Liquidity stress and risk monitoring: the case of Liability-Driven Investment funds

ESRB AWG-MPAG workshop 1 July 2024

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ESMA50-524821-2987

LDI funds and financial stability

Context. GBP LDI funds are used by UK pension funds to match defined benefits due to future pensions. LDI funds invest in long-dated gilts and use leverage via the repo market and IRDs to increase duration and returns.

Relevance. Although EU GBP LDI funds have a net asset value of around EUR 150bn, their use of leverage and their high market footprint in GBP sovereign bond markets make them relevant for financial stability.

Past stress episodes. Risks crystallised during the mini-budget crisis of September 2022, triggering an intervention by the Bank of England.

EU markets. Other entities might be subject to similar risks related to leverage and liquidity in the EU.

Using regulatory data to assess liquidity risk

Data. We merge three datasets related to entity (fund data) and activity-level information (EMIR for derivatives and SFTR for repo)

Risk analysis. We analyse vulnerabilities related to (i) counterparty concentration, (ii) portfolio similarity and (iii) liquidity risk

Stress testing. We apply a liquidity stress test framework to assess the resilience of EU GBP funds pursuing Liability Driven Investment (LDI) strategies

Relevance. Our framework can be applied to any type of entity (incl. banks, hedge funds, insurance or pension funds) to measure liquidity preparedness to interest rate shocks. Such work can inform (i) the supervision of financial institutions, (ii) ongoing risk monitoring and (iii) systemic risk assessment.

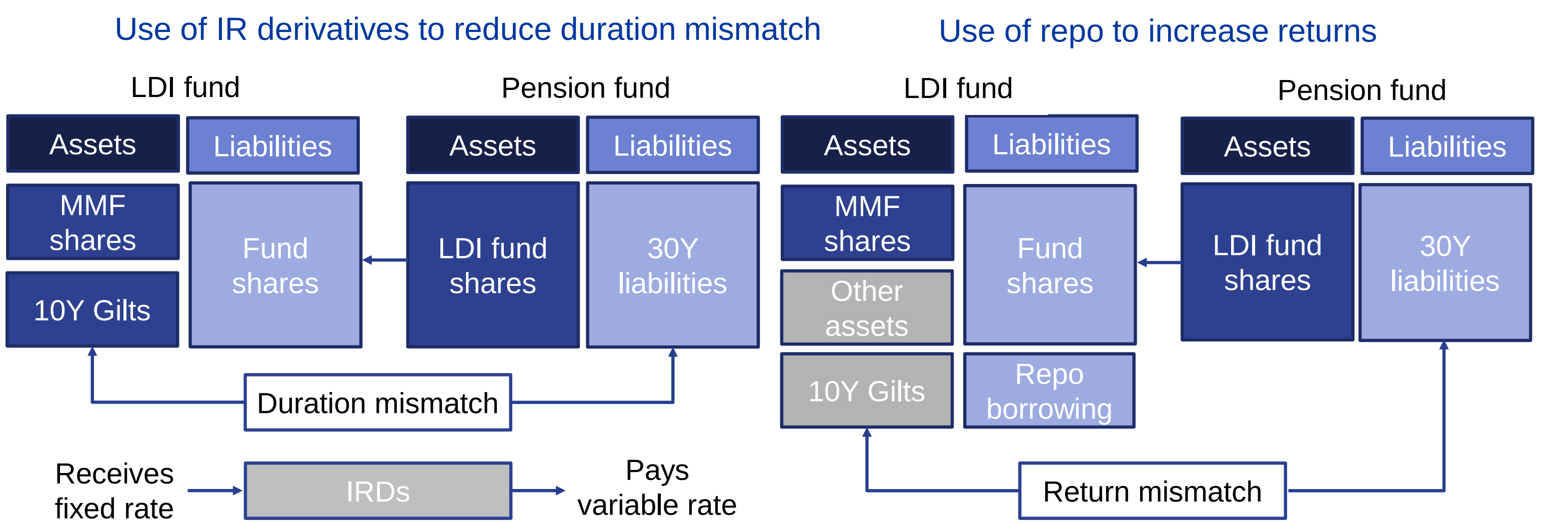
Overview

1. Motivation
2. Data
3. Analytical work
4. Stress test
5. Conclusion

Risks around LDI strategies

Business model: Exposure to duration risk

- UK defined-benefits pension funds need to provide guaranteed returns to future pensioners
- Pension funds use LDI funds to get duration exposure and enhance returns by leverage
- Use of IRDs to mitigate duration mismatch (pay float) and repo to reduce return mismatch, invest mainly in long-dated sovereign bonds (Gilts)
- Use of inflation swaps to buy inflation protection (receive float)



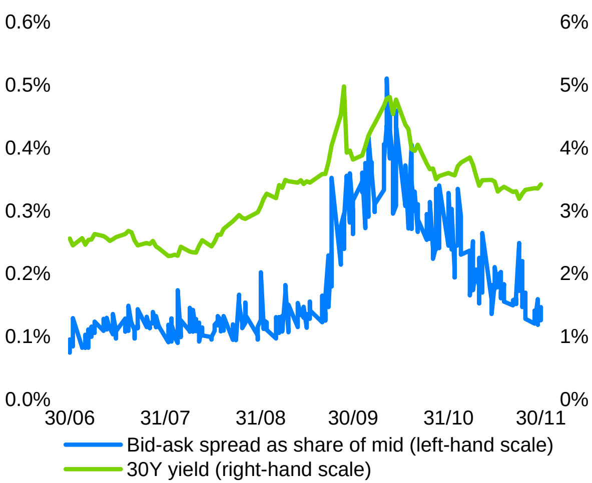
Source: ESRB 2023 NBFI Monitor

The LDI crisis of 2022

Trigger: Mini-budget announcement

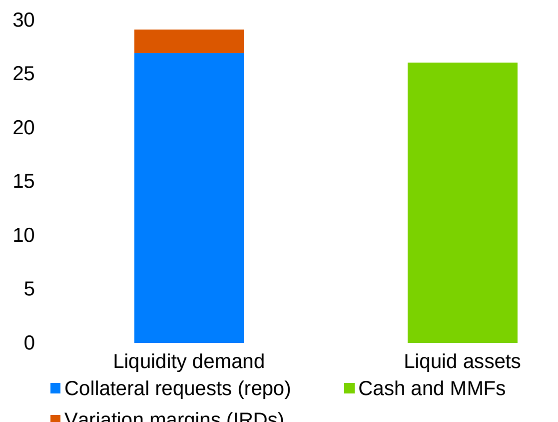
- Adverse market reaction: sharp increase in GBP yields…
- …triggering (i) MtM losses on bonds holdings, (ii) variation margins on IRDs and (iii) collateral requests on repo…
- …forcing LDI funds to liquidate Gilts and redeem from money market funds (MMFs) to raise cash…
- …amplifying the downward price pressure on Gilts and transmitting stress to MMFs…
- …forcing the Bank of England to intervene through asset purchases

30Y GBP yields surged amid low liquidity



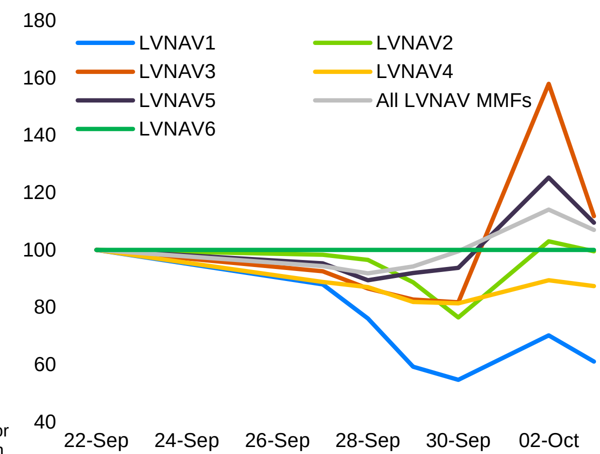
Note: Bid ask spread on 30Y Gilt yields and levels.
Sources: refinitiv EIKON, ESMA., ESRB

…triggering large liquidity demands



Note: Liquidity demand based on estimated changes in collateral value for repos and based on reported changes in market value for IRDs, in EUR bn. Changes between 22 and 27 September 2022 for collateral requests and 23 and 30 September for variation margins..
Sources: AIFMD, EMIR, SFTR. ESMA.

…and MMF redemptions



Note: Cumulative changes in total assets compared to 22 September 2022 in % of NAV.
Sources: Crane. ESMA.

Source: ESRB 2023 NBFI Monitor

Growing literature on risks related to IR risk

ESRB (2022): Impact of IR shocks on EU bonds funds

- Estimates impact of increase in IR on 200 EU bonds funds on bond portfolio and IRD exposures

Jukonis et al. (2022): Impact of shocks on liquidity of investment funds

- Apply IR, FX and equity shocks to derivatives used by EA funds and compare to liquid assets holdings

Bianchi and Ruzzi (2024): Impact of IR shock on banks

- Use of EMIR and bond portfolio data to assess the impact of a 100bps shock on the solvency of Italian banks and evaluation of EMIR data quality

Growing literature on risks related to LDI

Chen and Kemp (2023): Analysis of LDI vulnerabilities

- High concentration within LDI funds and high concentration towards long-term Gilts
- Lack of liquidity risk preparedness
- Challenges related to cross-border nature of GBP LDI funds

Pinter (2023): LDI selling behaviour during the crisis

- Firms in the LDI-pension insurance sectors (LDI-PI) with large repo and swap exposures sold more gilts during the crisis. Use of transaction data (MiFID II), EMIR and repo data

Pinter and Walker (2023): Concentration of exposures the in gilt market

- Joint analysis of gilt and derivatives exposures by NBFIs using MiFID II and EMIR, high concentration of IR exposures by LDI-PI sector

ESRB (2023): Stress testing LDI funds

- Use of June 2022 regulatory data to assess risks and perform stress tests on EU LDI Funds
- Identification of large liquidity shortfall for IR shocks of 100-150bps

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Merging different regulatory datasets

Alternative Investment Fund Manager Directive (AIFMD) dataset

- Quarterly data on size, exposures and leverage of 366 EU GBP LDI funds for 2021-2023 (identification based on names and feedback from NCAs)

EMIR dataset

- Daily data on positions on derivatives by counterparties and daily valuation (Trade state). Snapshot of around 9,400 positions.

SFTR dataset

- Daily data on repo borrowing/lending by counterparty along with collateral information at ISIN-level (see ESMA, 2024a); 3,182 LDI-ISIN positions; 1,481 LDI-Counterparty positions

Reference date for the stress test

- Reference date as of 13 December 2023 to avoid end-of-the-year effects (window dressing for repo and derivatives, in line with ESMA practices for market report)

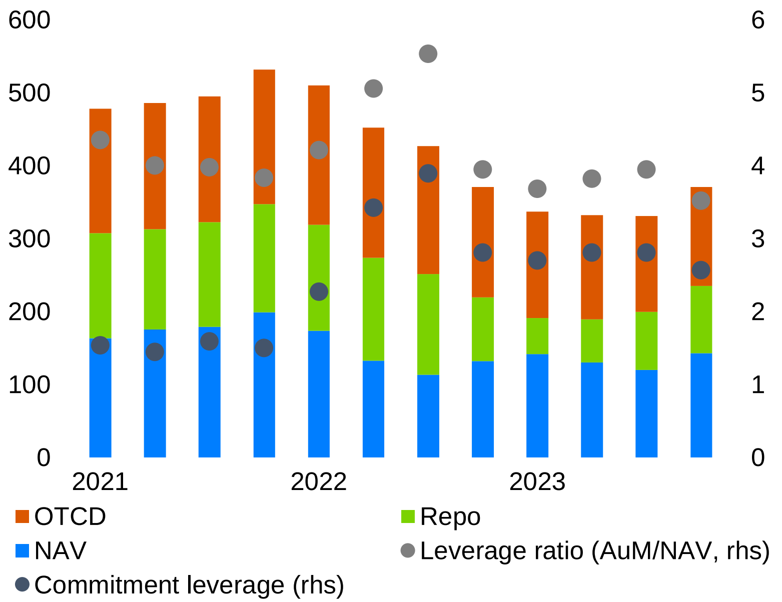
Use of Legal Identity Identifiers (LEIs) at fund level to merge the datasets

Overview of EU LDI GBP funds

Concentrated exposures and large leverage

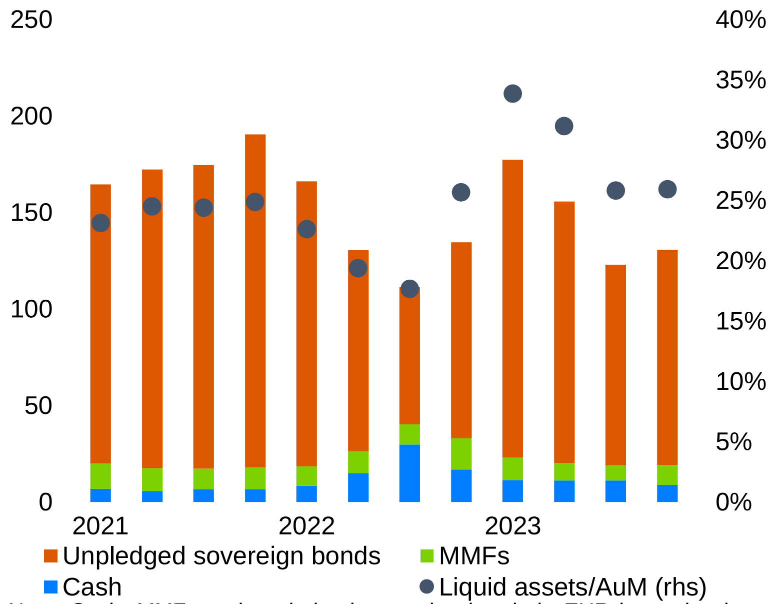
- High leverage used by GBP LDI funds: repo and derivatives (mainly IRDs); jump in 2022H1
- High portfolio concentration: UK sovereign bonds account for 150% of NAV; most funds have very similar structures
- Relatively low levels of liquid assets in 2022H1

NAV, repo borrowings and OTC derivatives exposures



Note: EU GBP LDI funds net asset value and borrowing through repo and borrowing embedded in OTC derivatives in EUR bn.
Sources:AIFMD, ESMA.

Composition of unencumbered liquid assets



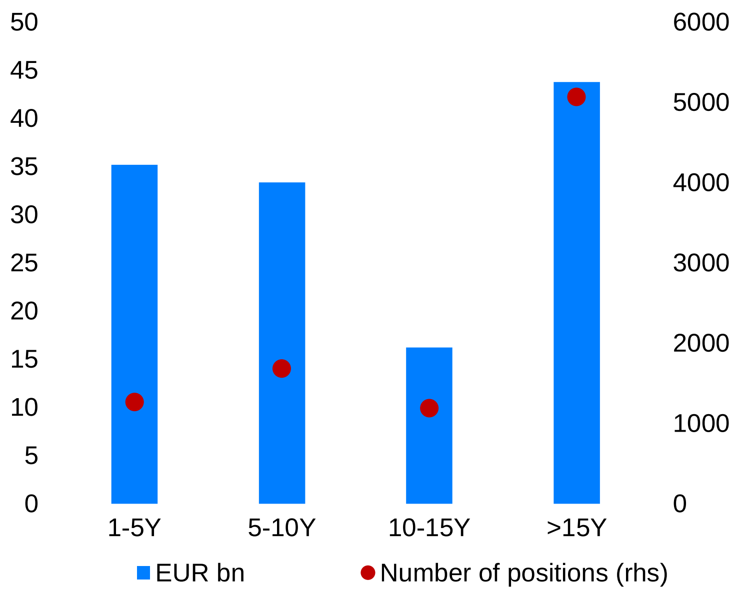
Note: Cash, MMFs and unpledged sovereign bonds in EUR bn and ratio to AuM in %
Sources:AIFMD, ESMA.

Some insights from EMIR

Derivatives exposures

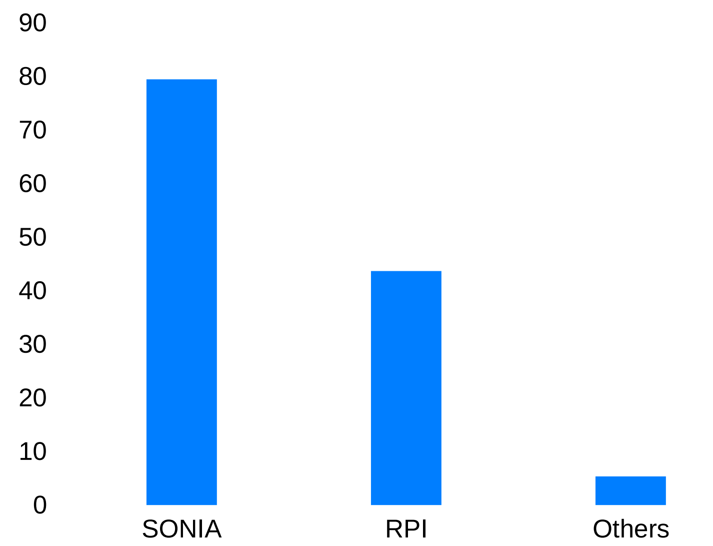
- Mostly IRDs
- Mainly swaps with overnight underlying (SONIA) or inflation(UK RPI)

Large exposures to long-end of the curve…



Note: Gross notional exposures to IRD, in EUR bn and number of positions.
Sources: EMIR, ESMA.

…concentrated on overnight rates and inflation swaps



Note: Gross notional exposures to IRD, in EUR bn by underlying reference rate.
Sources: EMIR, ESMA.

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Using regulatory data for monitoring and supervision

Stress testing

- Use EMIR and SFTR data to calculate potential liquidity demands for a large interest rate shock
- Use AIFMD data to assess available liquid assets

Monitoring

- Analysis of concentration: Network of counterparties for IRDs and repo transactions
- Amplification: Estimation of portfolio similarity to assess spill-over effects

Supervision

- Results of the analysis can (i) feed the annual risk assessment of AIFs under Article 25 of AIFMD (leverage limits and other measures) and (ii) be used to engage with supervised entities

Valuation of interest rate derivatives

Data requirements

- IRD characteristics (maturity, fixed/floating leg, reference rate)
- Market data: Discount rate and forward curve

Pricing models

- Static approach: Estimate IR sensitivity to a 1bp shock (DV01) but biased for large shocks
- Dynamic approach: Full repricing of IRD

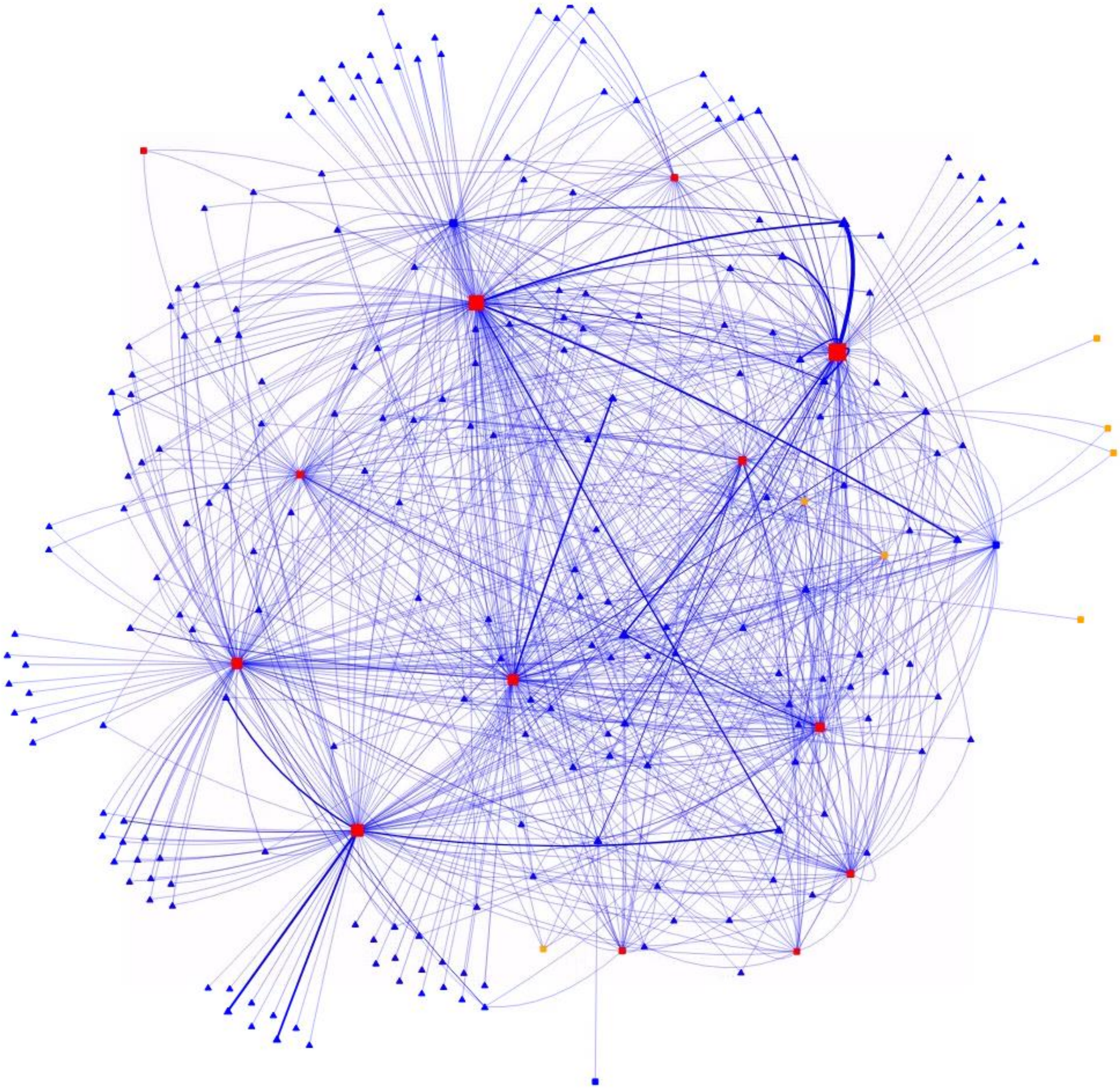
Goodness of fit

- Comparison of estimated valuation to reported valuation in EMIR (as in Bianchi and Ruzzi; 2024) and to commercial pricing models (Refinitiv EIKON)

Network at LDI fund level

country	color
EU1	blue
EU2	blue
EU3	blue
EU4	blue
EU5	blue
EU6	blue
ROW1	orange
ROW2	orange
ROW3	orange
GB	red

LDI	triangle
OTHER	square

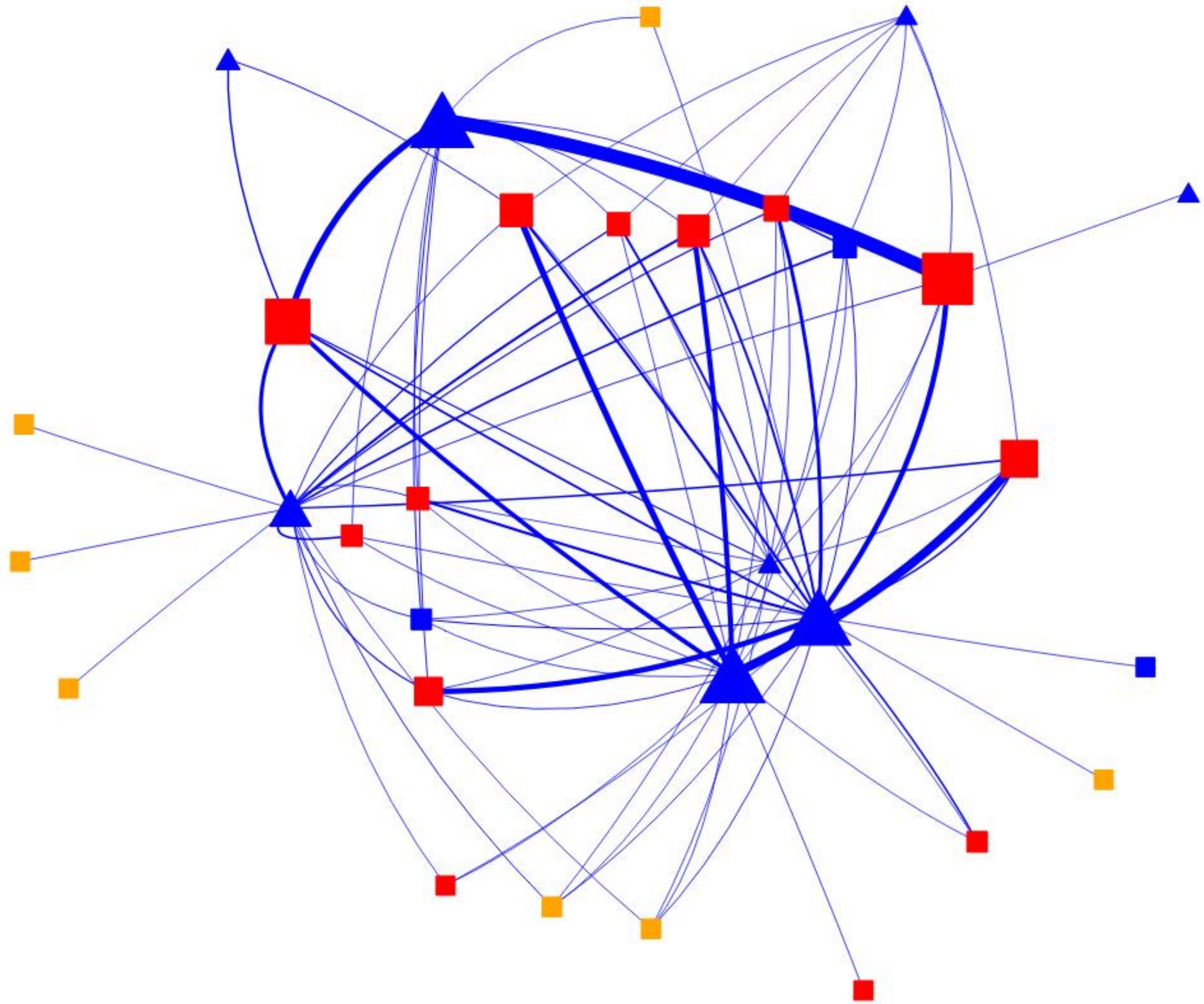


Note: The size of the nodes is related to gross notional exposures and the thickness of the edges is related to bilateral exposures.

Network at LDI fund-manager level

country	color
EU1	blue
EU2	blue
EU3	blue
EU4	blue
EU5	blue
EU6	blue
ROW1	orange
ROW2	orange
ROW3	orange
GB	red

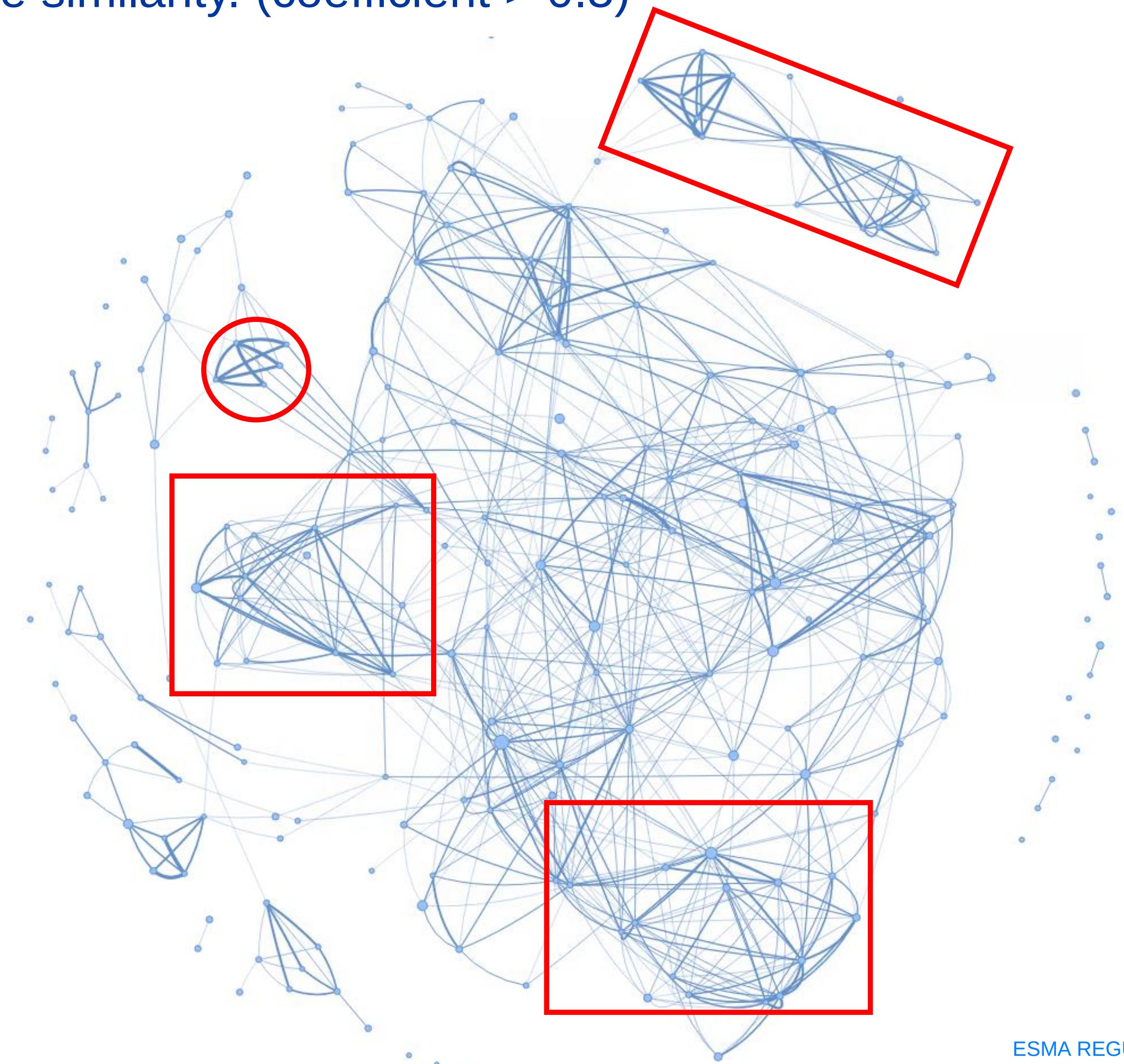
LDI	triangle
OTHER	square



Note: The size of the nodes is related to gross notional exposures and the thickness of the edges is related to bilateral exposures.

Collateral portfolio similarity: large overlap

Network of LDI exposures to the same bonds used as collateral. Analysis based on cosine similarity. (coefficient > 0.5)



Note: The size of the nodes is related to collateral pledged and the thickness of the edges is related to the cosine similarity index.

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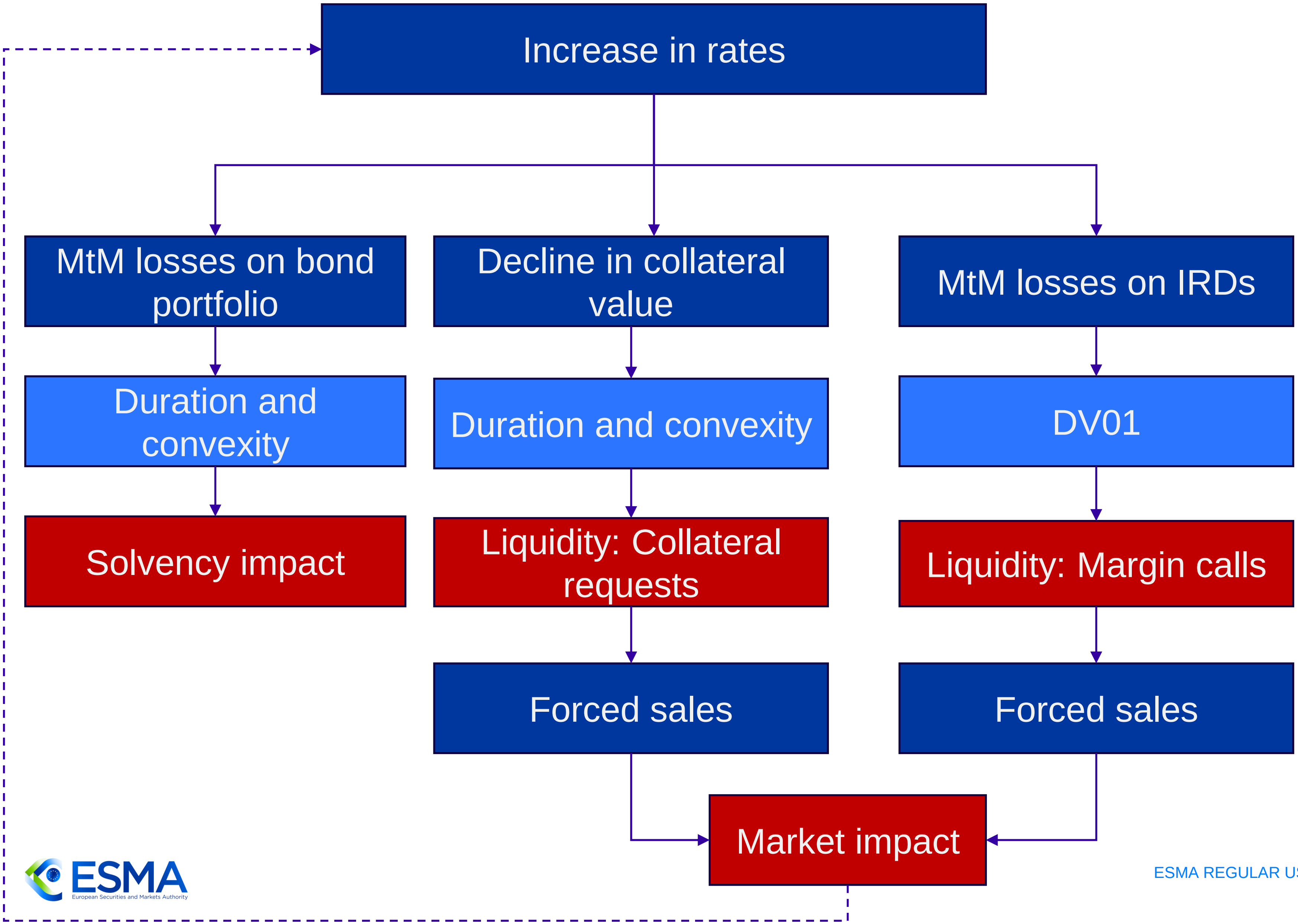
Impact of an interest rate shock: Mechanics

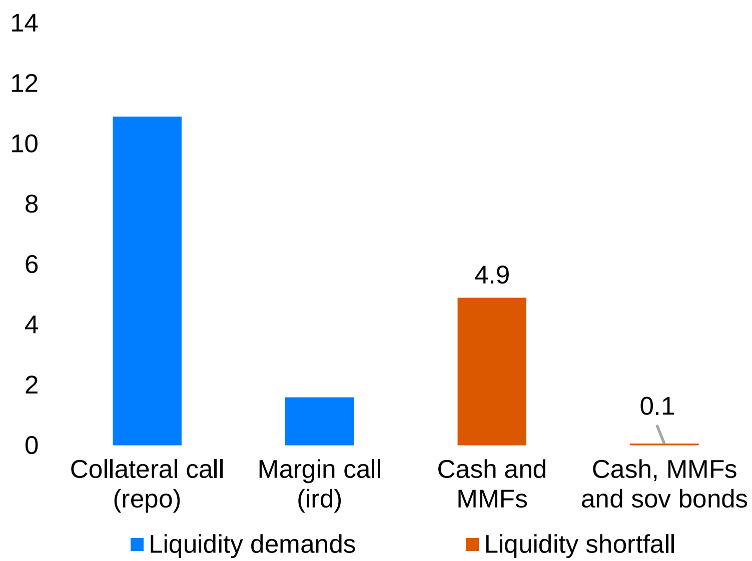


Impact of an interest rate shock

Impact of a 100-300 bps rise in GBP yields

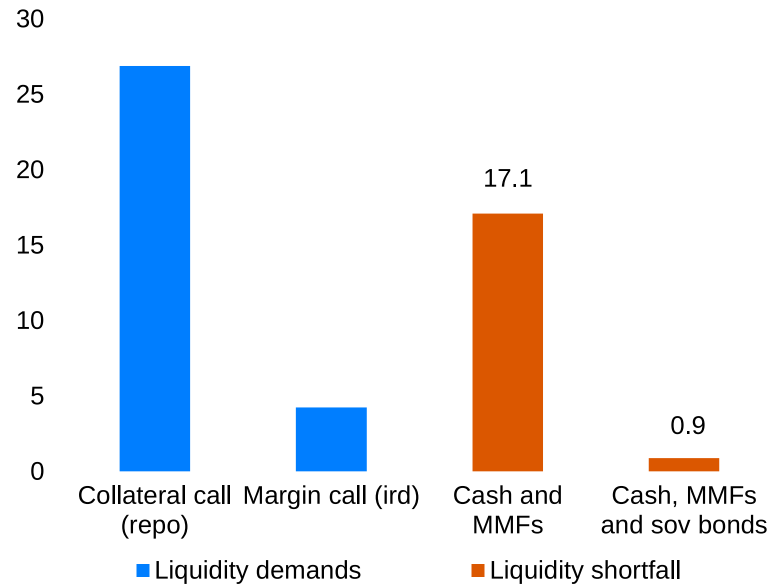
- Lower liquidity demands than in June 2022 for a 100bps shock (EUR 13bn vs 22bn)
- Almost all funds able to withstand the shock with existing liquid assets (incl. gilts)
- LDI more resilient than in June 2022 (for a 100bps shock liquidity shortfall of EUR 5bn compared to 7bn in 2022 considering cash and MMFs only)
- Large redemptions from MMFs (EUR 4.5/6.6bn~43%-64% of holdings, or 3% of all GBP MMFs); use of cash (EUR 2-2.5bn); asset sales (EUR 4/18bn vs ADV of 18bn)
- However, MtM losses on unpledged sovereign bonds proxied by collateral information

Impact of a 100 basis point shock to GBP yields



Note: Impact of a 100bps interest rate shock on pledged collateral for repo and liquidity shortfall, in EUR bn.
Sources: AIFMD, EMIR, SFTR, ESMA.

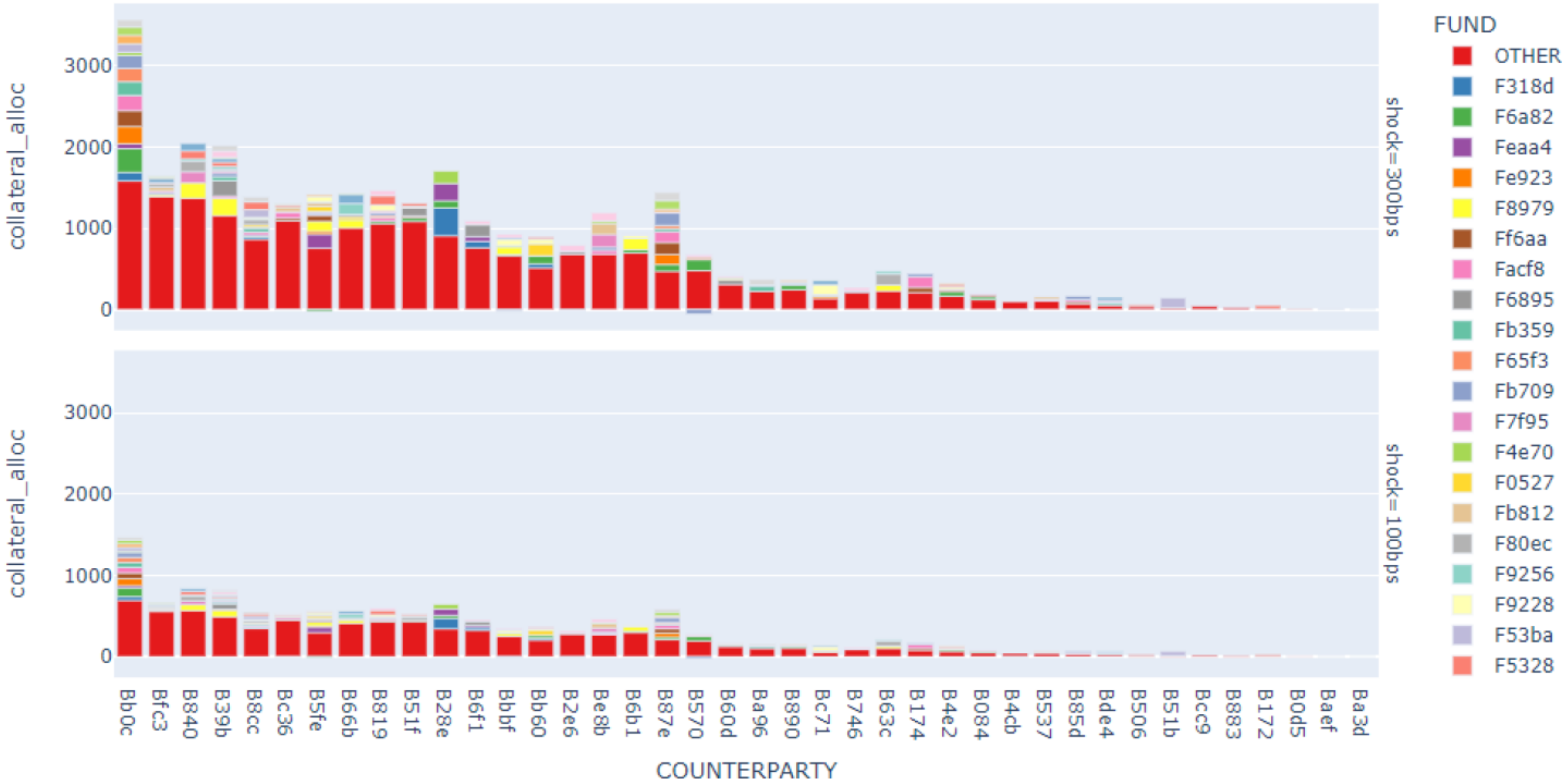
Impact of a 300 basis point shock to GBP yields



Note: Impact of a 300bps interest rate shock on pledged collateral for repo and liquidity shortfall, in EUR bn.
Sources: AIFMD, EMIR, SFTR, ESMA.

Impact of an interest rate shock: Repo borrowing

Impact of a 100-300 bps rise in GBP yields on banks



Note: Banks are anonymised and shown on x-axis. LDI funds are anonymised and shown in bars.

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Key takeaways

Show how regulatory datasets can be used to monitor risks

- Derivatives exposures (EMIR) and repo borrowing (SFTRs)
- Liquidity demands can be monitored using valuation data from EMIR (trade activity)
- Liquidity risk preparedness and use of leverage (AIFMD)
- Vulnerabilities related to portfolio similarity and concentrated counterparty exposures (network analysis)

Liquidity stress testing framework

- Use scenario to estimate liquidity demands related to margin calls (EMIR) and collateral requests (SFTR)
- Possibility to use a reverse stress testing approach: determine size of IR shocks that funds could withstand

Possible extensions

- Apply similar framework to other entities: banks, insurance and pension funds, hedge funds etc.

Technical appendix and additional slides

Data quality issues in EMIR

Data preparation

- Underlying:
  - Use of free text requires string matching. Around 20 different labels for OIS underlying (SONIO, SONIA WMR, SONIA ON …) and 16 labels for inflation swap underlying (RPI, UK-RPI,UKRPI…); some fields related to underlying might be empty (need to rank sources)
- No clear consistency in reporting of leg 1 vs leg 2 (fixed-float and float-fixed)
- Coupon payment for overnight index swaps: Reported at daily flows but market convention is annual.
- For some fields, expert judgment has to be used to attribute the correct characteristic of the swap

See also Bianchi et al. (2024) and ESMA (2024b) for further discussion of data quality issues in EMIR

Object-oriented python library to price IR derivatives contract
leg 1 : Fixed Leg
leg 2 : Floating Leg

```
FixedLeg1 = {
 'legType': 'fixed',
 'legSide': 'pay',
 'fixed_rate': 0.6648/100,
 'notional': 15973700,
 'maturity_date': (22, 11, 2032),
 'start_date': (22, 11, 2018),
 'first_fixed_rate_coupon_date': (22, 11, 2018),
 'dayCounter_fixed_leg' : 'ACTUAL/ACTUAL',
 'initial_margin_posted': 0,
 'settlement_days_floating_rate': 2,
 'timeUnit_fixed_leg': 12}

fxLeg1 = FixedLeg.from_dict(FixedLeg1)
fxLeg1
```

```
FloatingLeg2 = {
 'legType': 'floating',
 'legSide': 'receive',
 'notional': 15973700,
 'maturity_date': (22, 11, 2032),
 'start_date': (22, 11, 2018),
 'floating_rate_name': 'SONIA',
 'first_floating_rate_coupon_date' : (22, 11, 2018),
 'dayCounter_floating_leg' : 'ACTUAL/ACTUAL',
 'initial_margin_posted': 0,
 'settlement_days_floating_rate': 2,
 'timeUnit_floating_leg': 12}

fltLeg2 = FloatingLeg.from_dict(FloatingLeg2)
```

Object-oriented python library to price IR derivatives contract

Data filtering : trade state, LEI of LDI funds on 2023-12-15

```
df = (read_emir("trade_state")
        .MakeEmirSparkDataFrame()
        .clean_cols()
        .repartition(10000)
        .filter(F.col('COUNTERPARTY_ID').isin(AAF_LEI))
        .filter(F.col('ASSET_CLASS') == 'IR')
        .filter(F.col('CONTRACT_TYPE') == 'SW')
        .filter(F.col('NOTIONAL').isNotNull())
        .filter(F.col('MATURITY_DATE') >= '2023-12-15')
        .filter(F.col('EXECUTION_TIMESTAMP') <= '2023-12-15')
        .filter(F.col('AS_OF_DATE') == 231215)
        .MakeEmirSparkDataFrame()
        .define_legs()
        .clean_cols(drop=True)
)
df.count()
```

(3) Spark Jobs

df: pyspark.sql.connect.dataframe.DataFrame = [COUNTERPARTY_ID: str

```
9209
```

Object-oriented python library to price IR derivatives contract

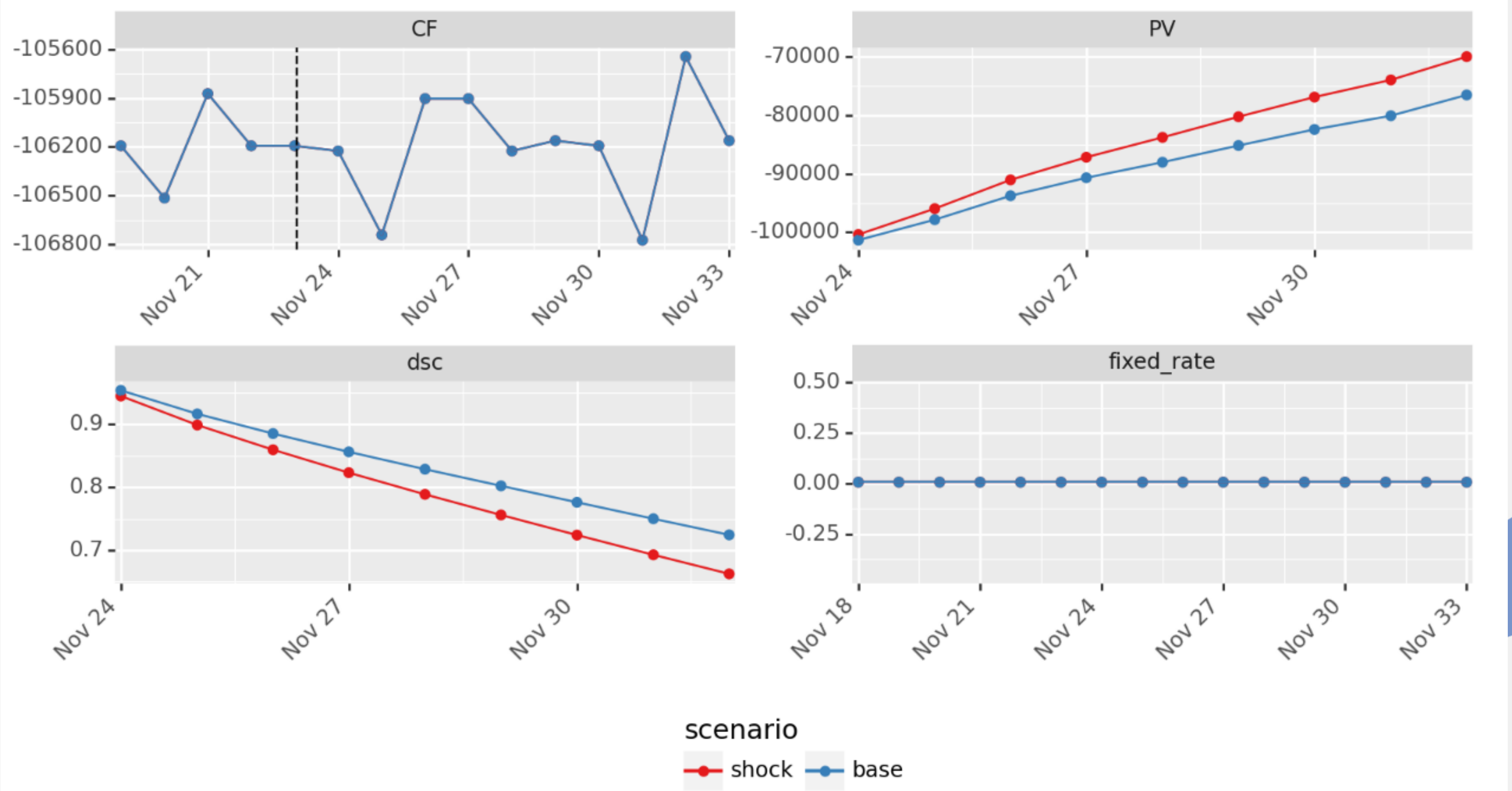
IR Swap object made from FixedLeg and FloatingLeg objects

```python
irs = IRSwap.from_dict({'leg_1': fxLeg1,
                        'leg_2': fltLeg2})

irs = irs.valuation(valuation_date = (13, 12, 2023),
                     update=True,
                    discount_factor_leg_1 = sonia_swp_gbp_20231213,
                    floating_rate_index_leg_1 = sonia_swp_gbp_20231213)

irsShock = irs.shock(valuation_date = (13, 12, 2023),
                     shock_bps_dsc=100,
                     shock_bps_forward=100,
                     discount_factor_leg_1 = sonia_swp_gbp_20231213,
                     floating_rate_index_leg_1 = sonia_swp_gbp_20231213)
```

Object-oriented python library to price IR derivatives contract

Fixed Leg valuation and shock

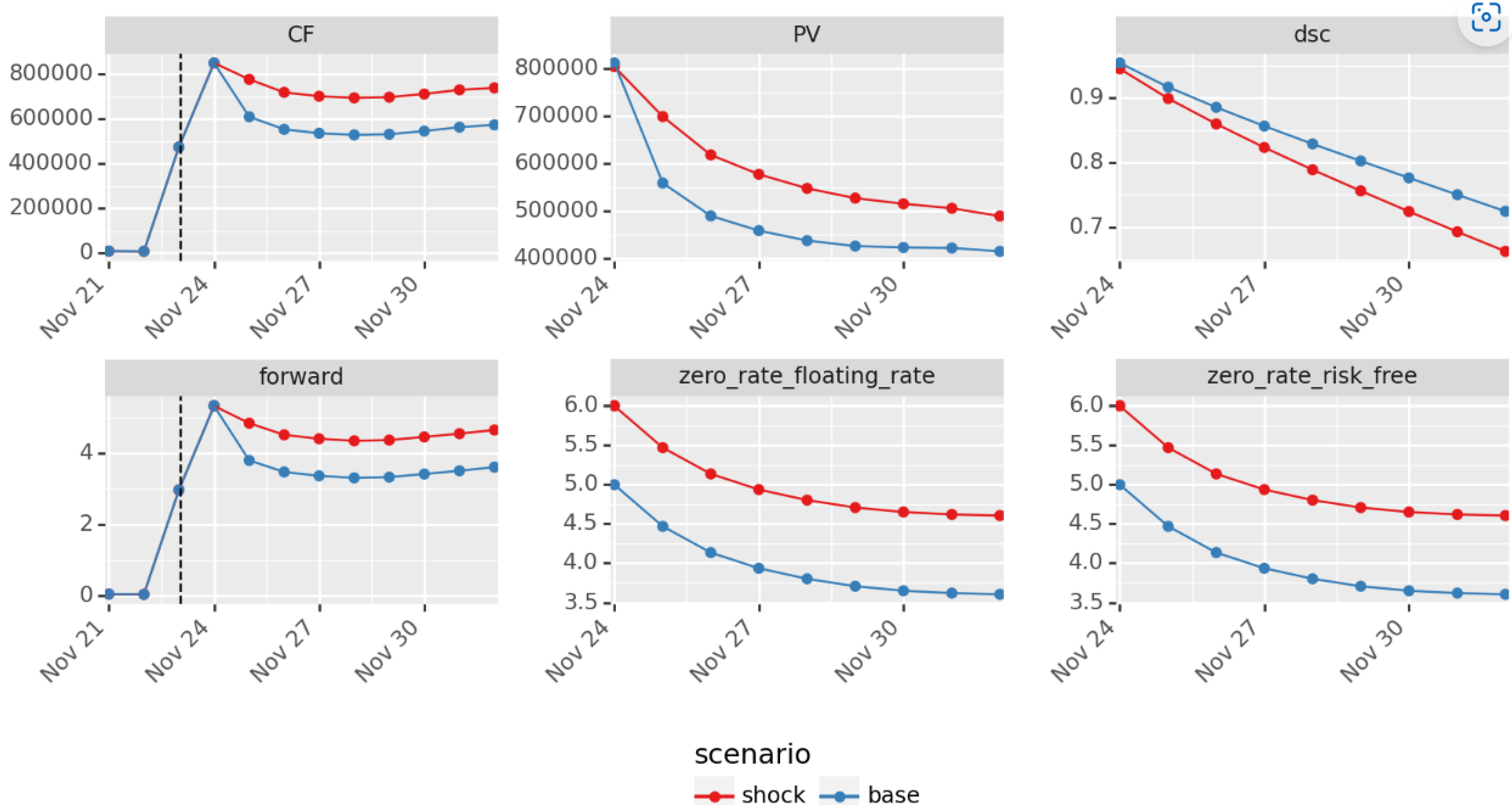
CF = cashflows, PV = present value (discounted cashflows), Dsc = discount factor



Object-oriented python library to price IR derivatives contract

Floating Leg valuation and shock

CF = cashflows, PV = present value (discounted cashflows), Dsc = discount factor



Object-oriented python library to price IR derivatives contract

EmirDataFrame object: data cleaning, leg definition, valuation and shock on LDI IR swap with SONIA as floating rate

```
irsw2 = (irsw
         .MakeEmirDataFrame()
         .clean_notional()
         .clean_fixed_rates()
         .clean_floating_rates()
         .clean_daycounts()
         .clean_payment_frequency()
         .clean_reference_period()
         .define_legs()
         .clean_cols()
         .move_b_col()
         .query("FLOATING_RATE_OF_LEG_1 == 'SONIA' or FLOATING_RATE_OF_LEG_2 == 'SONIA'")
         .shock()
)
display(irsw2)
```

Overview of the pricing framework

Value of floating vs fix interest rate swap for a short position (receive fixed)

$$V^{swap} = B^{fix} - B^{float}$$

We have a swap of maturity T, notional N, with q^{fix} payments per year (q^{float} for the floating leg) for a total of I (J) payments between t_0 and T. We note n_i (d_i) the time frame in months (days) between t_0 and the i^{th} payment date, $s^{(T)}$ the fixed rate and $z^{(.)}$ the spot rates for each maturity.

We can value the fixed leg as

$$B^{fix} = \sum_{i=1}^{I} \frac{C^{fix}}{\left(1 + z^{(n_i)} \frac{d_i}{365}\right)} + \frac{N}{\left(1 + z^{(n_I)} \frac{d_I}{365}\right)}$$

with $C^{fix} = \frac{s^{(T)}N}{q^{fix}}$

We use the forward curve to value the floating leg:

$$B^{float} = \sum_{j=1}^{J} \frac{C_j^{fl}}{\left(1 + z^{(n_j)} \frac{d_j}{365}\right)} + \frac{N}{\left(1 + z^{(n_J)} \frac{d_J}{365}\right)}$$

with $C_j^{fl} = \frac{f^{\left(n_{j-1}, n_j\right)}N}{q^{float}}$ and $f^{\left(n_{j-1}, n_j\right)}$ the forward rate between times n_{j-1} and n_j

Assessing common exposures to the same collateral

Different portfolio similarity measures (Euclidean distance, cosine similarity etc.). We chose the cosine similarity as it is unaffected by the size of the LDIs (see Girardi et al., 2021, JFE). The similarity is equal to the dot product of the pair's portfolio weights normalised by the vector's lengths:

$$Similarity_{i,j} = \frac{w_i \cdot w_j}{\|w_i\| \, \|w_j\|}$$

With w_i the vector asset weights in the collateral posted by LDI i and w_j for LDI j

Impact of interest rate shocks

Impact on IRDs: Full revaluation (rather than sensitivity using DV01)

- IR shock triggers a parallel shift of the yield curve (discount rate and forward rate). The impact is equal to the change in swap value:

$$Impact_{\Delta IR} = V_0^{swap} - V_{\Delta IR}^{swap}$$

Impact on bonds (incl. those pledged as collateral): MtM losses related to duration D_t^j and convexity C_t^j and the size of the shock ΔIR:

$$PnL(t,j) = FV_t^j r_{ir}^i(t,j)$$

$$r_{ir}^i(t,j) = -D_t^j \Delta IR + \frac{1}{2} C_t^j (\Delta IR)^2$$

References

Bianchi, M., Sorvillo, B., Ruzzi, D., Apicella, F., Abate, L. and L. Del Vechio (2024), 'EMIR data for financial stability analysis and research', BIS Bulletin, forthcoming

Bianchi, M. and D. Ruzzi (2024), 'Shifting the yield curve for fixed-income and derivatives portfolio', unpublished manuscript

Chen, R. and E. Kemp (2023), 'Putting out the NBFIre: Lessons from the UK liability-driven investment (LDI) crisis ', IMF Working Paper No. 23/210

ESMA (2024a), EU Securities Financing Transactions markets 2024

ESMA (2024b), 2023 Report on Quality and Use of Data

ESRB (2022), EU Non-bank Financial intermediation Risk Monitor 2022

ESRB (2023), EU Non-bank Financial intermediation Risk Monitor 2023

Jukonis, A., Letizia, E. and L. Rousová (2022), 'The impact of derivatives collateralisation on liquidity risk: evidence from the investment fund sector', ECB Working Paper No. 2756

Pinter, G. (2023), ' An anatomy of the 2022 gilt market crisis', Bank of England Working Paper No.1,019

Pinter, G. and D. Walker (2023), 'Hedging, market concentration and monetary policy: a joint analysis of gilt and derivatives exposures', Bank of England Working Paper No. 1,032