

EURAXI: a benchmark for Euro credit spreads

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Abstract

We study the feasibility and benefits of implementing an across-the-curve credit spread index for the Eurozone. We propose a methodology which takes into account specific features of Euro-denominated wholesale funding markets. We discuss the role for hedge accounting and the advantages of using such a benchmark in the framework of current benchmark reforms and in stressed conditions. Finally, we discuss how our proposal aligns with international guidelines and regulations for market benchmarks.

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1 Introduction

The fallout from the LIBOR manipulation scandal have underlined the inherent shortcomings of the design underlying the LIBOR benchmarks [Cont, Guo, and Xu \[2021\]](#) and the need for interest rate and credit benchmarks based on market transactions rather than declarative inputs, leading to various proposals for reforming these benchmarks [\[Duffie and Stein, 2015\]](#).

In this context, [Berndt, Duffie, and Zhu \[2023\]](#) have proposed an *across-the-curve index*(AXI), a credit spread benchmark for USD interbank markets defined as a weighted average of recent credit spreads of unsecured US bank funding transactions with maturities ranging from overnight to five years, with weights that reflect both transactions volumes and issuances.¹ Unlike LIBOR, AXI is not limited to short-term unsecured markets and not based on quotes or expert judgement but rather on actual recent transactions, thus reflecting actual funding costs of banks. [Berndt et al. \[2023\]](#) argue that this construction satisfies three requirements: effectiveness as a tool for hedging, robustness and adaptability to changes in issuance patterns.

It is therefore a natural question whether this methodology may be applied to other markets and currency zones. The response is not as obvious as it may seem at first glance, as the structure of wholesale money markets and data availability on such transactions is quite different across jurisdictions. The applicability of the AXI methodology to the Chinese market has recently been studied by [Li, Zhang, Zhang, and Zhang \[2022\]](#).

In the case of the Eurozone in particular, there is a greater heterogeneity both in terms of reference rates and debt instruments. Inspired by the approach of [Berndt et al. \[2023\]](#), we propose a methodology for constructing EURAXI, a transaction-based credit spread benchmark for Euro interest rates, which takes into account specific features of the Euro-denominated wholesale funding. We examine the feasibility and benefits of implementing such an across-the-curve index for the Euro. We discuss the role for hedge accounting and the advantages of using such a benchmark in the framework of current benchmark reforms and in stressed conditions, in conjunction of the new risk-free reference rates. Finally, we discuss the robustness and representativeness of EURAXI in line with [IOSCO \[2013\]](#) principles for benchmark design and EU benchmark regulation.

Outline Section 2 describes the EURAXI methodology and Section 3 discusses data sources for calculating the proposed benchmark. Section 4 examines the role and benefits of EURAXI in the context of the transition from LIBOR to new benchmarks and under stress scenarios. Section 5 discusses the compliance of the benchmark design with [IOSCO \[2013\]](#) principles.

¹USD-AXI has been operationalized and available via Invesco Indexing LLC.

2 EURAXI : an across-the-curve benchmark for Euro credit spreads

Across-the-curve credit spread indices were introduced by [Berndt et al. \[2023\]](#) as a transaction-based measure of the recent average cost of wholesale unsecured debt funding for publicly listed U.S. bank holding companies and their commercial banking subsidiaries. AXI, the index proposed by [\[Berndt et al., 2023\]](#), is a weighted average of credit spreads for unsecured debt instruments with maturities ranging from overnight to five years, with weights that reflect transactions volumes and issuance volumes.

We define in this section EURAXI, an across-the-curve credit spread benchmark for Euro transactions.

2.1 Universe of debt instruments

EURAXI is defined as a weighted average of credit spreads for unsecured Euro-denominated debt issued by European banks with maturities up to five years, with weights that reflect transactions volumes and issuance volumes. Given that €STR already includes overnight unsecured transactions, these are not included in the calculation (see Section 2.2). Spreads are computed with respect to a Euro-denominated sovereign debt yield benchmark.

The universe underlying the index calculation is divided into

- Short term debt, which includes all Euro-denominated secondary market transactions of commercial paper (CP) and certificates of deposit (CDs) with a maturity less than or equal to 397 days issued by a Eurozone banking entity, and
- Long term debt, which includes all secondary market Euro transactions of senior unsecured corporate bonds with a remaining maturity greater than or equal to one year and less than or equal to five years issued by a Eurozone banking entity.

We exclude from the universe all transactions with

- optionality (puttable or callable bonds)
- indexed or periodic principal
- extendable maturity or renewable note
- changeable interest payment, interest rate reset, step-up, exchangeable or periodic (pre-maturity) coupons.

2.2 Short-term EURAXI

The ECB calculates daily the Euro short-term rate (€STR) which reflects the wholesale euro unsecured overnight borrowing costs of banks located in the Euro

area. As €STR already includes overnight unsecured transactions, we focus on maturities longer than overnight and up to one year for the short-term universe.

Short-term EURAXI is computed as a weighted average of credit spreads of short term debt instruments with maturities longer than overnight.

For these transactions, the yield-to-maturity (YTM) is calculated based on the transaction price and compared with the value of the ECB Euro yield curve¹⁰ for the same maturity as the transacted security is interpolated from the current Euro yield curve. This difference is the spread associated with the debt instrument.

Short-term EURAXI is defined as the principal-weighted average of spreads of all debt instruments in the short term debt universe.

2.3 Long-term EURAXI

For Long-term EURAXI we consider all Euro transactions of senior unsecured corporate bonds with a remaining maturity greater than or equal to one year and less than or equal to five years issued by a Eurozone banking entity.

Spreads are computed with respect to the Euro sovereign yield curve, published daily by the ECB¹⁰. For each transaction, the yield-to-maturity (YTM) is calculated based on the transaction price and compared with the Euro yield with the same maturity as the transacted security. The difference between the YTM and Euro yield is the spread associated with the debt instrument.

Long-term EURAXI is defined as as the principal-weighted average of spreads of all debt instruments in the long term debt universe.

2.4 EURAXI: definition

EURAXI is defined as a weighted average of the Short-term and Long-Term spreads defined above.

The weight $w_s(t)$ applied to the Short-Term Spread is the total principal amount of the relevant transactions multiplied by the time to maturity.

The weight $w_l(t)$ applied to the Long-Term Spread is the total volume of the relevant transactions multiplied by the time to maturity.

These weights are applied to the Short-Term Spread and Long-Term Spread to determine the EURAXI on day t:

$$\text{EURAXI} = \frac{w_s(t)}{w_s(t)+w_l(t)} \times \text{ShortEURAXI} + \frac{w_l(t)}{w_s(t)+w_l(t)} \times \text{Long EURAXI}$$

3 Data Sources

In the framework of our feasibility study we have explored data sources needed to produce EURAXI. We hereafter provide insights about the existing data for the index production.

3.1 Data for Short-term EURAXI

As mentioned above the production of a short-term raw EURAXI would require data (volumes and rates) on overall wholesale money market transactions with standard maturities up to one year.

Most of the short-term euro dominated money market transactions are over-the-counter. The absence of a centralized market, combined with the lack of regulatory reporting on effective wholesale funding transactions became a real concern especially during the GFC. The GFC events such as money market dysfunctioning and LIBOR scandal, pointed out to what extent these data were crucial for financial stability monitoring and safeguard. Efforts to collect and centralise data for both regulatory and research purposes has been made since.

The ECB has access to data on unsecured lending in money markets for O/N and longer tenor interbank transactions via payment systems such as Target2. Studies by central banks have used [Furfine \[1999\]](#)-type algorithms to identify wholesale money market transactions amongst all payment system flows. The algorithm has been originally developed to extract O/N interbank loans, but been extended to longer tenors afterwards [[Arciero, Heijmans, Heuver, Massarenti, Picillo, and Vacirca, 2014](#)]. However, the accuracy of the algorithm appears to be uncertain especially for longer than O/N tenors [[Armantier and Copeland, 2015](#)] and the access to the payment systems' raw data is restricted to central banks. We therefore further investigate relevant data sources for the production of a short-term EURAXI benchmark.

Based on the Money Market Statistical Reporting (MMSR) Regulation (EU) No 1333/2014, the ECB is collecting transaction-by-transaction money market data since 2016. Since then, a panel of about 50 large European banks reports on its unsecured, secured, foreign exchange swap and overnight index swap euro operations. The unsecured segment of this dataset consists of daily unsecured borrowings and lendings in euro with a maturity of less than 397 days after the settlement date. This data covers the issuance of banks' short-term unsecured debt through unsecured deposits, call accounts, fixed- or variable-rate short-term debt securities (Certificates of Deposit, Commercial Paper, etc.) as defined by the MMSR Regulation.

Though MMSR data concerns short-term funding of reporting banks only, it can be representative enough for the production of the short-term EURAXI. The production of €STRbenchmark itself is based on this MMSR data. The ECB's statistical data warehouse² provides daily MMSR aggregate level data on volumes and weighted average rates. The Short EURAXI production may

²<https://sdw.ecb.europa.eu/browse.do?node=9693569>

require more granularity but this dataset seems relevant to the task.

The overall European short term securities' (STS) market is quite fragmented as legal issuance frameworks vary between countries. Therefore, building a more exhaustive data than MMSR is challenging. The market is composed of a relatively large international market of Euro Commercial Papers and Certificate of Deposit (ECPs/CDs), and components such as the Negotiable European Commercial Paper (NEU CP) market and small domestic markets.

Despite its name, ECPs/CDs market is a multi-currency market, where euro denominated issuance represented roughly 40% of outstanding volumes in 2021 [ICMA Commercial Paper Committee, 2021]. This market has been historically centred in London and is mainly governed by English Law. Thus, there is some monthly data on this market published on the Bank of England's website.

Negotiable European Commercial Paper (NEU CP) market is the second most important component of the European STSs' market. It has been historically centred in Paris and governed by French Law. Therefore, data on this NEU CPs' issuance is centred at the Banque de France can be found on its website³.

The ECB also provides monthly issuance data on CPs with the Short-Term European Paper (STEP) label. The Short-Term European Paper label was launched in 2006 by the European Banking Federation (EBF) to enhance the integration of the European STS markets. This data provide information on monthly issued and outstanding volumes, and also on some rates by maturity bucket⁴.

Another dataset on EUR denominated securities, is the ECB's Centralized Securities Database (CSDB)⁵. The CSDB is a security-by-security monthly micro-database on issued and outstanding EUR denominated securities (amounts, issuer information, prices, maturities), issued by EU and non-EU issuers. This dataset is used by European System of Central Banks, including the ECB, for statistical and financial stability monitoring purposes [Pérez, Huerga, et al., 2016]. Based on the CSDB, the ECB provides aggregate level data on issued and outstanding volumes, issuer sector, security type, through its Security Issues Statistics⁶ and Securities Holdings Statistics⁷.

There are also a number of private data sources such as CMDPortal⁸, Dealogic and Euroclear⁹ that partially cover the STS euro market.

Given that the EURAXI index is computed as a spread, its computation requires also data on Euro short term government yields. For longer than O/N short term maturities we identified two data sources. One can find AAA rated Euro area government bond yields at different residual maturities available on

³<https://www.banque-france.fr/en/monetary-policy/market-financing/commercial-paper-and-medium-term-note-market-neu-cp-neu-mtn/statistical-reports-and-analysis>

⁴<https://sdw.ecb.europa.eu/browse.do?node=9691125>

⁵https://www.ecb.europa.eu/stats/financial_markets_and_interest_rates/securities/html/index.en.html

⁶<https://sdw.ecb.europa.eu/browse.do?node=9691129>

⁷<https://sdw.ecb.europa.eu/browse.do?node=9691594>

⁸<https://www.cmdportal.com/Home/PublicData>

⁹<https://www.euroclear.com/services/en/primary-issuance/primary-issuance-euroclear-bank/euro-commercial-paper.html>

the ECB's website ¹⁰.

A benchmark Euro area sovereign debt yield, such as the German treasury bill yield, can also be used for the task. Issuance data on one year Federal government's treasury discount paper (Bubill), shorter term treasury notes and other debt instruments, can be found on the website of German Finance Agency ¹¹.

3.2 Data for Long-term EURAXI

As discussed in Section 2 long term EURAXI production requires detailed data on Euro denominated long term MFI securities issuance and transactions (with residual maturities between one to five years). We identified the ECB's Centralized Securities Database (CSDB)¹² to be the best candidate for the exercise. The database contains security level information on euro denominated securities held and transacted by residents of euro area Member States. This granular data-set is destined to the use of the ESCB for statistical purposes and is not available for public use. The ECB provides aggregate level public data on issued securities through its Security Issues Statistics ⁶ and Securities Holdings Statistics ⁷.

Trax Pricing data from MarketAxess ¹³ also provides trade data on fixed-income security markets. According to MarketAxess the data comes from major European dealers operating in EU member states and the UK, but some Euro area countries such as Germany and Italy do not contribute at all.

A recent joint initiative by Bloomberg, MarketAxess and Tradeweb Markets for a consolidated tape for EU fixed income markets seems promising in terms of geographical coverage and representativeness¹⁴. If approved, it will provide MiFID II data on secondary debt markets and can provide a useful additional data source for computing EURAXI.

3.3 Recommendation

Our study suggests that datasets based on mandatory regulatory reporting would guarantee geographical and volume representativeness. We therefore suggest to use

- MMSR for short term EURAXI,
- CSDB and possibly the forthcoming ESMA-supervised 'consolidated tape' for long term EURAXI calculations.

¹⁰https://www.ecb.europa.eu/stats/financial_markets_and_interest_rates/euro_area_yield_curves/html/index.en.html

¹¹<https://www.deutsche-finanzagentur.de/en/federal-securities/types-of-federal-securities/treasury-discount-paper/>

¹²https://www.ecb.europa.eu/stats/financial_markets_and_interest_rates/securities/html/index.en.html

¹³<https://www.marketaxess.com/trax/market-data>

¹⁴<https://www.tradeweb.com/newsroom/media-center/news-releases/bloomberg-marketaxess-and-tradeweb-explore-eu-consolidated-tape-for-fixed-income/>

4 EURAXI and the Euro interest rate benchmark transition

4.1 Comparison with risk-free term benchmarks

In the framework of benchmark rate reforms and transition from LIBOR, the Euro short-term rate (€STR) was launched by the ECB on 2 October 2019. The new reference rate is computed based on overnight transactions, and represents the volume-weighted average rate of unsecured overnight wholesale funding of Euro area banks. Differently from its predecessor EONIA (Euro Overnight Index Average) that the ECB has ceased to publish since 3 January 2022, €STR reflects not only interbank deposit rates, but also unsecured overnight borrowing cost from non-bank wholesale counterparties.

Though €STR is a robust transaction-based benchmark computed using data from active short term wholesale refinancing markets [IOSCO, 2013], such risk-free rates cannot serve as an adequate benchmark for banks' term lending and funding activities. Traditionally banks' activities imply maturity transformation, meaning funding long term benchmark-based fixed rate assets with shorter-term (variable rate) liabilities. To hedge this interest rate risk banks contract interest rate swaps implying to pay fixed rates against floating interest rate payments they receive, determined by a benchmark rate that reflects bank's funding cost. Contracts based on risk-free benchmark do not take into account the actual funding cost of banks and their volatility and will expose banks to a substantial basis risk. Therefore, in the framework of ongoing benchmark rate reforms worldwide, there is a need to design robust term interest rate benchmarks that properly reflect banks' effective funding costs and can operate in conjunction of new RFRs, such as €STR.

Differently from LIBOR, there is no end of publication date announced for EURIBOR in the euro area. Instead a hybrid methodology has been developed and implemented by the European Money Markets Institute (EMMI) in order to align EURIBOR with the EU Benchmark Regulation (BMR) based upon the IOSCO [2013] principles of robustness and representativeness. Regardless the absence of a foreseeable end-of-EURIBOR date, the EU Benchmarks Regulation (BMR) requires EU supervised users to include EURIBOR fallbacks in new contracts. Moreover, the private sector Working Group on Euro RFRs made recommendations regarding the choice of €STR-based EURIBOR fallbacks.

Term benchmarks are typically computed either as backward looking in-arrears compounded averages of realised O/N rates for standard maturities, or determined as forward looking rates. The former can only be computed once the full realisation of O/N rates is known at the end of the period. The ECB started publishing compounded €STR rates for standard maturities from 15 April 2021. The above-mentioned Working Group on Euro RFRs suggested to use the ECB's backward-looking compounded €STR for some cash products, but recommended forward-looking term rates for a range of other asset classes.

Forward-looking rates are usually extracted from market prices, and are

known at the beginning of the tenor. Thus differently from backward looking benchmarks they embed market expectations about the evolution of future interest rates. These market-based forward-looking term benchmarks are either term funding instrument rates (e.g. term unsecured funding rates (e.g. Commercial Papers, Certificate of Deposit), or are based on O/N interest rate hedging derivative prices (e.g. €STR-linked futures). In order to extract forward-looking rates from RFR-linked derivative quotes, the transition of Euro derivative markets towards €STR-linked instruments should be effective and related derivative markets liquid enough.

Though the transition towards €STR-linked derivative markets has started in the Euro area, it still remains incomplete. The Financial Stability Board has raised concerns about both liquidity and volatility of RFR-based derivative markets for building a robust term reference rate [[Financial Stability Board](#)]. A sufficiently liquid underlying market is a core requisite for producing robust benchmarks. EURAXI is an effective funding rate-based benchmark that takes into account most of wholesale funding transactions across-the-curve and is therefore representative by definition.

Additionally, there is a structural difference between forward-looking rates based on derivative pricing, and those based on term funding rates. Derivative-based term benchmarks take into account market expectations about O/N rate fluctuations over the tenor, but do not account for term risk. Whereas term benchmarks based on effective term rates reflect credit and term premia of borrowing institutions. Note that the Working Group on Euro RFRs which has suggested derivative-based forward-looking rates as EURIBOR fallbacks for some asset classes, has simultaneously recommended a spread adjustment mechanism to ensure the fallback is credit sensitive and economically equivalent to EURIBOR. EURAXI by construction is based on effective term rates of funding instruments. Thus, it incorporates credit and term premia of borrowing institutions and does not need any credit sensitivity adjustment. In this context, EURAXI appears as a natural forward-looking EURIBOR fallback candidate, especially in the absence of sufficiently liquid €STR-linked derivative markets.

4.2 EURAXI as credit-sensitive term benchmark

Reference rates are key tools both for monetary policy transmission and financial stability maintenance. Therefore, one should consider their behaviour and robustness in both quiet and stressed periods.

RFR references tend to move in the opposite direction to credit-sensitive rates when markets are under stress. RFR benchmarks, especially those designed as secured funding rates like the US SOFR (Secured Overnight Financing Rate), tend to fall, while credit-sensitive rates tend to go upwards by reflecting the reality of market stress. [Schrimpf and Sushko \[2019\]](#) argue that for term benchmarks this divergence seems to hold even in normal times. Therefore, in the absence of any credit-sensitive benchmark, banks are exposed to a much higher basis risk, especially in times of crisis.

Cooperman, Duffie, Luck, Wang, and Yang [2023] show that the choice of the reference rate impacts US banks' supply of revolving corporate credit loans in periods of stress, such as GFC or COVID. These examples illustrate that a fall in risk-free reference rates encourages borrowers to draw on committed corporate credit lines in stressed times, when banks' funding costs are high. In the framework of RFR benchmarks banks bear the majority of the funding spread and price it ex-ante into new credit lines. Authors argue that the negative impact on corporate loan supply can be mitigated through introduction of credit-sensitive benchmarks which reduce borrowers' incentives to draw on existing credit lines. These findings highlight the importance of credit-sensitive reference rates for basis risk management and credit provision by banks.

EURAXI reflects by construction effective marginal funding cost and risk premia of banks. It can be calculated under all economic conditions and adapts automatically to banks' funding maturity structure. EURAXI can therefore co-exist with €STR by complementing euro benchmark reform with a credit-sensitive and robust term index needed for efficient asset - liability risk management in the banking sector.

4.3 Adaptability to funding structures

Past global financial and economic turmoils, such as the 2008 crisis and the COVID crisis, have reshaped banks' funding habits at global scale. These historical crisis episodes have not only enhanced banks' reliance on CB funding, but also have redefined their wholesale funding structure and preferences. Increasing liquidity and credit risk concerns in interbank markets during the GFC made bank unsecured funding shift towards short term (O/N) maturities for unsecured loans, and from unsecured to secured CCP cleared (repo) transactions for longer tenors.

These tensions on interbank markets also made banks more reliant on non-bank wholesale funding, such as Money Market Funds (MMFs), insurance companies, etc. However, as observed during the European sovereign debt crisis and Covid crisis these non-bank wholesale funding sources are in their turn exposed to liquidity risk. For example following the outbreak of Covid crisis in March-April 2020 Low Volatility Net Asset Value (LVNAV) and Variable Net Asset Value (VNAV) MMFs that were allowed to invest in non-public debt instruments experienced substantial liquidity outflows, while Constant Net Asset Value funds (CNAV), experienced important inflows. This has highlighted the fragility of MMF funding and the necessity to further strengthen regulatory liquidity requirements for these non-bank financial institutions.

Given the current turmoil in the global banking sector, structural shifts in bank funding continue to take place. These changes in bank funding structure are relevant to the design and production of robust benchmark rates which require the pool of transactions to be representative. The post-2008 evolution in funding structure is one of the reasons for which €STR is not restricted to interbank transactions as EONIA was, but covers the entire spectrum of wholesale funding.

It is worth highlighting that EURAXI adapts by design to the evolution of banks' funding structure. This property is key in the context of continuously evolving and recurrently stressed global wholesale funding markets.

5 Alignment with IOSCO principles

In the framework of the transition from LIBOR [Duffie and Stein, 2015], International Organization of Securities Commissions (IOSCO), backed by the Financial Stability Board, published its Principles for Financial Benchmarks in 2013 [IOSCO, 2013]. IOSCO [2013] defines principles for benchmark determination, governance, quality and accountability to design robust and representative interest rate benchmarks as required. The EU Benchmark Regulation (EU) 2016/1011 that followed IOSCO [2013] and entered into force starting from 2018, provides requirements for EU used benchmark design and government. The regulation of Interest rate benchmarks used for financial instruments and contracts in the EU, are part of this EU Benchmark Regulation and is based upon the IOSCO [2013] principles of robustness and representativeness. The design of EURAXI is aligned with the main IOSCO [2013] recommendations related to the quality of the benchmark itself, such as

- Principle 6 – Benchmark Design, which should be reliable and represent the economic realities of the Interest it seeks to measure.
- Principle 7 – Data Sufficiency, which says that data used to construct a Benchmark should be sufficient to accurately and reliably represent the Interest measured by the Benchmark.

EURAXI represents by design the effective bank funding cost across maturities. As highlighted in 4.2 and 4.3 above it is a credit and term sensitive volume weighted index which adjusts to any change in funding costs related to structural maturity shifts or the tightening of market conditions. It reflects therefore the economic reality of banks' funding costs and mitigates "basis risk" as discussed in 4.1. Moreover, this credit sensitivity allows to avoid the pro-cyclical effects of RFR benchmarks inducing to credit supply fall in times of stress as evidenced by Cooperman et al. [2023] (see 4.2).

EURAXI is computed using effective funding rates, rather than prices from derivative markets which may encounter liquidity issues (see 4.1). Moreover, differently from benchmarks focusing only on the short end of the yield, it is an across-the-curve and volume weighted index, reflecting any shift from one maturity (market) to another. This adaptability feature allows EURAXI to comply with data sufficiency and market liquidity requisites of IOSCO [2013] and remain computable even in times of stress.

The universe of reporting financial entities underlying the EURAXI universe should be monitored on an ongoing basis to ensure the representativeness of the sample in compliance with IOSCO [2013] principles.

References

- Luca Arciero, Ronald Heijmans, Richard Heuver, Marco Massarenti, Cristina Picillo, and Francesco Vacirca. How to measure the unsecured money market? the Eurosystem’s implementation and validation using TARGET2 data. Occasional Paper 215, Banca d’Italia, 2014.
- Olivier Armantier and Adam M Copeland. Challenges in identifying interbank loans. *Economic Policy Review*, (21-1):1–17, 2015.
- Antje Berndt, Darrell Duffie, and Yichao Zhu. Across-the-curve credit spread indices. *Financial Markets, Institutions and Instruments*, 2023. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/fmii.12172>.
- Rama Cont, Xin Guo, and Renyuan Xu. Interbank lending with benchmark rates: Pareto optima for a class of singular control games. *Mathematical Finance*, 31(4):1357–1393, 2021. URL <https://onlinelibrary.wiley.com/doi/abs/10.1111/mafi.12325>.
- Harry R Cooperman, Darrell Duffie, Stephan Luck, Zachry Z Wang, and Yilin Yang. Bank funding risk, reference rates, and credit supply. Technical report, National Bureau of Economic Research, 2023.
- Darrell Duffie and Jeremy C Stein. Reforming LIBOR and other financial market benchmarks. *Journal of Economic Perspectives*, 29(2):191–212, 2015.
- European Central Bank. Euro money market study 2020. report April 2021, ECB, 2021.
- Financial Stability Board. Interest rate benchmark reform: overnight risk-free rates and term rates.
- Craig H Furfine. The microstructure of the federal funds market. *Financial Markets, Institutions & Instruments*, 8(5):24–44, 1999.
- ICMA Commercial Paper Committee. The european commercial paper and certificates of deposit market. White Paper September 2021, International Capital Market Association, 2021.
- IOSCO. Principles for financial benchmarks. final report FR07/13, International Organization of Securities Commissions, 2013.
- Zhiyong Li, Zijian Zhang, Fudong Zhang, and Xiaoyan Zhang. White paper on across-the-curve credit spread indices (AXI) for China. White paper, SOFR Academy, 2022.
- Asier Cornejo Pérez, Javier Huerga, et al. The centralised securities database (CSDB)-standardised micro data for financial stability purposes. *IFC Bulletins chapters*, 41, 2016.
- Andreas Schrimpf and Vladyslav Sushko. Beyond LIBOR: a primer on the new benchmark rates. *BIS Quarterly Review March*, 2019.

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