rate derivatives. Therefore, the results for these fund categories should be interpreted with caution.

We approximate the impact of interest rate changes on unpledged bonds based by assuming that their relative price change is the same as for repo collateral pledged by AIFs of the same category. We do have position-level information on fixed income securities pledged as repo collateral through SFTR reporting, but not on unpledged securities. However, we can compute the value of unpledged fixed income securities by subtracting the value of repo collateral from the total value of bonds and securitised products (see Appendix B for details).[29]

[29] If unpledged bonds differ considerably from the bonds used as collateral, our estimates might introduce some bias. However, given the lack of granularity in the AIFMD (only broad asset class exposures are reported), it is not possible to quantify this possible bias.

Figure 8

Sensitivity to changes in the risk-free rate



Sources: AIFMD, EMIR and SFTR data.

Notes: Panel a): AIFs with missing DV01 reported under the AIFMD are excluded. Panel b): impact on repo collateral is set to zero for EUR-denominated LDI funds due to data confidentiality. Panel c): the interval (x, y] refers to all values greater than x and equal to or less than y. Some bins contain fewer than three funds of a certain category. In these cases, we omit this fund category to preserve data confidentiality. Panel d): see the main text for details on the computation of liquidity needs and liquidity shortfall. Observations are discarded if unencumbered cash is missing, zero, or larger than the NAV or long position in cash. For confidentiality reasons, we do not show the decomposition of liquidity needs for hedge funds and we set the liquidity needs from repo to zero for EUR-denominated LDI funds.

Our computed DV01s[30] for AIF categories align well with the self-reported sensitivities in AIFMD data (Figure 8, panel a). For LDI funds, we find a reduction in NAV of 0.15% (EUR as base currency) and of close to 0.25% (GBP as base currency) in response to an increase of 1 basis point both in AIFMD data and using our approximation method. For hedge funds and other funds, the impact on NAV is substantially smaller than for LDI funds. However, we observe larger discrepancies between our computations and AIFMD data for these groups of funds: the interest rate sensitivity according to AIFMD data is close to zero in both cases, whereas our calculations point to a reduction in NAV of 0.05% (hedge funds) or 0.1% (other funds). Deviations are larger at the fund level. One possible reason is that our calculations capture the interest rate sensitivity of interest rate swaps but not of other types of interest rate derivatives, while hedge funds pursuing other strategies and other funds have non-negligible exposures to interest rate/bond futures and options. Moreover, we occasionally observe DV01s in AIFMD data with roughly the same absolute value as in our computations, but with the opposite sign. This could indicate that some fund managers use a different sign convention for DV01. Therefore, aggregate self-reported DV01s in AIFMD data could underestimate the negative impact on NAV.

A 100-bp increase in interest rates could lead to substantial losses among LDI funds (Figure 8, panel b). We select a 100 bps scenario due to its simplicity and close alignment with the approximately 130-bp increase observed during the LDI crisis. The average loss for GBP-denominated LDI funds is 22% of NAV, while the average loss for their EUR-denominated counterparts is 13% of NAV. Losses for other leveraged funds and hedge funds are lower, at 9% and 5% respectively.

For most AIFs, the losses are driven by mark-to-market losses on bonds rather than changes in the valuation of derivatives. For GBP-denominated LDI funds, unpledged bonds and bonds pledged as repo collateral contribute roughly equally to the 22% loss. Interest rate swap positions almost completely offset each other. A similar netting effect for interest rate swaps can be observed for hedge funds. For other leveraged funds, NAV losses are largely due to unpledged bonds. The only exceptions are EUR-denominated LDI funds, for which interest rate swap positions are main contributor to the 13% loss in the scenario involving the 100-bps interest rate shock.

There is substantial heterogeneity in the impact on NAV across AIF categories (Figure 8, panel c). The effect of a 100-bp shock on GBP-denominated LDI funds ranges from -40% to -10%, while EUR-denominated LDI funds exhibit an even wider dispersion. For most hedge funds and other funds, losses are below 10%. Additional computations for a 300-bp increase indicate that almost no GBP-denominated LDI fund in the sample directly breached a yield buffer requirement equivalent to one later introduced in Luxembourg and Ireland under Article 25 of the AIFMD in response to the 2022 gilt market crisis (see CBI, 2024 and CSSF, 2024). This holds true for EUR-denominated LDI funds, hedge funds, and other funds that are not subject to the requirement.

Changes in the valuations of repo collateral and derivatives in response to interest rate shocks trigger margin and collateral calls, which can lead to a liquidity shortfall. Variation margins on derivatives need to be paid with cash, while sufficiently high-quality collateral can be accepted as margin for repo transactions. We define liquidity needs from repos as the aggregate

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[30] DV01, or “Dollar Value of 01”, measures the change in the valuation of a portfolio in response to a 1-bp (0.01%) change in yield.

change in the valuation of repo collateral. Similarly, we define liquidity needs from interest rate swaps as the net decrease in the valuation of interest rate derivatives among those funds that experience a net decrease, with the value set to zero for all other funds. Combined liquidity needs means the overall change in valuation of repo collateral and interest rate swaps if this combined change is negative, and zero otherwise. Since variation margin received when derivatives increase in value can offset liquidity needs from repo transactions, combined liquidity needs may be less than the sum of liquidity needs from repo and interest rate swaps.

Highly leveraged AIFs face liquidity needs of €8.7 billion in response to a 100-bp increase in interest rates (Figure 8, panel d). Liquidity needs are largest among GBP-denominated LDI funds, which would face substantial reductions in the valuation of repo collateral. Meanwhile, the liquidity needs of EUR-denominated LDI funds arise from margin calls on derivatives and are substantially lower, also reflecting the smaller size of this fund sector. Liquidity needs among other leveraged funds and hedge funds are even less significant quantitatively and are due to a combination of margin calls and collateral calls.

Unencumbered cash is not enough to cover the liquidity needs in the case of a 100-bp interest rate increase. We define the liquidity shortfall for each fund as the difference between the fund’s liquidity needs and available liquidity if this difference is positive and zero otherwise. Unencumbered cash is enough to cover about one quarter of the liquidity needs of leveraged AIFs in the case of a 100-bp interest rate shock, resulting in an aggregate liquidity shortfall of €6.5 billion. Including money market fund shares into our measure of available liquidity reduces the liquidity shortfall further to €4.4 billion. Finally, the shortfall can be reduced to below €1 billion if unpledged bonds are also considered.[31] The redemption of money market fund shares and the procyclical sale of bonds to address liquidity could transmit stress to other parts of the financial system. However, liquidity needs arising from repos could also be addressed by pledging bonds instead of selling them, provided the unpledged bonds are of sufficiently high quality. This could reduce the transmission to sovereign bond markets.

Highly leveraged AIFs are subject to other types of market risk besides parallel shifts across all interest rate curves. Interest rate risk can also arise from changes in the shape of the yield curve and changes in interest rate spreads between different currencies. Moreover, AIFs are exposed to other types of market risk, such as changes in credit spreads, equity prices, commodity prices, foreign exchange rates and volatility. While our work focused on shifts in the yield curve due to the prevalence of bonds and interest rate derivatives on the balance sheets of AIFs, significant vulnerabilities to other types of shocks could also exist. However, a detailed assessment of the vulnerabilities of leveraged AIFs to all sources of market risk goes beyond the scope of this analysis: the quality of self-reported net equity deltas, net FX deltas etc. in AIFMD data is poor for most groups of funds, and the computation of these metrics based on transaction-level data would require pricing models for a wide range of derivatives.

Most relative value hedge funds are vulnerable to increases in credit spreads. For eight relative value hedge funds, accounting for more than 75% of the total NAV of EU-domiciled relative

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31 Since only a small number of funds face a liquidity shortfall under this definition, we cannot provide a breakdown by AIF type in panel d) of Figure 8 for data confidentiality reasons.

value hedge funds in our sample, the CS01s[32] reported by fund managers are substantially negative. The implied NAV losses in the event of a 100-bp increase in credit spreads are about 13% in this sample of funds, if we ignore convexity. In the exposures data reported under the AIFMD, we can see that these funds build large positions in corporate bonds through repo borrowing and hedge the risk of interest rate changes through interest rate swaps. However, their credit default swap positions are too small to protect the funds against credit risk from their corporate bond portfolios. Using information on the time to maturity of the corporate bonds, we compute approximate CS01s ourselves and find that they broadly confirm the self-reported sensitivity to credit spreads. This is just one example of a vulnerability to forms of market risk other than the one we focus on in this paper (i.e. the parallel shift in the yield curve).

[32] CS01, or "Credit Spread 01", measures the change in the valuation of a portfolio in response to a 1-bp (0.01%) change in credit spreads.

4 Assessing policy tools to contain leverage in AIFs

Now that we have identified and measured risks associated with leverage, the next step is to explore the range of policy tools available to authorities for addressing these risks. As previously outlined, risk factors vary significantly across various types of entities and depend also on the investment strategies pursued by funds. Therefore, selecting and calibrating the right tools calls for careful consideration of the characteristics and vulnerabilities of funds (FSB, 2025).

We examine entity- and activity-based measures for containing risks posed by leverage. Entity-based tools include both direct and indirect leverage limits, such as yield buffer requirements, which (directly or indirectly) limit the level of leverage employed by an entity. Activity-based tools include minimum haircuts for repo transactions and minimum margin requirements for derivative portfolios, because such measures target activities that are sources of leverage-related risks.

To evaluate the potential impact of these policy tools, we propose various metrics that quantify their hypothetical effects under different calibrations. As a first step, we compute the fraction of affected funds or transactions as a function of the strength of the calibration. Depending on the specific policy target, we suggest measuring the impact on gross exposures, net exposures, repo borrowing, or synthetic exposures as a second step. Most of this analysis is intentionally mechanical, relying on minimal assumptions, such as holding the NAV of affected funds constant. Where stronger assumptions are required, we mention them explicitly. We complement our quantitative assessment in Sections 4.1 to 4.3 with a qualitative discussion in Section 4.4.

Our policy assessment varies in sophistication due to the complexity of the analysis. Our assessment of direct leverage limits and minimum haircuts is detailed and thorough, whereas the sections on indirect leverage limits and margin requirements are notably shorter. This is because a more comprehensive assessment of these policy options is complex. Additionally, the data required for a thorough evaluation is either not available or of insufficient quality, thus limiting the depth of the analysis than can be conducted.

It is important to make clear that the analysis presented here should not be viewed as a comprehensive evaluation of the policy options considered. A more complete evaluation would also look at potential unintended consequences, second-round effects, and regulatory leakages. For example, tighter constraints in one segment could prompt activity migration to less regulated entities or jurisdictions, or alter the provision of market liquidity. These broader system-wide dynamics warrant further analysis and may meaningfully influence policy design, calibration and implementation.

4.1 Direct leverage limits

Direct leverage limits seek to restrict the exposures of funds. Leverage limits affect the risk profile of funds by limiting the size of exposures to a certain percentage of NAV. We offer a qualitative discussion on the possible impacts on portfolio allocation in Section 4.4.

The impact of a direct leverage limit on AIFs is measured by the fraction of such funds affected by the limit and by the resulting reduction in exposures. An AIF i is affected by the limit if its leverage L_i is above threshold T. To account for the size of AIFs, we compute the percentage of NAV of funds above the limit:

$$\text{Fraction of affected AIFs}(T) = \frac{\sum_i 1_{L_i>T} NAV_i}{\sum_i NAV_i}$$

The reduction in exposures is computed as the deleveraging needed to comply with the leverage limit in place:

$$\text{Reduction of exposures}(T) = \frac{\sum_i (L_i - min\{L_i, T\}) \cdot NAV_i}{\sum_i L_i \cdot NAV_i}$$

If the leverage metric chosen for the limit is gross leverage, this quantity represents a reduction in gross exposures. If the relevant leverage metric is net leverage, it represents a reduction in net exposures. The computed reduction in exposures is a purely mechanical result of leverage limits and does not require additional assumptions as to how funds adjust their strategy in response to a leverage limit.

Figure 9

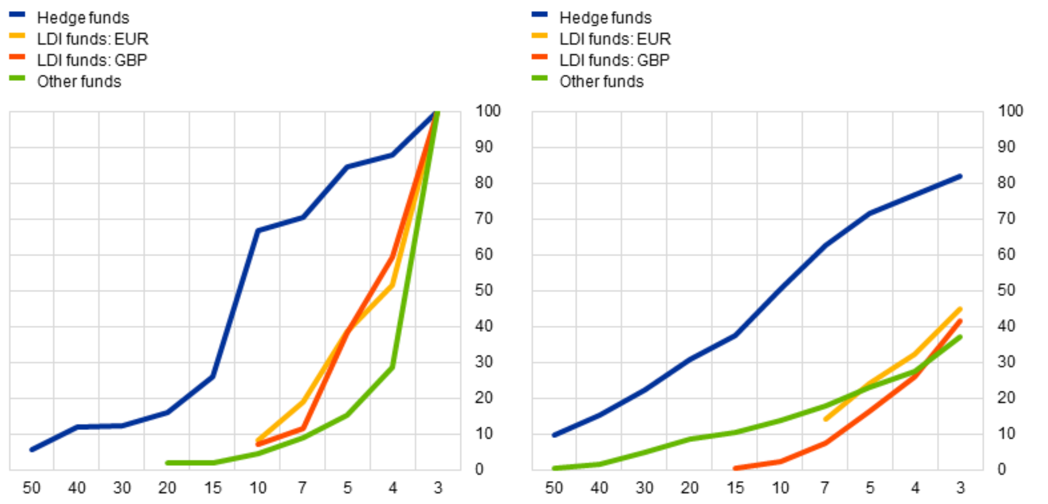
Gross leverage limit (AuM/NAV)

a) Fraction of AIFs affected

(x-axis: leverage limit, y-axis: percentage of NAV)

b) Reduction in gross exposures

(x-axis: leverage limit, y-axis: percentages)



Source: AIFMD data.

Notes: Panel a): the figure shows the share of AIFs in terms of their NAV that would be affected by a given gross leverage limit. For example, a leverage limit of 10 times the NAV would affect 67% of hedge funds and 7% of GBP-denominated LDI funds. Panel b): the figure shows the percentage reduction in gross exposures for a given gross leverage limit. For example, a *leverage limit of 10 times the NAV would trigger a 50% reduction in gross exposures for hedge funds and a 2% reduction for GBP-denominated LDI funds. Panels a) and b): to ensure data confidentiality, the effect of leverage limits is shown only for a category of leveraged funds if a sufficiently large sample of funds is affected.*

Many hedge funds would be heavily affected even by relatively permissive gross leverage limits, whereas most LDI funds and other leveraged funds would be affected only if more stringent gross leverage limits were applied (Figure 9). The impact of leverage limits depends on the initial leverage levels of the entities in scope. Funds that employ high levels of leverage will be affected even by moderate leverage limits, while only tight limits will affect funds with lower levels of leverage. Panel b) of Figure 3 shows the distribution of gross leverage across funds, revealing that high leverage levels above 10 are very common among hedge funds, but not among LDI funds or other leveraged funds. Consequently, 67% of hedge funds in terms of NAV would be affected by a limit on gross leverage of 10 times NAV, while for LDI funds and other leveraged funds, even a much stricter limit of 5 times NAV would be binding for fewer than half of them. Since our sample consists solely of funds with gross leverage above 300% of NAV, a leverage limit of 300% would be binding for all AIFs in our sample by construction. A gross leverage limit of 10 would lead to a 50% reduction in gross exposures among hedge funds. For LDI funds and other leveraged funds, such a large reduction in gross exposures cannot be achieved even with a relatively stringent gross leverage limit of 3.

The effects of a net leverage limit based on the commitment method are qualitatively similar to those of a gross leverage limit (Figure 10). Since hedge funds also tend to have higher net leverage ratios than other funds, a larger fraction of hedge funds would be affected by a given limit compared with LDI funds and other leveraged funds. As net leverage levels are lower than gross leverage levels, a lower net leverage threshold is needed to affect the same proportion of funds as would a given gross leverage threshold. For example, a net leverage limit of 10 times NAV would be binding for only 23% of hedge funds measured in terms of NAV. A net leverage limit of 5 would be needed in order to affect a similar proportion of hedge funds as would a gross leverage limit of 10.

Figure 10

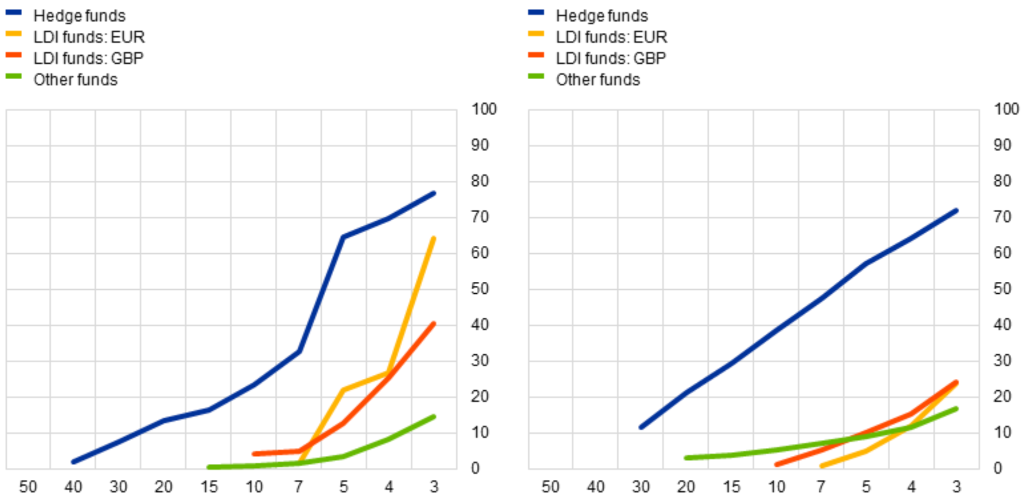
Net leverage limit (commitment method)

a) Fraction of AIFs affected

(x-axis: leverage limit, y-axis: percentage of NAV)

b) Reduction in net exposures

(x-axis: leverage limit, y-axis: percentages)



Source: AIFMD data.

Notes: Panel a): the figure shows the proportion of AIFs measured in terms of their NAV that would be affected by a given net leverage limit. For example, a leverage limit of 10 times NAV would affect 23% of hedge funds and 1% of GBP-denominated LDI funds. Panel b): the figure shows the percentage reduction in net exposures for a given net leverage limit. For example, a leverage limit of 10 times NAV would trigger a 38% reduction in gross exposures for hedge funds and 1% reduction for GBP-denominated LDI funds. Panels a) and b): to protect the confidentiality of the data, the effect of leverage limits is shown only for a category of leveraged funds if a sufficiently large sample of funds is affected.

Box 1
Indirect leverage limits

Indirect leverage limits can be used to target risks not adequately captured by direct measures. For example, limits on market risk for funds pursuing complex strategies using derivatives might be captured more effectively by Value-at-Risk limits rather than leverage limits. Relatedly, interest rate risk might be better mitigated through the use of yield buffer requirements rather than direct limits on exposures. For instance, the yield buffer requirement (see CBI, 2024 and CSSF, 2024) requires GBP-denominated LDI funds managed by an Alternative Investment Fund Manager (AIFM) domiciled in Ireland or Luxembourg to be able to absorb at least a 300-bp upward shift in yields.

To formalise these ideas, let us denote the NAV following a shock of a certain size Δ as $NAV_i(\Delta)$. If the indirect leverage limit requires funds to withstand such a shock, an AIF i is affected by that limit if $NAV_i(\Delta) < 0$ and hence:

$$\text{Fraction of affected AIFs}(\Delta) = \frac{\sum_i 1_{NAV_i(\Delta)<0} NAV_i}{\sum_i NAV_i}$$

The calibration becomes stricter as the shock size Δ increases. If funds reduce all exposures proportionally to comply with the indirect leverage limit, the maximum leverage allowed is given by

$\frac{NAV_i}{NAV_i - NAV_i(\Delta)} L_i$, where L_i is the level of leverage before the introduction of an indirect leverage limit. Therefore, we can define:

$$\text{Reduction in exposures}(\Delta) = \frac{\sum_i \left(L_i - min\{L_i, \frac{NAV_i}{NAV_i - NAV_i(\Delta)} L_i\}\right) \cdot NAV_i}{\sum_i L_i \cdot NAV_i}$$

In this paper, we do not assess the effectiveness of indirect leverage limits due to the sheer variety of possible design options and lack of high-quality data on sensitivity to market risk. A well-designed indirect leverage limit for a group of funds targets the type of market risk this group is most vulnerable to. For LDI funds, shifts in the yield curve are most relevant, while for hedge funds and other leveraged funds, the variety and complexity of the investment strategies they undertake makes it challenging to identify the key market risks. Furthermore, as discussed in Section 3.4, data quality issues with self-reported sensitivities and the challenges in estimating them from transaction-level data further complicate the task of quantifying such vulnerabilities.

4.2 Minimum haircuts

Minimum haircuts on repo transactions constrain financial leverage, as a certain fraction of a leveraged position must be financed with the fund's own resources. A haircut is the difference between the initial market value of an asset and the purchase price paid for that asset at the start of a repo. With a haircut of zero or below, an agent can borrow the full value of the security used in the repo transaction. This allows for theoretically infinite levels of financial leverage if the securities purchased with the borrowed cash are themselves offered for repo without a haircut. With a positive haircut, $h > 0$, $(1-h)B_C$ is the amount borrowed for a given portfolio of collateral B_C, while hB_C is the fraction financed with the fund's own resources. Therefore, the maximum level of financial leverage through successive repos is $1/h$.[33]

In existing frameworks, minimum haircuts reflect collateral risk, proxied by the type of collateral and the maturity. For example, the haircut floors suggested by the FSB (2015) are a function of the collateral type (corporate bonds, securitised products, index equities or other assets) and – for fixed income products – the residual time to maturity. Similarly, the haircut floors for collateral used in Eurosystem market operations depend on credit quality, asset categories that proxy liquidity, and residual maturity. In both minimum haircut frameworks, floating rate notes are treated the same way as fixed coupon bonds with less than one year to maturity. Government bond repos fall outside the scope of the FSB haircut framework but are covered by the Eurosystem haircut schedule.

33 We assume that hB_C cannot be financed through unsecured borrowing.

Table 1

Simplified Eurosystem haircut schedule (in %)

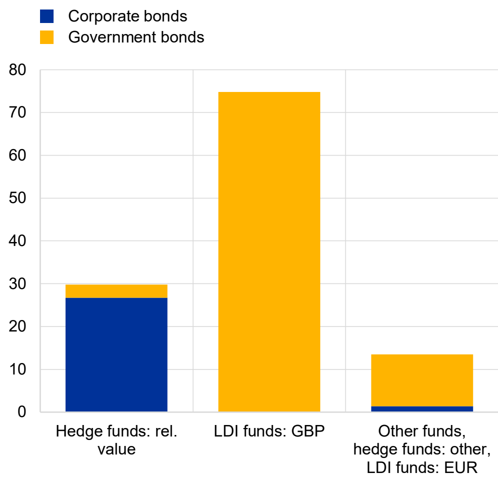
Residual maturity in years	Government bonds (AAA to A-)	Government bonds (BBB+ to BBB-)	Corporate bonds (AAA to A-)	Corporate bonds (BBB+ to BBB-)
0-1 or floating	0.5	5.5	1.5	8
1-3	1.5	6.5	3	18
3-5	2.5	7.5	5	25.5
5-7	3	8	6.5	28
7-10	4	9	8.5	29
> 10	5.5	10.5	11	29.5

Source: Haircut schedule for assets eligible for use as collateral in Eurosystem market operations.
Notes: We restrict the schedule to liquidity categories I and III and assume that the categories perfectly correspond to government bonds and corporate bonds, respectively. Moreover, we omit haircut floors for asset-backed securities, zero coupon bonds, inverse floaters, and non-marketable credit claims.

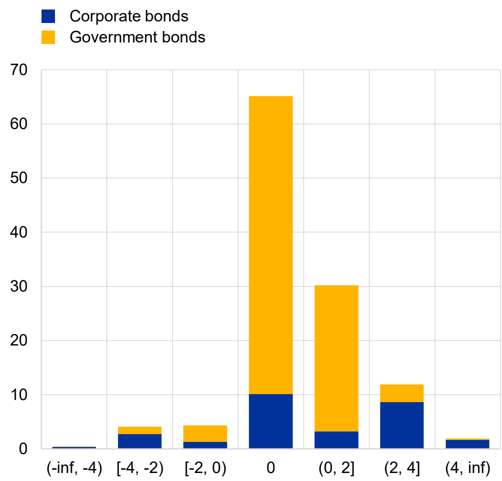
We consider a simplified version of the haircut schedule for collateral used in Eurosystem market operations (Table 1) to apply it subsequently to repo transactions carried out by highly leveraged AIFs. Since the available data on repo collateral does not readily permit classification into the five liquidity categories, we assume that all government bonds belong to liquidity category I (“Central government debt instruments and debt instruments issued by central banks”) and that all corporate bonds belong to liquidity category III (“Traditional covered bank bonds, structured covered bank bonds, multi-cédulas and debt instruments issued by corporate and other issuers”). We ignore haircut floors for asset-backed securities, zero coupon bonds, inverse floaters, and non-marketable credit claims because these asset types are not commonly used as collateral by the funds included in our sample.

Figure 11
Haircuts

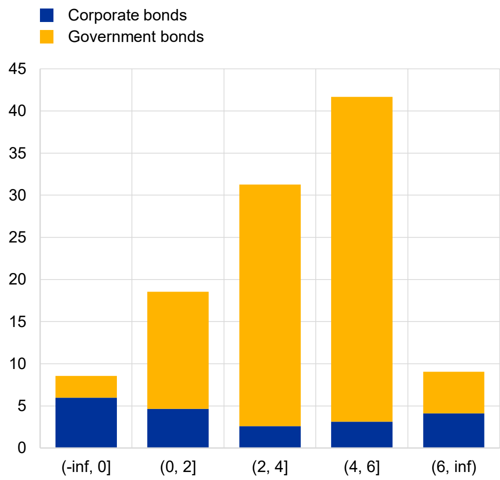
a) Type of collateral posted by AIFs
(y-axis: collateral value in EUR billions)



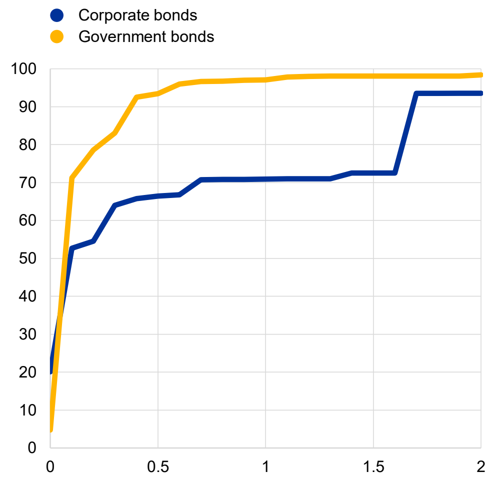
b) Current haircuts
(x-axis: haircut in %; y-axis: collateral value in EUR billions)



c) Eurosystem haircuts minus current haircuts
(x-axis: difference in p.p.; y-axis: collateral value in EUR billions)



d) Fraction of transactions affected
(x-axis: calibration; y-axis: fraction of collateral value in %)



Sources: AIFMD and SFTR data.
Notes: Collateral values, haircuts and collateral characteristics relevant for the determination of Eurosystem haircuts are taken from SFTR data. The categorisation of AIFs shown in panel a) is taken from AIFMD data. An interval (x, y] in panels b) and c) denotes values strictly greater than x but equal to or less than y. The calibration variable on the x-axis of panel d) refers to the constant that is multiplied with the simplified Eurosystem haircut schedule shown in Table 1. A calibration of 1 corresponds to the Eurosystem haircut framework, 0.5 means half of the proposed haircut floors, and 0 means a minimum haircut of 0%.

Relative value hedge funds tend to pledge corporate bonds as repo collateral, whereas GBP-denominated LDI funds and other leveraged funds typically pledge government bonds (Figure 11, panel a). Most collateral pledged by the AIFs in the sample has good credit quality (A- or better). Long residual times to maturity beyond ten years are common for government bonds pledged as collateral, whereas corporate debt securities posted by relative value hedge funds are typically floating-rate notes or have less than one year to maturity.

Government bond collateral typically has a haircut of zero (Figure 11, panel b).[34] Positive haircuts of between 0% and 2% are also common for government bond repos, while negative haircuts of more than 2% are rare in the current interest rate environment. For corporate bond collateral, haircuts range from -4% to 4%.

For most repo transactions among highly leveraged AIFs, Eurosystem minimum haircuts are several percentage points higher than current haircuts (Figure 11, panel c). For more than 90% of the transactions in terms of collateral value, applying Eurosystem haircut floors would increase haircuts by several percentage points.[35] For example, government bonds with more than ten years to maturity have a haircut floor of 5.5% in the Eurosystem framework, while the AIFs in our sample undertook most such transactions with a 0-2% haircut at the end of 2023.[36] This implies an increase in haircuts on these transactions of 3.5 to 5.5 percentage points.

Even with a more lenient calibration, Eurosystem haircut floors would imply higher haircuts for most repo transactions (Figure 11, panel d). We can adjust the calibration by multiplying the haircut floors from our reference framework with a constant. A calibration of 1 corresponds to the Eurosystem haircut framework. A calibration of 0.5 means half of the proposed haircut floors, and 0 means a minimum haircut of 0%. Even a calibration of one-fifth of the Eurosystem haircut floors would still imply higher haircuts for about 80% of government bond repos and for around half of corporate bond repos.

To understand how haircut floors would affect repo borrowing and financial leverage, we consider a hypothetical fund (Figure 12, panel a). Assets financed by the fund's own resources are unpledged bonds B_{NC}, unencumbered cash and other unpledged assets A, a fraction of the bonds pledged as repo collateral determined by the haircut hB_C, and the initial margin for the derivatives portfolio IM. For illustrative purposes, we assume that the same haircut $h = 1\%$ applies to all assets used as collateral. The remainder of the bonds on the balance sheet $(1-h)B_C$ are financed through repo borrowing.

Fund managers can respond to the introduction of haircut floors in various ways. We make the simplifying assumption of a uniform haircut floor $\tilde{h}$.

If the haircut floor is binding, $\tilde{h} > h$, and the net asset value of the fund stays constant, the fund manager has three options:

[34] Zero haircuts might occur due to netting (either within the repo exposure or across products). Positive minimum haircuts imply that the cash borrower has an uncollateralised exposure towards the cash lender. However, this may be less of an issue in the given context, where the framework is designed to target highly leveraged AIFs that borrow from other types of counterparties.

[35] The minimum haircut framework we consider assumes that the main determining factor is the underlying type of collateral. Market haircuts also often depend on the type of counterparty, on netting and on the repo rate as well. A more sophisticated minimum haircut framework may also consider these factors, albeit at the expense of simplicity.

[36] Eurosystem haircuts are designed to minimise losses for the Eurosystem and are therefore likely to be more conservative than market practice.

1. Leave the amount of repo collateral financed with the fund's own resources unchanged and reduce repo borrowing:

$$R_1(\tilde{h}) = \frac{1-\tilde{h}}{\tilde{h}}(hB_C)$$

2. Maintain current repo borrowing by pledging additional bonds. This option leads to a reduction in the fund's unencumbered liquid holdings. The maximum repo borrowing volume is:

$$R_2(\tilde{h}) = \frac{1-\tilde{h}}{\tilde{h}}(hB_C + B_{NC})$$

3. Sell other unpledged assets, buy bonds and then pledge them (in addition to pledging unencumbered bonds). This option implies a change in portfolio allocation. The maximum repo borrowing volume is:

$$R_3(\tilde{h}) = \frac{1-\tilde{h}}{\tilde{h}}(hB_C + B_{NC} + A)$$

The expressions for the maximum repo borrowing volume for a given behavioural response should be interpreted as follows: if implied maximum repo borrowing exceeds current borrowing volumes, the fund can sustain its current level of financial leverage through repo. Conversely, if the implied maximum volume is below the current volume, the fund will need to deleverage accordingly.

The effect of minimum haircuts on financial leverage obtained through repo borrowing varies significantly depending on the behaviour of the fund manager (Figure 12, panel b). In the case of option 1, minimum haircuts result in sizeable deleveraging for any haircut floor above current haircut levels $\tilde{h} > h$. In our numerical example, an increase in the haircut from 1% to 2% would have the effect of halving the repo borrowing volume under this behavioural assumption. If fund managers instead pledge unencumbered bonds (option 2), they might be able to maintain their current levels of repo borrowing if the available unpledged bonds are sufficient to make up for the increase in haircuts. In the numerical example, the fund only deleverages for haircut floors above 3% if available additional bonds are pledged. The same logic holds for option 3, in which other unpledged assets are transformed into bonds that can be used as collateral. In that case, deleveraging only happens for haircut floors above 5% in our numerical example.

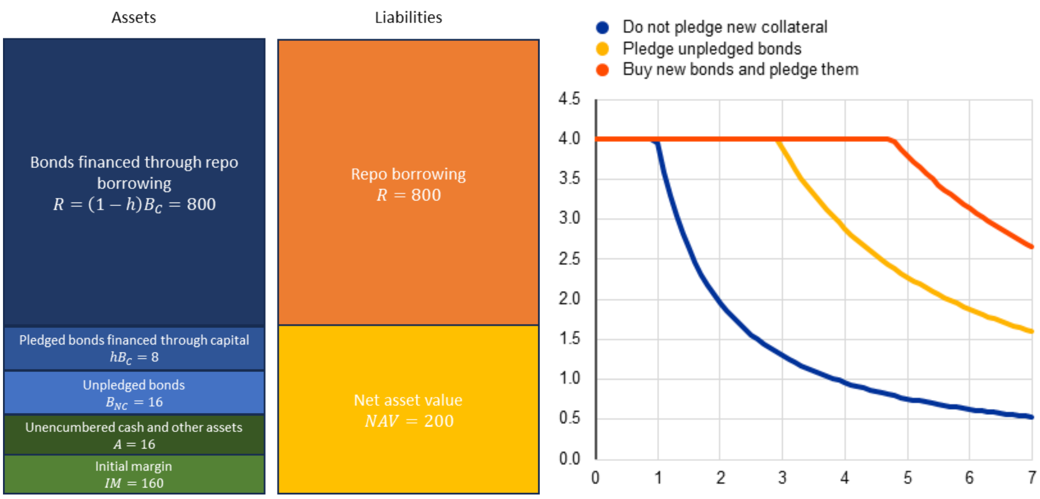
Figure 12

Effect of minimum haircuts on a hypothetical fund

a) Balance sheet

b) Effect of minimum haircuts

(x-axis: haircut floor in %; y-axis: repo borrowing/NAV)



Notes: Numerical example for illustrative purposes. We assume that the same initial haircut $h = 1\%$ applies to all assets used as collateral and that any haircut floor $\tilde{h}$ also applies uniformly. See the main text for the mathematical expressions describing the maximum repo borrowing possible, depending on the behaviour of the fund manager.

We assume below that fund managers will pledge additional available bonds if haircut floors are introduced, and will deleverage if they run out of suitable unencumbered bonds to pledge.[37] This appears to be the most likely response, as it does not require significant changes to the fund's portfolio or strategy, provided that unpledged bonds are sufficient to maintain repo borrowing. If fund managers decide instead not to pledge unencumbered bonds in order to maintain repo borrowing (option 1), they would then need to deleverage. Alternatively, using other unencumbered assets to purchase additional bonds and pledge them (option 3) implies a significant change to the fund's portfolio. Unencumbered cash, for example, is a key buffer for meeting margin calls and potential redemption requests.

Hedge funds pursuing relative value strategies tend to own very few or no unpledged bonds, while the unpledged bond positions of GBP-denominated LDI funds are often sizeable compared with the repo collateral (see Figure 13). For almost all relative value hedge funds, the market value of their unpledged bonds is less than 10% of the market value of their pledged bonds. Conversely, this is the case for less than 5% of GBP-denominated LDI funds in terms of repo borrowing. For most GBP-denominated LDI funds, the market value of unpledged bonds is more than 50% of the market value of their repo collateral. For GBP-denominated LDI funds, moderate financial leverage through repo borrowing is sufficient to achieve the interest rate sensitivities desired by their investors and allowed by the yield buffer requirement. Therefore, GBP-

[37] An alternative assumption is that the fund keeps a buffer of unpledged bonds equal to a certain fraction of its repo collateral, perhaps in order to respond to collateral calls. In that case, the implied leverage reduction would be even larger than in our analysis.

denominated LDI funds hold sizeable unpledged bond positions and do not aim for higher levels of financial leverage.

If the Eurosystem haircut schedule were applied to repo transactions among AIFs, relative value hedge funds would probably have to reduce their repo borrowing by about 50%, whereas GBP-denominated LDI funds would not be affected (see Figure 13, panel b). According to our computations, financial leverage through repo borrowing would drop from 8.5 to 4.2 among relative value hedge funds that are active in the repo market. Even a more lenient calibration of minimum haircuts at 50% of Eurosystem schedule levels would result in a reduction in repo borrowing of more than a quarter among these funds. This reflects the scarcity of unpledged bonds in their portfolios as well as the low levels of haircuts. GBP-denominated LDI funds, on the other hand, would not be constrained even by very high haircut floors of twice the Eurosystem levels thanks to their sizeable buffers of unpledged bonds. See Appendix B for details on the computation of the effects of minimum haircuts using AIFMD and SFTR data.

Figure 13

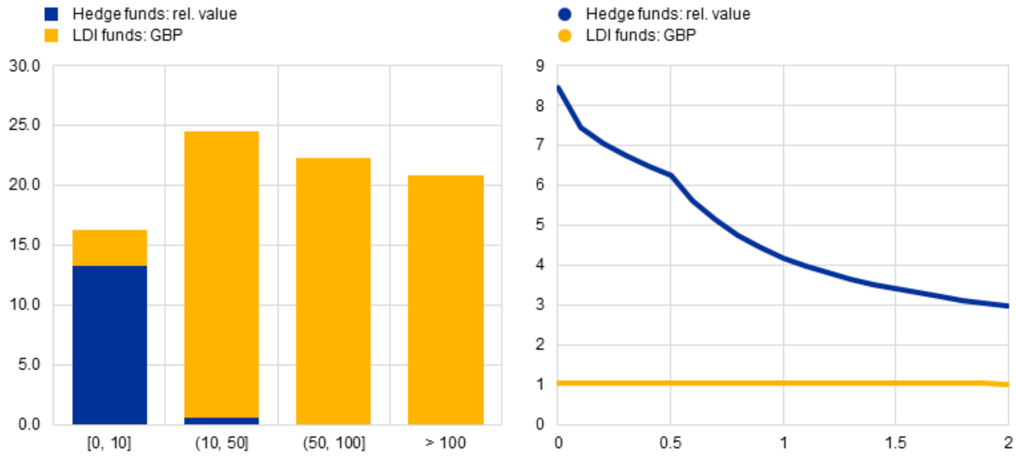
Effect of minimum haircuts on the sample of leveraged funds

a) Unpledged bonds divided by pledged bonds

(x-axis: in %; y-axis: repo borrowing in EUR billions)

b) Repo borrowing divided by NAV

(x-axis: calibration; y-axis: multiples of NAV)



Sources: AIFMD and SFTR data.

Notes: Hedge funds pursuing other strategies, EUR-denominated LDI funds and other leveraged funds are excluded because these types of funds are typically not active in the repo market. An interval (x, y] in panel a) denotes values strictly greater than x but less than or equal to y. There are only very few relative value hedge funds with an unpledged bonds ratio above 50. For this reason, the values in the two rightmost bins in panel a) are set to zero for data confidentiality reasons. The calibration variable on the x-axis of panel b) refers to the constant that is multiplied with the simplified Eurosystem haircut schedule in Table 1. A calibration of 1 corresponds to the Eurosystem haircut framework, 0.5 means half of the proposed haircut floors, and 0 means a minimum haircut of 0%.

4.3 Margin requirements

Setting minimum levels for initial margins would limit the synthetic leverage employed by entities, as a derivatives portfolio must be backed by sufficient collateral. The initial margin is collateral posted to cover future fluctuations in value that can occur between the last exchange of margins and the liquidation of positions if one counterparty defaults. Similar to haircuts of zero in the case of repo transactions, initial margins of zero imply that no collateral is needed to support synthetic exposures, enabling arbitrarily high levels of synthetic leverage. If the required minimum ratio of initial margins to notional derivative exposures is $d = IM/D$ for a derivatives portfolio with a certain composition, the maximum level of synthetic leverage is $1/d$.[38]

A comprehensive assessment of the potential impact of margin requirements based on a sophisticated margin model goes beyond the scope of this paper. Counterparties typically use the ISDA-SIMM model or similar models developed in-house to determine initial margins. These models are a natural starting point for any potential margin requirements but cannot be implemented using EMIR data in the context of this study.

Table 2
BCBS-IOSCO initial margin schedule

Asset class	Duration	Initial margin requirement (% of notional exposure)
Credit	0 - 2 years	2
Credit	2 - 5 years	5
Credit	Greater than 5 years	10
Commodities		15
Equity		15
Foreign exchange		6
Interest rates	0 - 2 years	1
Interest rates	2 - 5 years	2
Interest rates	Greater than 5 years	4
Other		15

Source: BCBS-IOSCO; see Bank for International Settlements (2020).

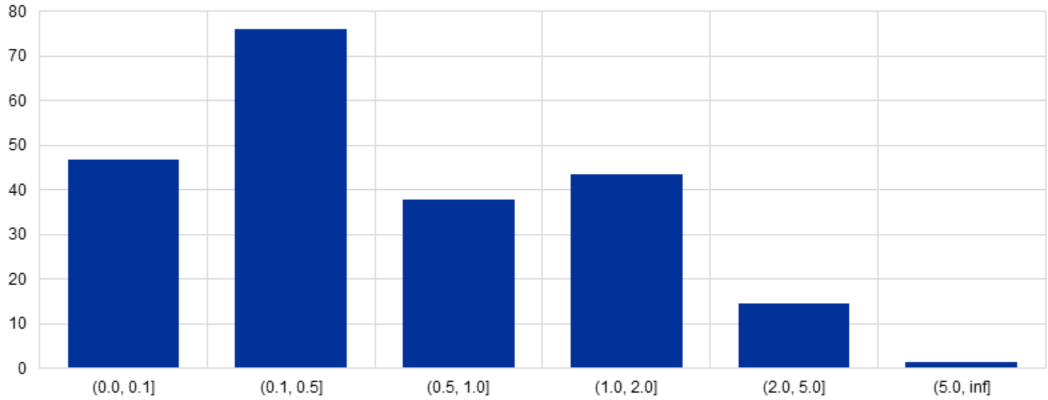
Instead, we compare initial margins posted by AIFs with those implied by the BCBS-IOSCO schedule and find that posted margins are generally well below the schedule (see Figure 14). The BCBS-IOSCO table, reproduced in Table 2 above, offers a very simple schedule that counterparties can use in the absence of a sophisticated margin model (see Bank for International

38 We assume that the initial margin must be financed with the fund's own resources. In particular, it cannot be financed through unsecured borrowing.

Settlements, 2020). We compute the BCBS-IOSCO margins for each contract in a derivative portfolio and aggregate them. We then compare the resulting BCBS-IOSCO margins with the reported margins, excluding derivative portfolios with missing or zero initial margins. Around 70% of the derivative portfolios measured in terms of notional amount have initial margins below the BCBS-IOSCO schedule, while around 30% exceed it. This pattern reflects both the conservative nature of the BCBS-IOSCO schedule and the absence of netting in our computation.

Figure 14
Initial margins posted vs BCBS-IOSCO margin schedule

(x-axis: initial margin posted divided by initial margin according to BCBS-IOSCO schedule; y-axis: notional amount in EUR billions)



Source: EMIR data.
Notes: Derivative portfolios with a missing value for the initial margin posted are not included. 1 means that the initial margin posted perfectly corresponds to the initial margin according to the BSBS-IOSCO schedule, while 0.5 means that the initial margin posted is half the BCBS-IOSCO level.

4.4 Discussion

An empirical analysis of policy options reveals that direct leverage limits and minimum haircuts have significant implications for AIFs, especially hedge funds. Direct leverage limits show a notable impact on hedge funds even under relatively lenient conditions, while other leveraged funds, such as LDI funds, are only affected when the limits are considerably stricter.[39] This finding highlights the differential sensitivity of various fund types to leverage restrictions, suggesting that direct leverage limits may need to be designed and calibrated differently across fund categories to achieve desired regulatory outcomes. Meanwhile, minimum haircuts on repo transactions predominantly affect hedge funds, as LDI funds in the sample maintain large unpledged bond positions. Our exploratory analysis of margin requirements also points towards substantial heterogeneity in the impact of this measure on margins posted for derivative portfolios.

[39] Article 25 of AIFMD allows NCAs to implement leverage limits (both direct and indirect).

The effectiveness of policies in reducing leverage-related risks depends on how fund managers adjust their portfolio allocation and strategy in response. The reduction in exposure to market risk is proportional to the decrease in gross notional exposure of a fund only if the relative portfolio allocation remains unchanged. However, this might not be the case, as some policies leave room for fund managers to shift their portfolio allocation towards riskier assets and thereby circumvent the aim of the policies. For example, a direct leverage limit sets a uniform price for leverage across a portfolio of assets and fund managers might maintain their exposure to market risk by investing in riskier assets instead (Fernandes et al., 2024). This is particularly relevant for multi-strategy funds, underscoring the need for robust measures. Alternatively, fund managers may respond by setting up structures outside the regular AIFMD perimeter.

Another important consideration when designing the policy response is the interaction between different regulatory measures. For instance, yield buffer requirements limit the use of leverage to increase exposure to interest rates. Therefore, GBP-denominated LDI funds subject to these rules maintain significant unpledged bond positions, which can reduce the effect of minimum haircuts on LDI funds. This interaction illustrates the need for a holistic perspective when implementing multiple policy tools, ensuring they complement each other.

Policies that trigger a large reduction in exposures require a sufficiently long transition period. Since the implementation of leverage limits or minimum haircuts may require a substantial reduction in exposures among the affected funds, a transition period should be considered to ensure gradual adjustment and to avoid procyclical effects.[40] Moreover, such policies would ideally be implemented during quiet times rather than stress periods.

Looking ahead, a key avenue for enhancing leverage regulation would be to develop risk-sensitive direct leverage limits, particularly for hedge funds pursuing complex strategies. The heterogeneity and complexity of fund strategies means that certain measures, such as indirect leverage limits, may be well-suited for funds exposed to a single source of market risk but prove less effective for those with multifaceted investment strategies. Direct leverage limits based on notional amounts are also ill-suited to such entities. This complexity underscores the importance of designing flexible, adaptive regulatory frameworks that can accommodate the diverse risk profiles and strategic objectives of various funds. A risk-sensitive approach would adjust according to the specific risk profiles of individual hedge funds, potentially mitigating excessive risk-taking without triggering unintended consequences such as risk-shifting or regulatory arbitrage. Further avenues of future might include (i) providing a comprehensive assessment of the potential impact of margin requirements based on a sophisticated margin model and (ii) computing the interest rate sensitivity of other types of interest rate derivatives beyond IRS.

Future work should move beyond the current analysis to deliver a comprehensive evaluation of policy options by explicitly accounting for unintended consequences, second-round effects, cross-measure interactions, and potential regulatory leakages. It could examine how tighter constraints may shift activity towards riskier assets, prompt migration outside the AIFMD perimeter, and alter liquidity provision. Further analysis would also be needed on

40 In the case of leverage limits applied to property funds in Ireland, a transition period of five years was used to avoid procyclical effects.

interactions between tools (e.g. yield buffers and minimum haircuts) that could blunt or amplify effects.

5 Conclusions

Our risk assessment points to the significant role played by leverage in amplifying risks within AIFs, with the level and source of leverage varying across fund types. Hedge funds exhibit the highest leverage ratios, reflecting their extensive use of derivatives and repo borrowing. This operational model leaves them highly exposed to market fluctuations. LDI funds, while employing lower leverage than hedge funds, are similarly at risk due to their reliance on interest rate swaps and, in the case of GBP-denominated funds, repo borrowing to increase their exposure to long-term interest rates. Consequently, a parallel upward shift in the yield curve generates substantial liquidity needs and leads to losses for their investors.

Our analysis underscores the value of employing a diverse set of metrics due to their complementary nature. While leverage ratios based on notional exposures are easy to calculate, they do not capture the netting of exposures and varying levels of risk sensitivity. Therefore, it is important to consider more risk-sensitive metrics as well. For instance, the ratio of initial margin posted to NAV provides a more nuanced measure of synthetic leverage. Additionally, assessing the sensitivity of funds to specific market risks, such as interest rate fluctuations, provides a clearer picture of the risks associated with leverage. Breaking down leverage metrics by the source of leverage and incorporating additional data on liquidity risks, counterparties, and haircuts further enhances risk monitoring.

We find that the effects of policy options vary considerably across fund types, indicating that a uniform treatment of fund types is not desirable. Direct leverage limits with a moderate calibration significantly restrict the leverage employed by hedge funds, while LDI funds and other leveraged funds would be affected only under much stricter limits. Minimum haircuts on repo transactions primarily affect hedge funds, as LDI funds tend to hold substantial unpledged bond positions due to existing yield buffer requirements. These findings point to the need for tailored policy design that accounts for all mitigants of financial stability risks posed by from leverage and the complex interplay between different regulatory measures.

Combining entity-level AIFMD data with transaction-level data is crucial both for risk monitoring and for assessing policies. Key parts of our analysis would not have been possible using only entity-level or transaction-level data. For instance, metrics based on initial margins require us to combine initial margins reported under EMIR with NAV or unencumbered cash from AIFMD data. Similarly, our assessment of minimum haircuts involved both current haircuts and repo collateral characteristics from SFTR data, along with information on the size of the bond portfolio from AIFMD data. We also examine the consistency of several variables available in both entity- and transaction-level data and identify significant discrepancies for some variables and fund types. This illustrates the advantages of having key variables reported under different frameworks, which must be weighed against the costs associated with reporting requirements.

Additional datasets could be considered to enhance our understanding of leverage captured through AIFMD data. SFTR and EMIR data provide transaction-level information on repo borrowing and derivatives, which are the primary sources of leverage among highly leveraged funds such as hedge funds and LDI funds. To shed light on leverage obtained through bank loans (the main source of leverage among real estate funds), AIFMD data could be merged with Anacredit data. Moreover, leverage among private equity funds along the investment chain is currently unreported under AIFMD. Future studies could identify potential data sources to address this gap.

Potential future avenues for research include an analysis of the sensitivity of funds to a wider range of risk factors and an assessment of additional policy options. In our analysis of risk sensitivities, we consider only parallel shifts in interest rate curves and changes in credit spreads. If a pricing tool for equity and FX derivatives in EMIR were available, we could extend our analysis to stock price and exchange rate fluctuations. This would lay the necessary foundation for evaluating various indirect leverage limits. Moreover, implementing the ISDA-SIMM model to compute initial margins would make it possible to assess margins requirements as a policy to mitigate risks posed by leverage. A further avenue for future work might be to develop and evaluate a risk-sensitive direct leverage limit for hedge funds pursuing complex strategies.

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Appendix

A) Approximating the effects of interest rate shocks on bonds and interest rate derivatives

Approximation for bonds with a fixed coupon rate

Consider a bond with a fixed coupon rate:

$$P = \sum_{i=1}^{N} e^{-R(T_i)T_i}\, CF_i$$

$$P' = \sum_{i=1}^{N} e^{-(R(T_i)+\Delta R)T_i}\, CF_i$$

where:

- P: price of the bond
- P': price of the bond after a parallel shift in the yield curve by ΔR
- $R(t)$: yield curve
- CF_i: pre-determined cash flow at time T_i

For a typical bond with face value F and fixed coupon rate c, the cash flows are $CF_i = c\,F$ for $\mathrm{i} = 1, \ldots N-1$ and $CF_N = (1+c)F$.

The main variables of interest in the following are $\Delta P = P' - P$ and $\Delta P/P$, i.e. the absolute and the relative change in the price of a fixed coupon bond. Computing these quantities requires us to construct the relevant yield curve, which is cumbersome. We therefore consider ways to approximate the effect of a parallel shift in the yield curve that do not require knowledge of the yield curve.

In the paper, we use the following approximation:

$$\tilde{P}' = \sum_{i=1}^{N} e^{-(\tilde{R}+\Delta R)T_i}\, CF_i$$

where $\tilde{R}$ is the yield to maturity, defined as the interest rate that satisfies the following equation:

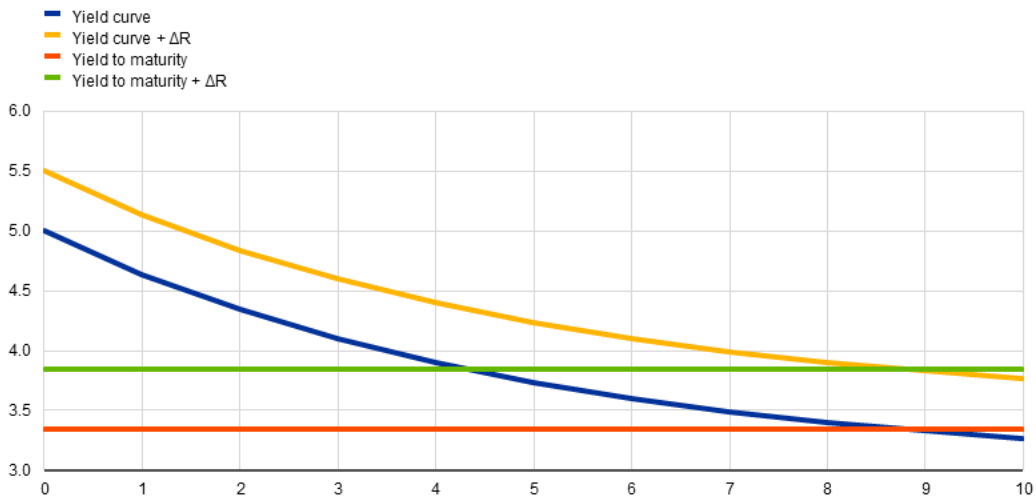
$$P = \sum_{i=1}^{N} e^{-\tilde{R}T_i}\, CF_i$$

$\tilde{P}' - \mathrm{P}$ and $(\tilde{P}' - P)/\mathrm{P}$ are approximations of ΔP and $\Delta P/P$. $\tilde{P}'$ is different from P' because $\tilde{P}'$ is the price after shifting the yield to maturity and not the yield curve (see Figure 15 below).

This approximation assumes that deviations of the yield curve from the yield to maturity $\mathrm{R}(T_i) - \tilde{R}$ are sufficiently small. However, we do not assume that the yield curve shift ΔR is small. Figure 15 illustrates the key idea of the approximation using a simple numerical example.

Figure 15
Approximating the effect of interest rate shocks on bonds

(x-axis: time to maturity in years; y-axis: interest rate in %)



Source: Own computations.
Notes: Consider a bond with a coupon rate of 5%, a face value of 1 and a time to maturity of 10. Coupons are paid at times 0, 1, … 10. For the given yield curve, its price is 1.189 and the yield to maturity is approximately 3.344%. The new price after an upward shift in the yield curve by 50 bps is 1.144. The approximation considers a shift in the yield to maturity instead of a shift in the yield curve and also results in a new price of 1.144.

Derivation:

Deriving a condition on $\mathrm{R}(T_i) - \tilde{R}$ that is implied by the definition of $\tilde{R}$

$$\mathrm{P} = \sum_{i=1}^{N} e^{-R(T_i)T_i}\, CF_i = \sum_{i=1}^{N} e^{-\tilde{R}T_i} e^{-(R(T_i)-\tilde{R})T_i}\, CF_i$$

Taylor approximation of $(R(T_i) - \tilde{R})$ around 0:

$$\mathrm{P} \approx \sum_{i=1}^{N} e^{-\tilde{R}T_i}\left(1 - \left(R(T_i) - \tilde{R}\right)T_i\right) CF_i = \mathrm{P} - e^{-\tilde{R}\sum_{i=1}^{N} e^{T_i}\left((R(T_i)-\tilde{R})T_i\right) CF_i}$$

This implies that $\sum_{i=1}^{N} e^{T_i}\left(\left(R(T_i) - \tilde{R}\right)T_i\right) CF_i \approx 0.$ (*)

Approximating P' by $\tilde{P}'$:

$$P' = \sum_{i=1}^{N} e^{-(R(T_i)+\Delta R)T_i}\, CF_i = \sum_{i=1}^{N} e^{-(\tilde{R}+\Delta R)T_i} e^{-(R(T_i)-\tilde{R})T_i}\, CF_i$$

Taylor approximation of $\left(R(T_i) - \tilde{R}\right)$ around 0:

$$P' \approx \sum_{i=1}^{N} e^{-(\tilde{R}+\Delta R)T_i}\left(1 - \left(R(T_i) - \tilde{R}\right)T_i\right) CF_i = \tilde{P}' - e^{-(\tilde{R}+\Delta R)} \sum_{i=1}^{N} e^{T_i}\left(\left(R(T_i) - \tilde{R}\right)T_i\right) CF_i = \tilde{P}'$$

The final step uses the condition (*) on $\mathrm{R}(T_i) - \tilde{R}$ that we derived above.

An alternative approximation of $\Delta P/P$ is $-\Delta R\, \hat{T}$ where $\hat{T}$ is the average duration of the bond. The average duration is defined as the average maturity of the cash flows weighted by the discounted values of these cash flows (using the yield to maturity for discounting instead of the actual yield curve):

$$\hat{T} = \frac{\sum_{i=1}^{N} e^{-\tilde{R}T_i}\, CF_i T_i}{\sum_{i=1}^{N} e^{-\tilde{R}T_i}\, CF_i}$$

This approximation is based on the assumptions that the shift in the yield curve ΔR is small and that deviations of the yield curve from the yield to maturity $\mathrm{R}(T_i) - \tilde{R}$ are sufficiently small.

Derivation:

$$P' = \sum_{i=1}^{N} e^{-(R(T_i)+\Delta R)T_i}\, CF_i = \sum_{i=1}^{N} e^{-\tilde{R}T_i} e^{-(R(T_i)-\tilde{R})T_i - \Delta R T_i}\, CF_i$$

Taylor approximation of $\left(R(T_i) - \tilde{R}\right) + \Delta R$ around 0:

$$P' \approx \sum_{i=1}^{N} e^{-\tilde{R}T_i}\left(1 - \left(R(T_i) - \tilde{R}\right)T_i - \Delta R T_i\right) CF_i$$

$$P' \approx P - e^{-\tilde{R}\sum_{i=1}^{N} e^{T_i}\left(\left(R(T_i)-\tilde{R}\right)T_i\right) CF_i} - \Delta R \sum_{i=1}^{N} e^{-\tilde{R}T_i}\, CF_i\, T_i$$

The second term is approximately zero because of condition (*), hence:

$$\frac{P' - P}{P} \approx -\Delta R \frac{\sum_{i=1}^{N} e^{-\tilde{R}T_i}\, CF_i\, T_i}{\sum_{i=1}^{N} e^{-\tilde{R}T_i}\, CF_i} = -\Delta R \hat{T}$$

Extending the scope to floating rate notes and interest rate swaps

- Floating rate bonds: ΔP is approximately zero because increases in forward rates almost fully offset the higher discount rates.
- Interest rate swaps: an interest rate swap is essentially a long position in a fixed-rate bond and a short position in a floating-rate bond (or vice versa). Since the interest rate sensitivity of floating rate bonds is approximately zero, the ΔP of an interest rate swap is effectively the ΔP of an equivalent fixed rate bond.

B) Computing the effects of minimum haircuts using AIFMD and SFTR data

1. We consider a sample of AIFs that borrows in the repo market according to SFTR data.

2. For each AIF that borrows in the repo market according to SFTR data, we:

   - Combine the information on repo borrowing R in AIFMD and SFTR as follows:

     - Use gross repo borrowing from AIFMD data if both AIFMD and SFTR data are available.

     - Use gross repo borrowing from SFTR data if this variable is missing in AIFMD data.

   - Compute the average haircut h, weighted by collateral values reported under SFTR.

   - Compute pledged bonds as $B_C = \frac{R}{1-h}$.

   - Compute unpledged bonds as $B_{NC} = B - B_C$, where B represents government bonds, corporate bonds, and securitised products in AIFMD exposures data.

3. For each AIF and each calibration of minimum haircuts, we:

   - Compute the new haircut for each piece of collateral.

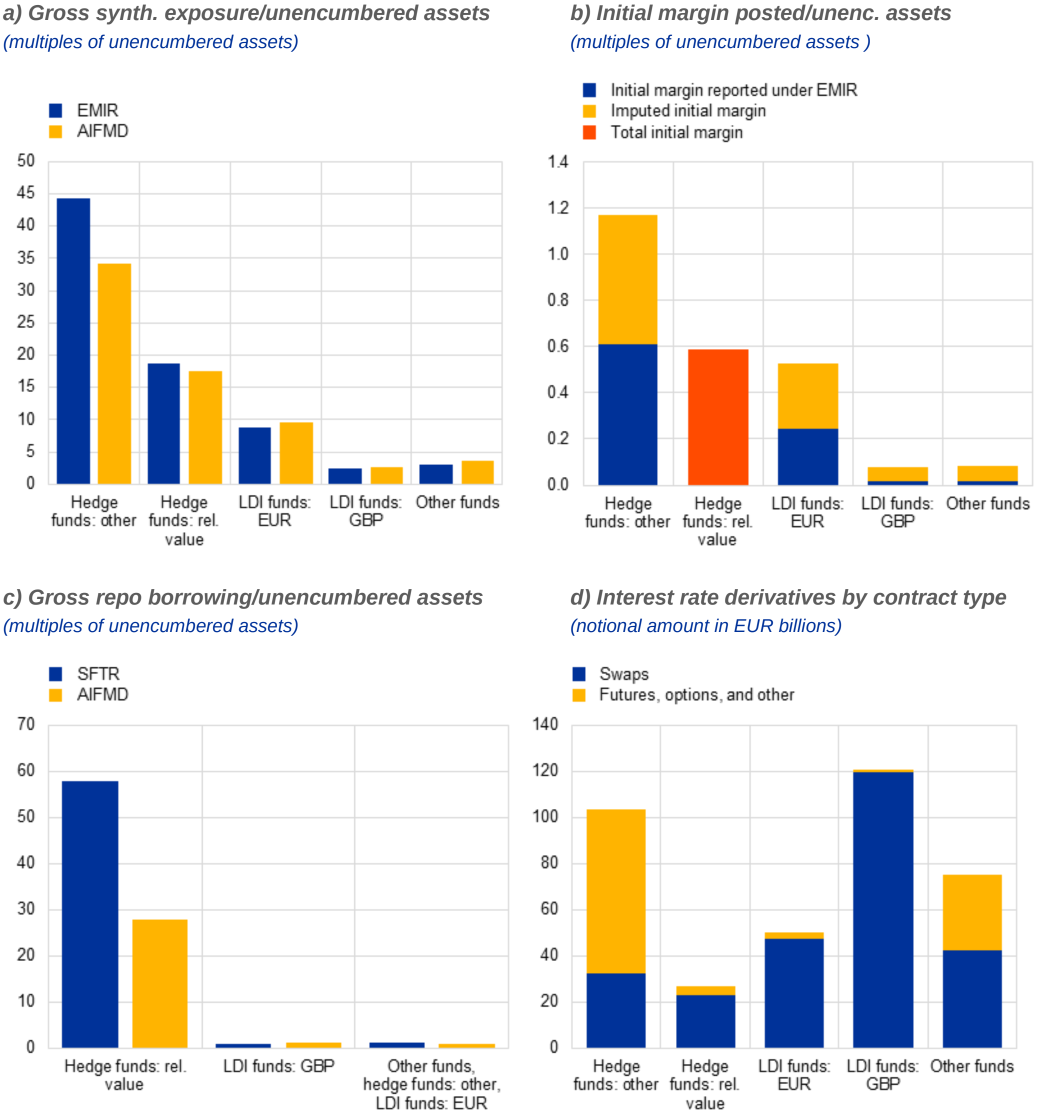
   - Compute the average new haircut $\tilde{h}$ weighted by collateral values reported under SFTR.

   - Use the formulas set out in Section 4.3 to compute new repo borrowing.

C) Additional figures

Figure 16

Synthetic leverage and financial leverage: additional statistics



Sources: AIFMD, SFTR and EMIR data.

Notes: Panels a), b) and c): unencumbered (liquid) assets refer to the sum of unencumbered cash and unpledged bonds, computed according to Appendix B. Unencumbered cash is taken from AIFMD data, whereas the computation of unpledged bonds makes use of both SFTR and AIFMD data. These three panels complement Figures 6, panel d), 7, panel b), and 4 panel d), which use unencumbered cash instead of the broader measure of unencumbered liquid assets. Observations are discarded if unencumbered cash is missing, equal to zero or larger than the NAV or long position in cash. Panels a) and b): unencumbered assets of AIFs that do not trade derivatives are not considered. Panel a): the legend indicates the source of the gross synthetic exposures data. Panel b): we impute missing initial margins on the assumption that the ratio of initial margins posted to synthetic exposures is constant across portfolios held by the same group of AIFs. Reported and imputed initial margins are combined for relative value hedge funds to preserve data confidentiality. Panel c): unencumbered assets of AIFs that do not borrow in the repo market are not considered. The legend indicates the source of the gross repo borrowing data.

Figure 17

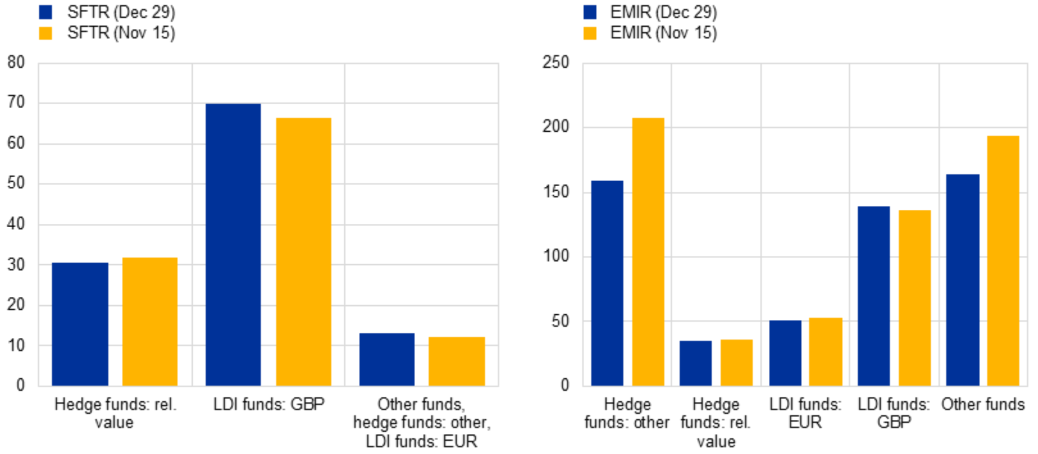
Synthetic leverage and financial leverage: comparison with mid-quarter data

a) Gross repo borrowing

(EUR billions)

b) Gross synthetic exposures

(EUR billions)



Sources: AIFMD, SFTR and EMIR data.

Notes: Comparison of end-of-year data (blue) used throughout our analysis with data from 15 November (yellow) as a robustness check, due to concerns over window dressing.

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

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