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[LIBOR's Borrowed Time?]

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The LIBOR Transition

Frequently Asked Questions

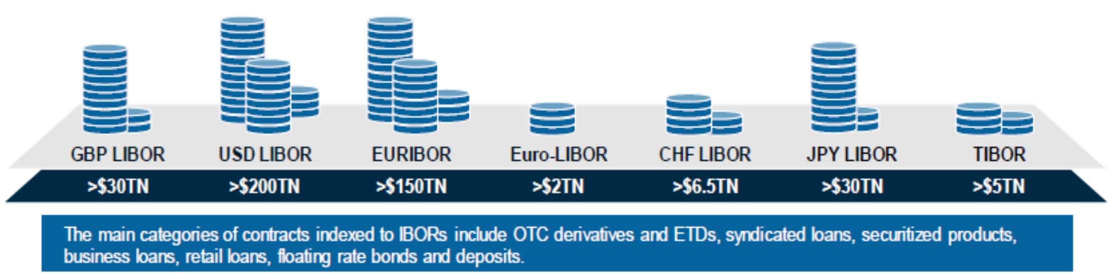
Planning for the market's transition from the London Interbank Offered Rate (LIBOR)[1] to the Secured Overnight Financing Rate (SOFR)[2] has accelerated recently, but substantial uncertainty remains as to exactly how and when the conversion of nearly $370 trillion of financial products will occur.

Much has happened since PGIM Fixed Income first published a whitepaper on LIBOR cessation, titled "LIBOR's Borrowed Time" in April 2018, including the daily reporting of SOFR by the Federal Reserve Bank of New York (NY Fed), the introduction of SOFR-based swaps and futures contracts, the significant progress in developing standardized LIBOR fallback provisions, and the issuance of SOFR-based Floating Rate Notes (FRNs). Still, much needs to be done. This second LIBOR whitepaper, structured in the form of frequently asked questions, is meant to address: (1) the progress to date; (2) critical future milestones; and (3) concerns regarding the sufficiency of SOFR as an adequate LIBOR replacement.

Q. What is significant about LIBOR cessation?

LIBOR permeates nearly every aspect of financial markets with its link to approximately $370 trillion of financial products across the globe, including nearly $200 trillion in USD LIBOR. Given LIBOR's enormous scope, a carefully planned transition to an alternative index is essential to avoid potential significant market disruptions that could affect every financial market participant.

FIGURE 1: LIBOR'S MARKET PRESENCE



Source: IBOR Global Benchmark Survey 2018 Transition Roadmap, ISDA February 2018. TIBOR is based on interbank lending amongst Japanese banks; ETDs = exchange-traded derivatives.

[1] LIBOR reflects the average cost of borrowing for approximately twenty AA- and A-rated banks across seven different maturities, five currencies, and is based on a combination of observed transactions and estimates/judgement.

[2] SOFR will reflect the volume-weighted median of the previous day's Treasury repo transactions across three categories, which excludes all trades longer than overnight.

Q. When will LIBOR cease to be published?

LIBOR is expected to be published until the end of 2021. The Financial Conduct Authority (FCA), the UK regulator of LIBOR, announced that it will no longer compel banks to make LIBOR submissions beyond 2021. **While LIBOR could potentially exist after 2021, its future beyond this date is highly uncertain.**

While there are ongoing efforts—particularly by the Intercontinental Exchange (ICE), the administrator of LIBOR—exploring the possibility of publishing LIBOR after 2021, regulators in the U.S. and UK continue to encourage the adoption of an alternative reference rate, particularly for new business contracts. **If LIBOR continues to exist beyond 2021, its use will likely be limited to legacy contracts.**

Q. Is SOFR still the preferred alternative to LIBOR? What about the proposed Bank Yield Index?

In the United States, the Alternative Reference Rates Committee[3] (ARRC), a NY Fed-sponsored working group, has endorsed the use of SOFR as "the most appropriate for widespread and long-term adoption as a reference rate."

Despite the ARRC's support, ICE recently published a whitepaper describing a potential SOFR competitor, specifically, a Bank Yield Index (BYI) that could replace LIBOR. While the BYI might appeal to the market since it would be quoted in various tenors (e.g., 1-month, 3-month, and 6-month) and would include a spread that reflects bank credit risk, its construction would likely be plagued by the same problem affecting LIBOR today, namely the limited number of observable transactions. SOFR is a far more transparent index that is supported by daily trading volumes of approximately $750 billion-$1 trillion. **PGIM Fixed Income will track any developments in the BYI. However, given the limited amount of underlying bank borrowing transactions and ARRC's recommendation of SOFR, we don't expect the BYI to gain much traction as a viable LIBOR replacement.**

Q. How has daily SOFR traded relative to overnight LIBOR?

We had expected LIBOR to trade above SOFR given: (1) the historical relationship between the two rates going back to 2014, (2) the fact that LIBOR is based upon the credit risk of AA-rated and A-rated banks while SOFR is a risk-free rate, and (3) LIBOR is an unsecured lending rate while SOFR is a secured lending rate. However, SOFR has surprisingly traded above overnight LIBOR on a consistent basis since its introduction in April 2018, as observed in Figure 2.

PGIM Fixed Income believes that SOFR has traded above LIBOR for the following reasons:

(1) SOFR's high correlation to Treasury bill (T-bill) rates. As T-bill issuance volume has ramped higher over the last year, the T-bill rate, along with the repo level (SOFR), has risen in order to attract sufficient demand;

(2) The movements in overnight LIBOR have been "sticky" given its high correlation to the level of Interest on Excess Reserves (IOER), or the interest rate the Federal Reserve (Fed) pays on member banks' balances at the Fed. This correlation is created through arbitrage, in which a bank can borrow from non-IOER approved entities (such as mutual funds and government-sponsored entities), amassing reserves at the Fed, and earning IOER in the process. This trade is profitable for the bank when the borrowing cost (overnight LIBOR) sets a few basis points below IOER. Since IOER can be viewed as a quasi "fixed" rate, this arbitrage has also kept LIBOR remarkably stable;

(3) Significant changes in bank capital rules (e.g., the liquidity coverage ratio) have reduced bank demand for short-term borrowing and have increased demand for longer-term funding. Reduced short-term borrowing demand has contributed to a lower LIBOR level;

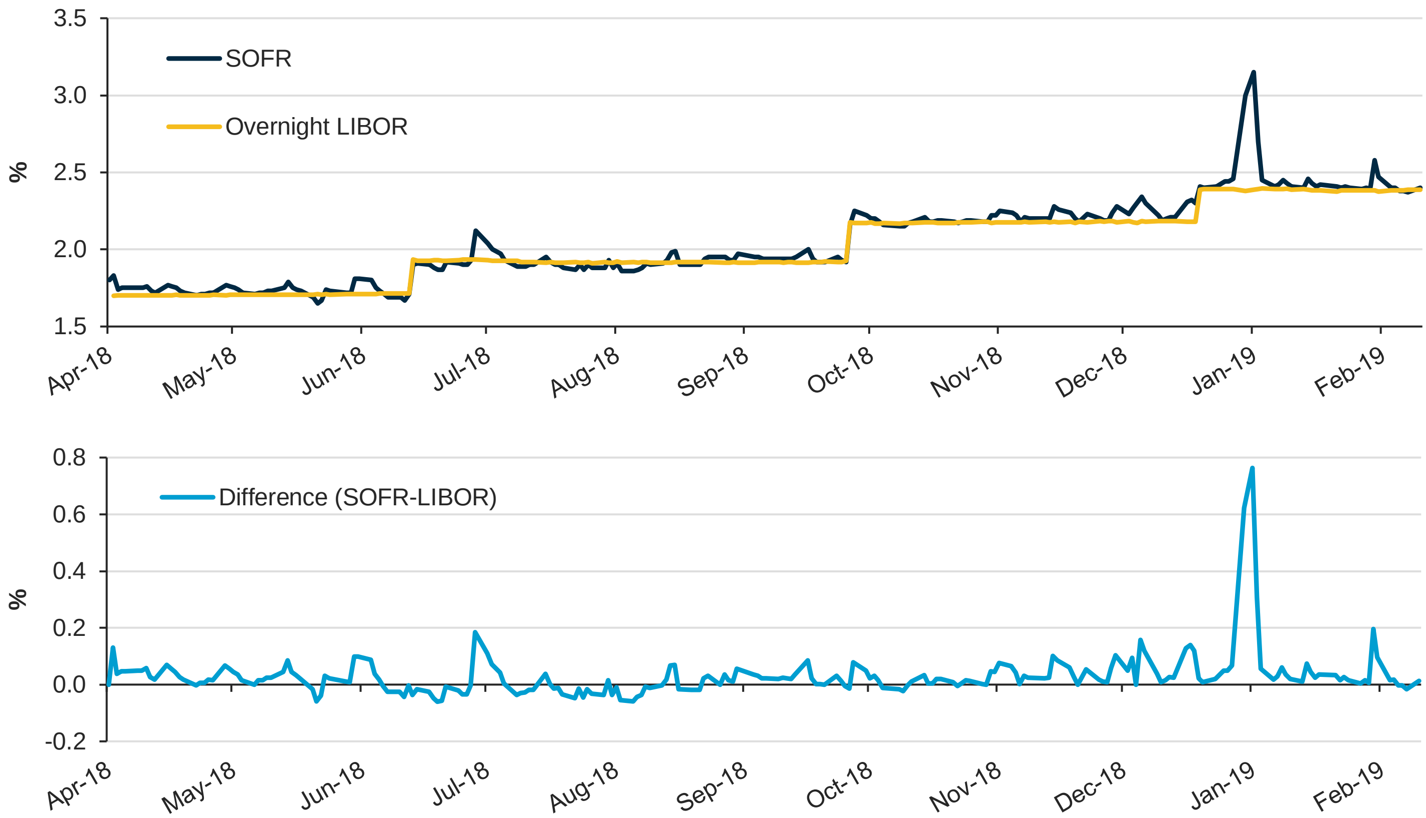
(4) SOFR tends to exhibit sudden spikes at month-end and quarter-end that often reflects reduced supply in the Treasury repo market given bank balance sheet constraints. The spikes in SOFR tend to persist for a day or two before reverting to more normal levels.

Consistent with expectations, SOFR has been more volatile than LIBOR since its daily reporting began in April 2018 with volatility peaking at the end of 2018 following a rate spike of 70 basis points (bps). We'd note that SOFR quickly retraced to more normal levels in early January given the removal of these constraints (Figure 2).

[3] The Financial Stability Oversight Council and Financial Stability Board called for the development of alternative interest rate benchmarks. In 2014, the Board of Governors of the Federal Reserve System and the Federal Reserve Bank of New York convened the Alternative Reference Rates Committee in order to identify best practices for alternative reference rates, identify best practices for contract robustness, develop an adoption plan, and create an implementation plan with metrics of success and a timeline.

In addition, we believe volatility in overnight LIBOR is suppressed as a result of several factors: (1) a limited number of actual transactions on which to base LIBOR submissions, (2) the substantial reliance on "expert judgement" that might favor a continuation of existing (smooth) trends, and (3) a trimmed-mean methodology that excludes nearly half of the daily submissions.

FIGURE 2: SOFR vs. OVERNIGHT LIBOR OVER TIME (%)

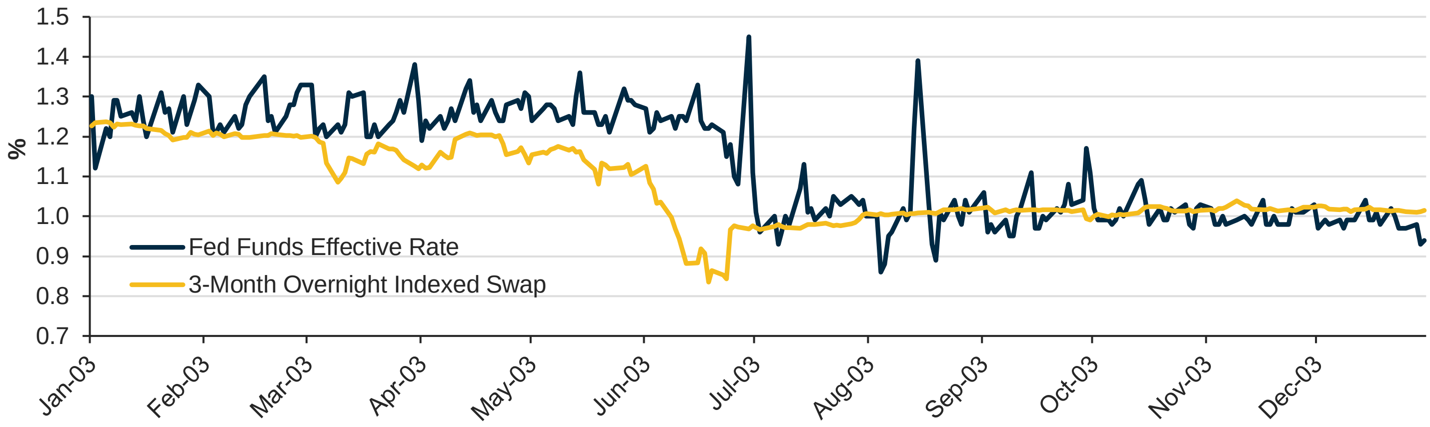


Source: Bloomberg as of February 13, 2019.

Q. Is SOFR's heightened volatility relative to LIBOR a concern?

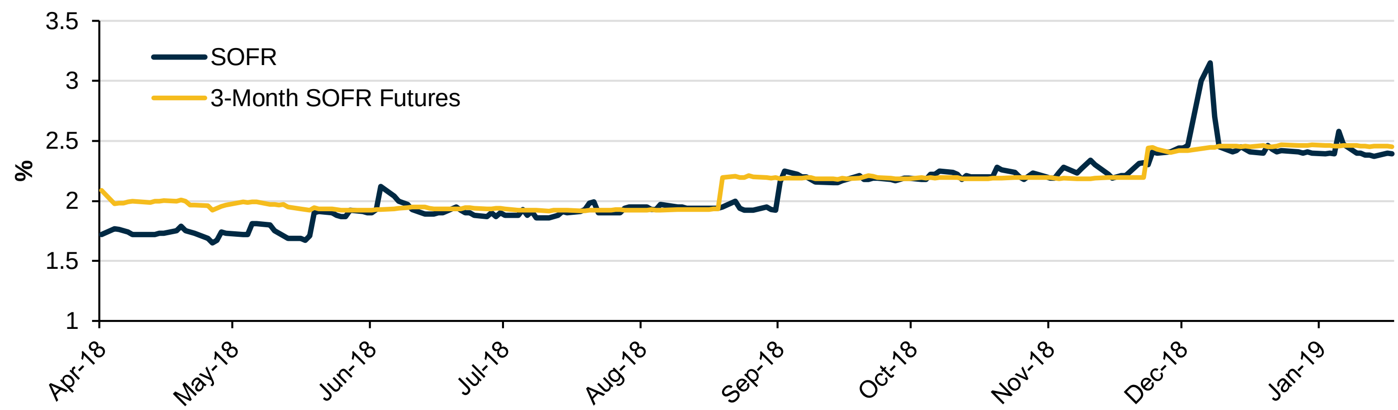
While we are not necessarily concerned with SOFR volatility, it would be preferable to avoid using a single overnight rate as a replacement for a reference rate with longer tenors (e.g., 1-month LIBOR, 3-month LIBOR, 6-month LIBOR, etc.). An overnight lending rate can experience bouts of volatility given short-term swings in market technicals. However, daily variation often disappears when longer averages of the daily rate are observed. For example, the overnight federal funds (fed funds) rate has exhibited substantial volatility, particularly before the global financial crisis (GFC), but that volatility has had a negligible impact on longer-term expectations of the fed funds rate, as observed in Figure 3a. Similarly, although SOFR volatility tends to increase over month- and quarter-ends, daily variation has had a negligible impact on 3-month expectations of SOFR, evidenced by the nearest 3-month SOFR futures contract in Figure 3b. **Despite SOFR spiking by nearly 70 bps at year-end due to a temporary dislocation in the Treasury repo market, 3-month expectations of SOFR remained stable.**

FIGURE 3a: FEDERAL FUNDS EFFECTIVE RATE VS. 3-MONTH OVERNIGHT INDEXED SWAP RATE (%)



Source: Bloomberg as of February 13, 2019.

FIGURE 3b: DAILY SOFR RATE VS. 3-MONTH SOFR FUTURES (%)



Source: Bloomberg as of February 13, 2019.

Q. How can SOFR data be adjusted to account for the tenor difference between term LIBOR and overnight SOFR?

Most existing LIBOR-based bonds reference a LIBOR tenor that is longer than overnight (e.g., 1-month, 3-month, etc.). However, SOFR data only cover a single day's trading activity. **In order for SOFR to function as a suitable replacement for LIBOR, the overnight rate will need to be transformed into a longer-tenor term rate. There are two viable options that would make this transformation possible:**

(1) **Compound the overnight rate**. For example, a transaction that references 1-month LIBOR could instead reference a 30-day compounded overnight SOFR;

(2) **Observe market expectations of future SOFR rates through the derivatives market (i.e., SOFR-based futures and swaps).** For example, as of publication in March 2019, a 1-month SOFR rate can be derived from the observed trading level of the 1-month SOFR futures contract that expires in April 2019. However, we'd note that the use of derivative trading activity to establish a SOFR term-curve requires: (1) a deep and liquid derivatives market; and (2) a standard methodology to compute various SOFR tenors. Unfortunately, while the SOFR derivatives market continues to expand, it is still in its infancy with limited trading volume and a computational standard that has not yet evolved.

Q. Which option will derivatives market participants choose to derive longer-tenor SOFR rates?

Based upon the ARCC's direction, derivatives market participants are likely to use compounded SOFR to replicate tenors longer than overnight. A survey of market participants indicates a preference for this compounding be done "in arrears," i.e., compound overnight SOFR daily during the applicable interest period. Although compounding in arrears most closely replicates the actual path of interest rates, this approach creates significant operational issues since the compounded interest rate won't be known until the last day of the interest period. Under the existing LIBOR framework, the interest rate is known at the beginning of the period and provides sufficient time for both borrowers and lenders to make/receive periodic payments and produce any required reporting.

Q. What about the cash bond market?

Cash market (FRNs, business loans, and securitized products) participants have expressed a strong interest in establishing a forward-looking SOFR term curve based upon SOFR-based futures and swaps trading observations. The preference for forward-looking term rates, rather than compounding in arrears, is based upon market convention and the desire to avoid the operational complexities mentioned above. However, trading volume in SOFR derivative contracts is currently not yet sufficient to establish reliable estimates of longer tenors, and the ARRC "paced transition" plan does not anticipate the development of a forward-looking SOFR term curve until the end of 2021. Since the year-end 2021 target is uncomfortably close to the potential LIBOR-cessation date of December 31, 2021, the ARRC has encouraged cash market participants to craft interim solutions (similar to the derivatives market) that rely on compounding until a reliable SOFR term curve can be observed.

Q. How will the market adjust for credit risk differences between tenor SOFR rates and LIBOR?

As previously mentioned, LIBOR is based upon the credit risk of a double-A/single-A rated banks while SOFR is a risk-free rate. And while details need to be vetted, both cash market and derivatives market participants have expressed a strong interest for a constant SOFR/LIBOR credit spread that will be calculated using the mean/median of the difference between the two rates based upon an historical lookback analysis. **PGIM Fixed Income has advocated for an approach that would utilize the mean of the difference combined with a sufficiently long lookback period (greater than 10 years) to ensure that the entire business cycle is captured.**

Based upon our recommendation, we estimate that the credit spread adjustment will be roughly +15 bps for a 1-month tenor, + 25 bps for 3-month tenor, and +40 bps for a 6-month tenor. It's important to note that the precise length of lookback period, along with start- and end-dates, can meaningfully impact these estimates.

Market participants have indicated a preference for either the ARRC or the International Swaps and Derivatives Association (ISDA) to compute and publish the credit spread adjustment for each tenor. Once calculated, these adjustments will remain static and will not change. Any financial product that includes fallback provisions from LIBOR to SOFR will add the ARRC/ISDA-computed credit spread adjustment to the relevant SOFR tenor. For example, a one-month floating rate student loan deal would transition from one-month LIBOR to one-month SOFR plus the one-month credit spread adjustment of +15 bps**. While this approach is meant to compensate investors for transitioning from an index that reflects bank credit risk to a risk-free rate, the compensation is static and will not adjust to changing credit conditions and liquidity events.**

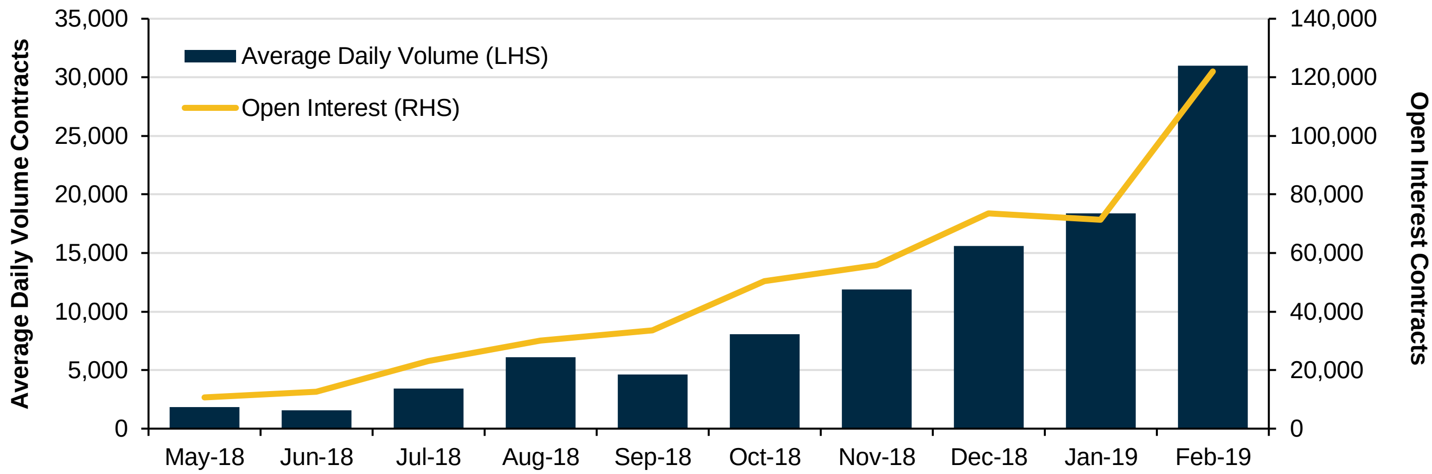
Q. Is the SOFR derivatives market expected to become liquid?

Yes, but it will take some time. The creation of a deep and liquid SOFR derivative market is critical to ensuring a smooth transition away from LIBOR and remains the primary focus of regulators—derivatives represent over 95% of the estimated $200 trillion of financial products indexed to USD LIBOR.

The SOFR derivatives market, while only a fraction of the Eurodollar (LIBOR) futures market, has developed faster than the ARRC transition plan expected. The Chicago Mercantile Exchange (CME) launched SOFR futures (1-month and 3-month) on May 7, 2018, and futures trading volume continues to expand—open interest now exceeds 120,000 contracts (which equates to a notional amount of approximately $350B), and average daily trading volume now exceeds 30,000 contracts, as observed in Figure 4. In addition, both the London Clearing House (LCH) and CME began clearing SOFR swaps, and like SOFR futures, volumes are relatively small but growing rapidly. **While the development of the SOFR futures and swaps market is encouraging, liquidity is lacking when compared to the equivalent LIBOR derivatives market, which has open interest of more than 12 million contracts and daily trading volume of nearly 2 million.**

The development of a liquid SOFR-based cash market is expected to follow the derivatives market, a reversal of the more typical sequence whereby a derivatives market follows the creation of a liquid cash market in order to satisfy hedging needs. Without hedging demand from cash bond holders, other sources of demand must drive the growth of the SOFR derivatives market. The hope is that this demand can be created by requiring central clearing parties (CCPs) to use SOFR instead of the fed funds rate to compute the price alignment of interest (PAI) and function as the discounting mechanism for exiting LIBOR-based swaps.[4] The ARRC has noted that "market participants see a tight link between PAI and discounting as crucial to the effectiveness of their hedging strategies"[5] and anticipates that this change will create meaningful demand for SOFR derivatives moving forward.

FIGURE 4: CME SOFR FUTURES



Source: CME Group as of February 28, 2019.

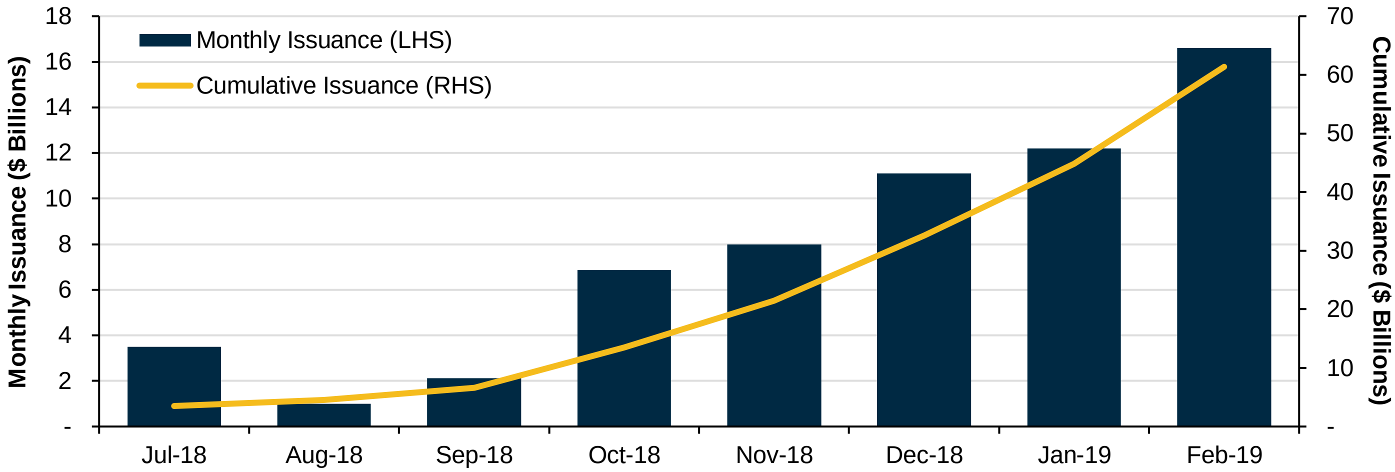
Q. Are new cash-product transactions using SOFR? Has the market created standardized fallback provisions where LIBOR continues to be used?

There has been approximately $62 billion of SOFR-based FRN issuance from a variety of institutions, including government-sponsored entities, federal home loan banks, and other financial intermediaries (Figure 5). The SOFR-linked bonds issued thus far have relatively short maturities (typically two years or less), and we expect the maturity spectrum to increase as the sources of demand for SOFR floaters continue to grow.

[4] *PAI represents the compensation paid by the swap party that receives collateral to the swap party that posted collateral.*

[5] *Source: The Alternative Reference Rates Committee Second Report, page 2. Published in March 2018. https://www.newyorkfed.org/medialibrary/Microsites/arrc/files/2018/ARRC-Second-report.*

FIGURE 5: SOFR FRN ISSUANCE (U.S. $ BILLIONS)



Source: CME Group as of February 28, 2019.

While regulators remain hopeful that SOFR-linked business loans and securitizations will be issued in 2019, none materialized through the first two months of the year. However, all markets have made significant strides in developing robust fallback provisions for new transactions that will control how and when the transition from LIBOR to SOFR will occur. Public consultations on fallback provisions have been posted by ARRC-sponsored working groups for FRNs, securitizations, and business loans.

Standardization of fallback provisions, including conversion triggers (i.e., conditions that must be satisfied before a transaction converts from LIBOR to an alternate rate) and the alternate index rate specification, is critical to ensure that market efficiency and liquidity are not impaired. Bespoke fallback solutions across deals and sectors could: (1) result in operational complexities; (2) slow the trading process given the need to understand unique deal-by-deal interest rate calculations; and (3) complicate the hedging process.

Once the best practices are published, we remain hopeful that the ARRC, along with industry trade groups, will encourage broad adoption and standardization of fallback provisions to minimize the potential for market disruption during the market's transition from LIBOR to SOFR.

Q. What about fallback provisions for the derivatives market?

ISDA, in conjunction with the ARRC, also posted recommendations for LIBOR fallback provisions and has subsequently published the initial findings. ISDA plans to publish a supplement to its 2006 ISDA definitions that defines all relevant LIBOR fallback provisions such that transactions initiated on or after the date of the supplement will automatically incorporate the amended definitions. Transactions entered into prior to the supplement will not include the amended definitions. However, ISDA plans to publish a voluntary protocol to facilitate multilateral amendments for legacy transactions.

There are some significant differences between the derivative and cash product fallback provisions, including the timing of transition from LIBOR (triggers) and reliance upon a SOFR term curve. Ideally, fallback provisions in cash and derivatives would be identical to ensure hedge effectiveness. **PGIM Fixed Income has communicated our desire for consistency across all sectors to the ARRC.**

Q. How will the transition impact legacy cash-product transactions?

Unfortunately, while most legacy derivative contracts can potentially be amended through the ISDA protocol described above, amending legacy cash transactions will be quite difficult, if not impossible. Changing the reference rate from LIBOR to an alternate index in cash transactions often requires a super-majority investor vote (67-100%), the achievement of which is highly unlikely. As a result, existing fallback provisions, which have historically been weak (and non-existent at times), will prevail in legacy deals.

While fallback provisions in legacy securities were not standardized, four potential outcomes generally seem likely upon LIBOR cessation, none of which are optimal: (1) bonds continue to reference the "last published LIBOR," essentially converting these bonds to a fixed interest rate for their remaining life; or, (2) bonds transition to the prime rate; (3) the absence of fallback provisions leads to no solution, likely leading to litigation; and (4) an administrative agent is granted complete discretion to transition to a different rate. The ARRC estimates that over $8 trillion of legacy cash products are linked to LIBOR, of which approximately $2.4 trillion will be outstanding at the end of 2021.[6]

Given the scope of the legacy problem, market participants and regulators have recognized the benefits of ICE continuing to publish LIBOR after 2021 in order to avoid the suboptimal outcomes outlined above, even if its computation is changed and its relevance diminished (i.e., "Zombie" LIBOR). A synthetic LIBOR option has been discussed, in which LIBOR would continue to be published after 2021 as the alternate index (SOFR) plus the credit spread adjustment. The FCA has made it clear that once it deems that LIBOR no longer represents borrowing costs, any subsequent "Zombie" LIBOR could only be used for legacy deals and could not be used for new transactions. In addition, it has been suggested that legal challenges could result if ICE simply reported a surrogate for LIBOR as if it were LIBOR, unless the surrogate measure actually represented a bank's borrowing cost.

Since most new issue transactions continue to reference LIBOR rather than SOFR, issuers and investors remain focused on limiting the scope of legacy problems by enhancing fallback provisions to avoid suboptimal outcomes. The ARRC consultations previously discussed represent a critical step in standardizing these provisions. **While ARRC recommendations are considered "best practices," we are hopeful broad market acceptance will help minimize disruption to the legacy market upon LIBOR cessation.**

Q. What's happening with other IBORs?

Progress is being made in each of the other four IBOR jurisdictions: the European Union (EU), United Kingdom (UK), Japan, and Switzerland, detailed below in Figure 6. Japan and the UK are furthest along in transitioning from IBOR to a risk-free rate, while the EU is somewhat delayed—the EU's recommended alternative rate, Euro Short-Term Rate (ESTER), isn't expected to be published until October 2019.[7]

FIGURE 6: LIBOR TRANSITION SUMMARY

Administrator	Working Group	Current Rate	Replacement Rate	Rate Type	Tenor	Rate Published?
Federal Reserve Bank of New York	Alternative Reference Rates Committee	USD LIBOR	Secured Overnight Financing Rate (SOFR)	Secured	Overnight	Yes
European Central Bank	Working Group on a Risk-Free Rate for the Euro Area	EURIBOR Euro-LIBOR	Euro Short Term Rate (ESTER)	Unsecured	Overnight	October 2019
Bank of Japan	Study Group on Risk-Free Reference Rates	TIBOR JPY LIBOR	TONAR (Tokyo Overnight Average Rate)	Unsecured	Overnight	Yes
Bank of England	Working Group on Sterling Risk-Free Rates	GBP LIBOR	SONIA (Sterling Overnight Index Average)	Unsecured	Overnight	Yes
SIX Swiss Exchange	National Working Group on Swiss Franc Reference Rates	CHF LIBOR	SARON (Swiss Average Rate Overnight)	Secured	Overnight	Yes

Source: Citi Research, ISDA as of February 28, 2019.

Q. How is PGIM Fixed Income planning for the transition from LIBOR?

PGIM Fixed Income remains actively involved in industry efforts to transition to an alternate index in all affected markets. We continue to participate in ARRC and industry working groups—the Structured Finance Industry Group and the Loan Syndication and Trading Association—which are charged with developing industry-wide best practices for LIBOR fallback provisions, including triggers and the replacement index "waterfall." **We recently responded to several LIBOR fallback consultations including ISDA's request for comment on derivatives, the ECB's request for comment on the creation of an ESTER-term curve, and the ARRC securitization working**

[6] *Source: The Alternative Reference Rates Committee Second Report, page 2. Published in March 2018. https://www.newyorkfed.org/medialibrary/Microsites/arrc/files/2018/ARRC-Second-report.*

[7] *See Figure 1 for an estimate of notional exposure outstanding by IBOR jurisdiction.*

group. We have also joined the recently formed ARRC working groups that will focus on the implementation of SOFR in consumer loans and mortgages.

We have proactively sought improvements to fallback provisions in new issue securitizations since the FCA's announcement regarding LIBOR-panel banks in July 2017. **We have assumed a leadership role in the CLO market for recommending and standardizing LIBOR fallback provisions and have also made meaningful progress in improving the provisions included in other structured products sectors. Finally, we continue to evaluate LIBOR fallback provisions in our legacy portfolios and have incorporated the adequacy of such provisions into our relative value analysis.**

NOTICE: IMPORTANT INFORMATION

Source(s) of data (unless otherwise noted): PGIM Fixed Income as of March 2019.

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