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# Does SOFR-linked Debt Cost Borrowers More Than LIBOR-Linked Debt?*

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**Abstract**

We investigate if the benchmark transition from London Interbank Offered Rate (Libor) to Secured Overnight Financing Rate (SOFR) affects the costs of borrowing floating rate debt. The primary market for dollar-denominated floating rate notes (FRNs) provides an ideal laboratory to study these effects. Comparing the spreads of FRNs linked to LIBOR and SOFR, issued by the same entity during the same month, we find a significantly *lower* yield spread for SOFR-linked debt after adjusting for the maturity-matched spreads from the swap market. In addition, despite identification challenges, we observe a quantitatively similar pattern in the syndicated loan market.

**Keywords:** Benchmark rates, floating rates, financial regulation, LIBOR, SOFR

**JEL:** E43, G12, G18, G29

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# Introduction

The Secured Overnight Financing Rate (SOFR) is replacing the London Interbank Offered Rate (LIBOR) as reference rate in loans and other floating rate debt worth trillions of dollars. While LIBOR proxies banks' funding costs and increases when funding conditions deteriorate, SOFR captures the cost of funding US Treasuries overnight and is therefore detached from market-wide funding conditions (e.g., Schrimpf and Sushko, 2019 and Klingler and Syrstad, 2021). This qualitative difference between the two rates is a central issue—lenders in SOFR-linked debt lose the hedging benefit of receiving higher interest payments during funding crises (e.g., Jermann, 2019, and Cooperman et al., 2022) and banks prefer tying their lending to a credit-sensitive reference rate (Marshall et al., 2019). Despite these arguments for credit-sensitive reference rates, regulators endorse SOFR, which became the reference rate for most dollar-denominated floating rate debt.

If lenders prefer floating rate debt with cash flows tied to a credit-sensitive reference rate, the benchmark transition from LIBOR to SOFR can have an adverse effect on credit supply. The aim of this paper is to test for this adverse effect by comparing the borrowing costs for floating-rate debt tied to LIBOR and SOFR. The yield spreads from the primary market for dollar-denominated floating rate notes (FRNs) provide an ideal laboratory to study these effects: We observe issuances linked to both LIBOR and SOFR from *the same entity during the same month* and can use maturity-matched spreads from the swap market to adjust for the expected difference in variable rate payments (LIBOR is higher than SOFR). Contrasting with the concerns outlined above, we find borrowers benefit from a discount when issuing SOFR-linked debt. We observe a qualitatively similar discount in the syndicated loan market, where identification is more challenging.

After the agency overseeing LIBOR announced in 2017 that the publication of LIBOR cannot be guaranteed beyond 2021 (Bailey, 2017), SOFR became the preferred alternative reference rate in the US (ARRC, 2017), and issuing LIBOR-linked floating-rate debt was effectively banned in January 2022 (FDIC, 2021). This benchmark transition has sparked an ongoing debate between regulators and market participants. Regulators endorse SOFR because it is based on large transaction volumes and compliant with the principles for financial benchmarks (IOSCO, 2013). Market participants, on the other hand, argue that a term rate based on SOFR does not reflect banks' marginal funding costs. Because SOFR is an overnight rate based on repurchase agreements collateralized with US Treasuries, rates based on SOFR are (i) less sensitive to fluctuations in market-wide funding conditions and (ii) generally lower than LIBOR. While virtually all major data vendors have been trying to establish credit sensitive rates as alternative reference rates, regulators keep their preference for using SOFR as main reference rate (e.g., Gensler, 2021).

Because SOFR is typically lower than LIBOR, the yield spreads of SOFR-linked debt are not directly comparable to LIBOR-linked debt. Hence, to compare the two spreads we must adjust for the differences in the underlying reference rates. To illustrate this point, consider an investor who purchased a SOFR-linked FRN with two years to maturity. If the investor prefers receiving LIBOR as variable rate, he could combine a fixed payer position in a 2-year interest rate swap referencing LIBOR with a fixed receiver position in a 2-year overnight-index swap (OIS) referencing SOFR. This combination of instruments changes the variable cash flows from SOFR to LIBOR, but reduces the fixed spread by the difference between the LIBOR swap rate and SOFR OIS rate. Building on this argument, we use interest rate swaps and SOFR OIS to obtain precise spread adjustments and focus on adjusted yield spreads in our analysis.

Our analysis comprises three parts. First, we focus on the market for dollar-denominated

FRNs and compare the yield spreads of newly-issued FRNs with difference reference rates. Second, we we examine the credit spreads of syndicated loans. Finally, we discuss the interpretation and potential explanations of our findings.

Starting with the adjusted yield spreads from the primary FRN market, our first test is a panel regression in which the main independent variable is an indicator that equals one if the FRN is SOFR-linked and zero otherwise. Our rich sample allows us to control for issuer-month fixed effects, which absorb unobservable fluctuations in the credit quality of the underlying issuer. In addition, we control for issuance size, time-to-maturity, and squared time-to-maturity (which can capture non-linearities in the term structure), all interacted with year-month fixed effects to capture unobservable fluctuations in the role of the control variables over time. This regression suggests that SOFR-linked FRNs have a yield spread that is $-4.70$ basis points lower than the spread for LIBOR-linked FRNs.

We further explore this *SOFR discount* over time and across issuers. First, we run monthly cross-sectional regressions of the yield spreads for newly-issued FRNs on an indicator variable $\alpha_j^{SOFR}$, which equals one if the benchmark rate in FRN $j$ is SOFR, controlling, as before, for issuer-fixed effects, maturity and issuance volumes. This test reveals that the SOFR discount is stronger in the first half of our sample and most pronounced during March and April 2020. Second, we estimate $\alpha^{SOFR}$ for different issuer and find that the discount is strongest for US government sponsored entities (GSEs). We then use our estimates to quantify the SOFR discount and find that the benchmark transition reduced the FRN interest expenses of US GSEs by approximately 20% (or $300 million). Finally, we use an alternative approach to quantify the discount by interpolating the yield spreads of SOFR- and LIBOR-linked FRNs and find a SOFR discount of comparable magnitude.

In the second part of our paper, we examine the role of benchmark rates in the syndicated loan market. Drawing inferences for this market is more challenging. In contrast to FRNs, there was virtually no transition period with most syndicated loans still linked to LIBOR until December 2021. In addition, loan prepayments and hidden fees can cloud the inference from comparing the yield spreads of different loans. To address these challenges we perform two different tests. Focusing on the short time window between July 2021 and June 2022, we first study loan amendments. We examine changes in the loan spread from one amendment to the next and find a loan amendment that changes the reference rate from LIBOR to SOFR coincides with a drop in loan spreads of $-11$ basis points. Second, running panel regressions with issuer and time fixed effects, this effect increases to approximately $-30$ basis points. Hence, we obtain a qualitatively similar SOFR discount in the syndicated loan market.

To conclude, we explore different possible explanations for the observed pattern. We find that FRNs with maturities beyond the intended LIBOR cessation date are subject to the largest SOFR discount. One reason for this finding is that those FRNs expose lenders to legal risks and potential payment shortfalls (for instance, if borrowers refuse to pay a higher yield spread over SOFR compared to LIBOR). For syndicated loans, we find that the SOFR discount is strongest for older loans, which are less likely held by the originating bank. In addition, the SOFR discount is robust to a battery of robustness checks, using different spread adjustments and model specifications.

We address the question if SOFR-linked debt costs borrowers more than LIBOR-linked debt and find that borrowing SOFR-linked debt is actually *cheaper*. To compare the borrowing costs of floating rate debt tied to LIBOR and SOFR, it is a necessary evil to rely on a sample period with issuances linked to both reference rates. While our findings alleviate some of the concerns around the benchmark transition, it is still plausible that the benchmark transition has an adverse effect on future credit supply, especially during a financial crisis. In addition, although our findings provide suggest lower borrowing costs for SOFR-linked debt, they do not necessarily constitute an arbitrage opportunity. An arbitrageur would need to combine long and short positions in different FRNs with positions in the swap market and the associated transactions would likely subsume any arbitrage profits.

Despite its impact on financial markets, the benchmark transition has received little attention in the academic literature. To the best of our knowledge, this is the first paper to empirically examine the link between financing costs and benchmark rates. Jermann (2019), Cooperman et al. (2022), and Kirti (2022) argue that loans benchmarked against a manipulation-free and credit-sensitive benchmark offer a natural funding hedge to the lenders. Following up on this argument, Jermann (2020) estimates that, during the global financial crisis of 2008, banks would have missed interest income worth $30 billion if the interest payments in their loans were linked to SOFR instead of LIBOR. Schrimpf and Sushko (2019) and Klingler and Syrstad (2021) study the properties of the alternative benchmark rates that are set to replace LIBOR and note that the loss of the term premium is the most significant difference between LIBOR and the alternative rates. While the loss of credit-sensitivity is a key concern in the transition from SOFR to LIBOR, we find no evidence of elevated borrowing costs for SOFR-linked debt.

# 1 Institutional Background

LIBOR has been the primary benchmark rate for loans and floating rate debt since the 1980s, after it was introduced as variable rate that allows banks to charge syndicated loan borrowers a spread over their own funding costs (e.g., Vaughan and Finch, 2017). The LIBOR manipulation scandal and a shrinking interbank debt market (Wheatley, 2012) led to a transition from LIBOR to alternative benchmark rates. In July 2017, the agency overseeing LIBOR announced plans to cease the publication of LIBOR after December 2021 (Bailey, 2017) and the Alternative Reference Rates Committee (ARRC) recommended SOFR—an overnight rate calculated as weighted average of repo agreements in the US Treasury market—as alternative reference in the US (ARRC, 2017). In November 2020, the benchmark administrator postponed the cessation date for US LIBOR from December 2021 to June 2023 (Dorsey attorneys, 2020) and in July 2021 regulators banned the issuance of securities with LIBOR-related payments after December 2021 (FDIC, 2021).[1]

We highlight three issues for changing floating rates from LIBOR to SOFR. The first and most debated issue is the qualitative difference between LIBOR and SOFR. LIBOR contains a term premium that compensates lenders for the credit risk of the borrower and the cost of committing funds over a fixed term (e.g., Filipović and Trolle, 2013). Because of this term premium, LIBOR increases in times of financial distress. Schrimpf and Sushko (2019) and Klingler and Syrstad (2021) highlight the qualitative differences between LIBOR and SOFR, noting that compound term SOFR rates do not contain a term premium and collateralized overnight rates tend to remain stable during times of financial distress. This qualitative difference raises concerns about the loan market. Jermann (2019) argues that banks lose insurance against funding shocks when the floating rate in loans is SOFR instead of LIBOR and Jermann (2020) highlights that the term premium inherent in LIBOR helped loan suppliers during the global financial crisis of 2007-2009. According to Cooperman et al. (2022), the loan supply issues with SOFR-linked debt are most severe for credit lines, which are most likely drawn when funding conditions tighten.

[1] We focus on US LIBOR because dollar-denominated floating-rate debt volumes are by far the largest. In other currencies, such as British pounds and Swiss francs, the publication of LIBOR stopped by the end of 2021.

The ongoing attempt to establish a credit-sensitive alternative benchmark rate highlights that the qualitative differences between LIBOR and SOFR are a first-order concern for financial markets. Examples of credit sensitive benchmark rates are the Across-the-Curve Credit Spread Indices (AXI) developed by Berndt et al. (2022), Ameribor, the Bloomberg Short-Term Bank Yield Index (BSBY), the ICE Bank Yield Index, or the IHS Markit Credit Spread adjustment. The U.S. Securities and Exchange Commission stopped the attempt to establish BSBY as credit-sensitive alternative benchmark rate in September 2021, noting that "BSBY has the same inverted-pyramid problem as LIBOR" (Gensler, 2021).

The second issue is that discontinuing the publication of LIBOR is problematic for any outstanding security that still references LIBOR. For derivatives contracts, the International Swaps and Derivatives Association (ISDA) addressed this issue by implementing a fallback protocol that replaces LIBOR with compounded SOFR (in arrears) plus the five-year historical median spread between LIBOR and the compounded SOFR (ISDA, 2019). This fallback was fixed on March 5, 2021 at 26.1 basis points. Following the ISDA, the ARRC recommends the same fallback language for FRNs and syndicated loans (ARRC, 2021). Because the ARRC recommendation was widely anticipated (and already communicated in ARRC, 2019), it is not obvious that any legal differences in the fallback of swaps and floating rate debt affect the pricing of these instruments.[2]

Finally, the most common payment frequencies for floating rate debt are quarterly, monthly, or semi-annual. While LIBOR rates with 1-, 3-, and 6-month tenors were readily available, SOFR is an overnight rate and term rates with different tenors are not directly available. To obtain term rates based on SOFR, the market convention for FRNs and most

[2]One small difference is that the shift in the compounding window can differ by several days across instruments (see ARRC, 2019). However, this difference is unlikely to have a noticeable effect on the relative pricing of swaps and floating rate debt.

syndicated loans is to use "in arrears" compounding where the rate paid at time $t$ is the compounded overnight rate between $t-1$ and $t$ (ARRC, 2021). In contrast to term LIBOR, which is known at time $t-1$, the compound SOFR is only known at time $t$, that is, when an interest payment is due. Hence, the compounding in arrears convention gives the borrower little time to arrange the interest payments. To mitigate this issue, the convention for FRNs is to shift the compounding period backward by several business days (see ARRC, 2019 for more details).

## 1.1 Implications for Floating Rate Debt

To understand if SOFR-linked debt costs borrowers more than LIBOR-linked debt, it is crucial to ensure that the cashflows of debt instruments with different benchmark rates are comparable. The following replication argument illustrates the point from the perspective of the lender.

Consider the hypothetical situation in which an investor can choose between two virtually identical FRNs issued by the same borrower; the only difference is that the interest payments of the first FRN are linked to SOFR while those of the second are linked to LIBOR. The top row of Table 1 shows the cashflows from investing in the SOFR-linked FRN, which comprise a fixed credit spread $YS^S$ plus the variable SOFR payments $\mathscr{s}_i$.[3] If the investor prefers variable-rate payments linked to LIBOR, he could pay the fixed rate $L_0$ in a LIBOR-linked interest rate swap and receive the fixed rate $S_0$ in a SOFR-linked overnight index swap (OIS), both matching the maturity of the FRN. Table 1 shows that combining these two swap transactions with the SOFR FRN changes the variable rate from $\mathscr{s}_i$ to the LIBOR rate $\ell_{i-1}$.

[3] $\mathscr{s}_i$ is short-hand for the compounded overnight SOFR rate between time $t_{i-1}$ and time $t_i$ and we use the subscript $i$ to indicate that the rate depends on information up to time $t_i$.

Table 1: **Converting SOFR FRNs to LIBOR FRNs using swaps.** This table illustrates how an investor can convert the variable-rate payments of a SOFR-linked FRN with maturity $t_N$ and yield spread $YS^S$ from SOFR to LIBOR, using two swap transactions. The two swap contracts involve paying the fixed rate in a LIBOR-linked swap with maturity $t_N$ and receiving the fixed rate in a SOFR-linked OIS with the same maturity. $\ell_{i-1}$ is the LIBOR rate at time $t_{i-1}$ and $\mathscr{s}_i$ is short hand for the compounded average SOFR rate between time $t_{i-1}$ and $t_i$.

| | 0 | $t_1$ | ... | $t_N$ |
|---|---|---|---|---|
| *Cashflow from investing in SOFR FRN* | | | | |
| | $-1$ | $YS^S + \mathscr{s}_1$ | ... | $1 + YS^S + \mathscr{s}_N$ |
| *Pay fixed in LIBOR swap* | | | | |
| Pay fixed rate $L_0$ | 0 | $-L_0$ | ... | $-L_0$ |
| Receive LIBOR | 0 | $\ell_0$ | ... | $\ell_{N-1}$ |
| *Receive fixed in SOFR OIS* | | | | |
| Receive fixed rate $S_0$ | 0 | $S_0$ | ... | $S_0$ |
| Pay compound SOFR | 0 | -$\mathscr{s}_1$ | ... | $-\mathscr{s}_N$ |
| *Adjusted FRN cash flow* | $-1$ | $YS^S + \ell_0$ $-(L_0 - S_0)$ | ... | $1 + YS^S + \ell_{N-1}$ $-(L_0 - S_0)$ |
| *Cashflow from investing in LIBOR FRN* | | | | |
| | $-1$ | $YS^L + \ell_0$ | ... | $1 + YS^L + \ell_{N-1}$ |

Based on the argument outlined in Table 1, we obtain the following link between the yield spread $YS^L$ of the LIBOR-linked FRN and the yield spread $YS^S$ of the SOFR-linked FRN:

$$YS^L = YS^S - (L_0 - S_0). \tag{1}$$

In theory, the investor would be indifferent between receiving $YS^L$ in the LIBOR-linked FRN and receiving $YS^S - (L_0 - S_0)$ in the SOFR-linked FRN. In practice, using swaps to convert the cash flows in Table 1 is subject to a hedging cost (e.g., Cenedese et al., 2020, Andersen et al., 2019) and the investor would pay a higher rate in the LIBOR swap $L_0 + \varepsilon^L$ while receiving a lower rate in the SOFR OIS $S_0 - \varepsilon^S$. Based on this argument, we would obtain the modified spread adjustment $L_0 - S_0 + \varepsilon^L + \varepsilon^S$ and hence:

$$YS^L < YS^S - (L_0 - S_0). \tag{2}$$

Phrased differently, if investors prefer LIBOR-linked debt, we would observe a higher adjusted yield spread for SOFR-linked debt.

# 2 Borrowing Costs for Floating Rate Notes

In this section, we examine whether issuing SOFR-linked FRNs is more expensive for borrowers than issuing LIBOR-linked FRNs. The first SOFR-linked FRN was issued by Fannie Mae in July 2018 (Rozens, 2018) and the issuance of LIBOR-linked FRNs only stopped at the end of 2021 after US regulators announced in July 2021 that no LIBOR contracts should be traded after December 2021 (FDIC, 2021). As we explain below, this transition period provides an ideal laboratory to study how benchmark rates affect borrowing costs.

We proceed in three steps. First, we describe the data behind our analysis and explain how we implement the spread adjustment shown in Equation (3). Second, we estimate the spread between LIBOR- and SOFR-linked FRNs. Third, we further examine the spread over time and across issuers. Finally, we highlight that our results are robust to an alternative estimation approach.

## 2.1 The Data

We use the search function in Bloomberg's fixed income search to obtain information on all FRNs issued between July 2018 and December 2021. Our starting point are all dollar-denominated fixed income securities with floating coupon payments and we use the term FRNs for this sample throughout the paper (even though some securities have a maturity below one year and are therefore, technically not "notes"). To obtain spreads for comparable securities, we apply the following five filters.

First, we focus on non-exotic floaters that pay at maturity (bullet bonds) and remove subordinated debt, structured notes, insured bonds, inflation-linked notes, securities not issued at par or with a coupon cap or floor.[4] Second, we require a time to maturity between 0.5 and 11 years, excluding the few notes with maturity above 11 years. Third, to ensure that the spreads are comparable to those of swaps, we only include securities with a daycount convention of ACT/360, which are the vast majority and exactly mirror the payment conventions in swaps. Fourth, we only including floaters with LIBOR or SOFR as benchmark rate and restrict the SOFR-linked debt to securities with the same benchmark rate as SOFR OIS (Bloomberg ticker: SOFRRATE). For LIBOR-linked debt, the majority of FRNs either references the 1-month or 3-month LIBOR rate (Bloomberg tickers: US0001M or US0003M) and we include both benchmarks in our analysis. Fifth, we drop FRNs with missing issuance date, issuance amount, or spread information.[5]

We next repeat our filtering process using issuance-level data from the Mergent Fixed Income Securities Database (FISD) and combine the observed issuances with the Bloomberg data. However, only 0.6% of our sample appear in FISD but not in Bloomberg. By contrast, even though FISD contains issuance-level information on all US bonds, 75% of the FRN

[4] More specifically, we remove all FRNs with a coupon cap from our analysis but allow a coupon floor of zero. Approximately one third of all FRNs in the filtered sample have a coupon floor equal to zero and our conversations with market participants suggest that this floor is only a contract detail because FRN issuers want to avoid paying negative spreads. In practice, FRN spreads are generally positive and, more importantly, US monetary policy did keep a zero-lower bound on interest rates throughout our sample period.

[5] In addition, we remove FRNs with obvious mistakes in the FRN spreads—for few FRNs in our sample that were issued by non-GSEs, the FRN spread is zero or below; we remove those observations.

issuances in our sample appear in Bloomberg but not in FISD (Figure IA.1 in the appendix illustrates the overlap in samples). The reason for the wider coverage is that Bloomberg is that FISD does not contain information for certificates of deposits (CDs), which are a common form of short-term debt for banks. We use the combined FRNs sample in our main analysis and show in additional tests that our results remain unchanged when only using either of the databases.

**Issuer Information**

For each FRN in our sample we obtain the ultimate parent of the issuer and manually check if there is potential heterogeneity between different FRN issuers under the same ultimate parent. This heterogeneity is only a concern for debt issued by federal agencies sponsored by the US (e.g., FHLBs or Fannie Mae) and we use the agency instead of the ultimate parent (i.e., the US government) for those issuers.[6] In addition, because our goal is to examine the spreads between FRNs with different benchmarks from the same issuer, we only include borrowers that issue at least one LIBOR- and one SOFR-linked FRN during our sample period.

Taken together, these filters result in 7,384 FRN issuances from 66 individual borrowers. Figure 1 shows monthly issuance volumes of the FRNs in our sample. The monthly issuance volumes are substantial, ranging from \$12 billion to \$99 billion. In addition, the fraction benchmarked against SOFR increases over time from 0% in July 2018 to 100% in December 2021.[7]

Table 2 contains summary statistics of our filtered sample. Starting with the full sample,

[6] We also examine the yield spreads for the pool of all US GSEs and find similar results.

[7] Even though Fannie Mae issued the first SOFR FRN in July 2018, the SOFR issuance volume in July 2018 in our sample is 0% due to our requirement that we observe both LIBOR and SOFR-linked issuance during our sample period (Fannie Mae only issued SOFR FRNs after July 2018).

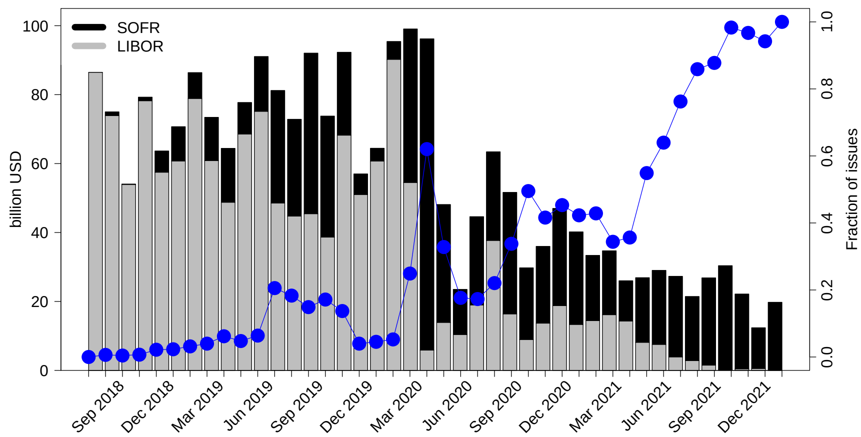


Figure 1: **FRN issuance volumes.** This figure shows the notional amounts of FRNs issued against SOFR (black bars) or LIBOR (grey bars). The blue dots represent the fraction of FRNs benchmarked against SOFR.

the first row shows that, out of the $2.3 trillion FRN issuance, 37% are benchmarked to SOFR. This percentage drops to 22% when we focus on the number SOFR-linked FRNs instead and we have a total of 37 year-months in which the same borrower issues a LIBOR-linked and SOFR-linked FRN. The remaining rows show all issuers with at least two year-months of issuing both LIBOR- and SOFR-linked FRNs. As we can see from the table, the two largest issuers in our sample are US GSEs and account for almost half of the FRN issuance volume in our sample. The most common issuer type are major bank holding companies with headquarters outside the US, followed by multinational companies.

### Spread Adjustments

Because our sample comprises FRNs with three different benchmark rates—SOFR, 1-month LIBOR, and 3-month LIBOR—we need to adjust the observed yield spreads using the replication argument from Table 1.[8]

[8] Figure IA.2 in the appendix shows the LIBOR-SOFR spread from derivatives markets over time.

Table 2: **FRN summary statistics.** This table provides summary statistics for our sample of FRN issuance data. Issuance amounts are in billion USD. #YMs both counts the number of year-months in which we observe issuance of both LIBOR and SOFR FRNs by the same issuer. We require at least two year-months with both LIBOR-linked and SOFR-linked FRNs to include the issuer in this table.

| | | Amount Issued | | #FRNs Issued | | #YMs |
|---|---|---|---|---|---|---|
| | Issuer | Total | %SOFR | Total | %SOFR | both |
| | Total (all issuers) | 2,340.64 | 37.07 | 7384 | 22.07 | 37 |
| 1) | FHLBs | 844.33 | 48.05 | 1154 | 29.20 | 27 |
| 2) | Fed Farm | 187.64 | 55.41 | 531 | 39.36 | 27 |
| 3) | Sumitomo Mitsui Fin. | 98.13 | 12.31 | 360 | 13.89 | 10 |
| 4) | Bk of Montreal | 90.75 | 21.08 | 364 | 25.27 | 20 |
| 5) | Bk of Nova Scotia | 66.21 | 26.80 | 268 | 23.88 | 3 |
| 6) | CIBC | 59.80 | 21.70 | 261 | 18.01 | 11 |
| 7) | Royal bk of Canada | 52.13 | 10.94 | 236 | 23.31 | 16 |
| 8) | Cred. Suisse | 43.06 | 57.17 | 171 | 57.31 | 13 |
| 9) | BNP Paribas | 42.69 | 12.36 | 213 | 13.15 | 7 |
| 10) | Mizuho | 42.37 | 4.22 | 239 | 5.02 | 2 |
| 11) | BPCE | 35.83 | 25.90 | 168 | 19.05 | 9 |
| 12) | TD | 35.46 | 20.12 | 147 | 13.61 | 5 |
| 13) | Rabobank | 28.77 | 6.94 | 228 | 10.09 | 5 |
| 14) | Std Chartered | 26.79 | 11.68 | 163 | 14.11 | 6 |
| 15) | Sumitomo Mitsui Trust | 25.33 | 24.09 | 119 | 26.89 | 2 |
| 16) | Toyota | 21.22 | 57.02 | 27 | 40.74 | 2 |
| 17) | Westpac | 20.51 | 28.70 | 100 | 23.00 | 3 |
| 18) | Cred. Agricole | 20.42 | 15.26 | 123 | 17.89 | 5 |
| 19) | Commonwealth bk of Australia | 17.63 | 34.60 | 93 | 23.66 | 2 |
| 20) | HSBC | 15.39 | 10.04 | 115 | 10.43 | 2 |
| 21) | Oversea-Chinese Bk | 12.98 | 18.07 | 80 | 17.50 | 4 |
| 22) | Farmer Mac | 11.40 | 21.31 | 176 | 44.89 | 17 |
| 23) | Lloyds | 9.38 | 14.18 | 83 | 20.48 | 5 |
| 24) | KB Fin. | 4.09 | 11.01 | 65 | 4.62 | 2 |

For FRNs with SOFR benchmark we first download LIBOR swap rates and SOFR OIS rates the maturities 1, 2, 3, 5, 7, 10, and 15 years from the Bloomberg system. In addition, we use SOFR rates with maturities 3, 6, and 9 months, as well as 3-month LIBOR rates and the 3-month LIBOR rates from 3x6 and 6x9 months forward rate agreements (FRAs) to construct our adjustments.[9] We then use bootstrapping to construct zero-coupon curves based on LIBOR and SOFR, which allows us to construct forward rates and discount factors based on this bootstrapping. Finally, for each SOFR-linked FRN $j$, we determine the payment schedule and construct the basis adjustment (which we subtract from the SOFR FRN yield spread) as:

$$b_j(0,N) = \frac{\sum_{i=1}^{N} n_{i,j} \cdot d(0,t_i) \cdot \left[f^{LIBOR}(0,t_{i-1},t_i) - f^{SOFR}(0,t_{i-1},t_i)\right]}{\sum_{i=1}^{N} n_{i,j} \cdot d(0,t_i)}, \tag{3}$$

where $n_{i,j}$ is the daycount between payment time $t_{i-1}$ and $t_i$ of FRN $j$, $f(0,t_{i-1},t_i)$ is the forward rate at time zero between coupon payment time $t_{i-1}$ and $t_i$, referencing either LIBOR or SOFR, and $d(0,t_i)$ is the discount factor between time zero and time $t_i$, following the market convention of discounting cash flows based on SOFR rates.[10]

To adjust the yield spreads of FRNs with 1-month LIBOR as benchmark rate we rely on LIBOR tenor swaps. In the tenor swaps used for our analysis, one party pays the 3-month LIBOR rate over the duration of the swap and receives the 1-month LIBOR rate. The spread in these contracts is the fixed rate that compensates the 3-month LIBOR payer for receiving lower 1-month rates. We obtain tenor swap spreads with 3, 6, and 9 months as well as 1, 2, 3, 5, 7, 10, and 15 years to maturity from Bloomberg and construct a maturity-matched spread adjustment for FRNs linked to 1-month LIBOR using cubic spline interpolation.[11] We later show in additional robustness checks that our main results are robust to using

[9] To obtain precise estimates, it is critical to use the 1-year LIBOR swap rate instead of the 1-year LIBOR rate (which would be substantially higher). Similarly, using 6-month and 9-month LIBOR rates would bias the results because the compounded three-month LIBOR rate is lower than LIBOR rates with longer tenors. Using these longer-term LIBOR rates would therefore bias the spread adjustment upward and result in lower adjusted spreads for SOFR-linked FRNs. By contrast, removing the 3x6 and 6x9 months FRAs from our curve construction leaves the results virtually unchanged.

[10] The two major derivatives clearinghouses CME and ICE switched from using OIS linked to the effective fed funds rate (EFFR) as discount rate to OIS linked to SOFR in October 2020. However, given that $d(0,t_i)$ appears in both numerator and denominator, using different OIS discount rates has virtually no effect on our adjustment terms.

[11] Alternatively, we could use the same cash-flow matching procedure as for SOFR-linked FRNs. However, doing so would require constructing swap rates with 1-month LIBOR payments by subtracting the tenor basis from observed swap rates. Using cubic spline interpolation instead gives less accurate adjustments but has the benefit of relying on widely-traded derivatives contracts.

different adjustments for SOFR FRNs and to removing FRNs linked to 1-month LIBOR rates.

## 2.2 Results

We now focus on the adjusted yield spreads in our sample of FRN issuances and test if the yield spreads of SOFR-linked FRNs differ from the yield spreads of LIBOR-linked FRNs. To that end, we use panel regressions in which the dependent variable is the adjusted issuance spread $s_{j,i}$ of FRN $j$, from borrower $i$. The main variable of interest in our analysis is a fixed effect $\alpha_{SOFR}$ that captures if the benchmark rate in the FRN is SOFR. A positive $\alpha^{SOFR}$ would confirm the concern that SOFR-linked debt is more expensive than LIBOR-linked debt.

We proceed in four steps. First, we start with a coarse regression specification of the following form:

$$s_{j,i} = \alpha_{SOFR} + \alpha_{1m} + \beta_a \log(a_j) + \beta_{ttm} ttm_j + \beta_{ttm^2} ttm_j^2 + FE_{Rtg} \times FE_t + \varepsilon_{t,j}, \qquad (4)$$

where we control for $\alpha_{1m}$, which capture if the benchmark rate in the FRN is 1-month LIBOR. Because we do not include a coefficient for the 3-month LIBOR benchmark, $\alpha_{SOFR}$ captures the spread between SOFR-FRNs and FRNs with 3-month LIBOR as benchmark rate. Similarly, $\alpha_{1m}$ captures the spread between FRNs linked to 1-month LIBOR and FRNs linked to 3-month LIBOR. In addition, we control for the issuance amount $\log(a_j)$, the time-to-maturity ($ttm$) and squared time-to-maturity at issuance ($ttm^2$), as well as rating-category fixed effects $FE_{Rtg}$ based on ratings from Standard and Poor's. Because the role of the rating category can change over time, we interact $FE_{Rtg}$ with year-month fixed effects

($FE_t$). Column (1) of Table 3 shows the average effect of SOFR-linked spreads in this specification is $-8.27$ basis points ($t = -5.28$).

Second, we exploit the fact that we observe LIBOR- and SOFR-linked FRN issuances from the *same issuer in the same month*. We further tighten our regression specification by replacing rating-time fixed effects with issuer-time fixed effects. Column (2) shows that this additional control leads to a small reduction in the effect on SOFR-linked FRNs to $-6.32$ basis points.

Third, we interact the issuance amounts and maturity proxies with year-month fixed effects and run panel regressions of the following form:

$$s_{t,j} = \alpha_{SOFR} + \alpha_{1m} + \sum_{t \in YMs} \left( \beta_{a,t} \log(a_j) + \beta_{ttm,t} ttm_j + \beta_{ttm^2,t} ttm_j^2 + FE_{i,t} \right) + \varepsilon_{t,j}. \qquad (5)$$

Doing so ensures that we capture unobservable fluctuations not only in the quality of the borrower (by adding issuer-month fixed effects $FE_{i,t}$) but also in the impact of issuance volume and maturity structure over time. This approach is inspired by the matrix pricing approach in fixed income markets where observed prices of recently traded securities are regressed on observed security characteristics to extrapolate the unobserved prices of non-traded securities. Liao (2020) uses a similar approach to examine the effect of currency denomination on corporate bond prices. We deviate from the standard approach by (i) solely focusing on primary markets, (ii) using continuous values for the issuance amounts and maturity profiles, and (iii) collapsing the analysis into one panel instead of using separate monthly cross-sectional regressions. As we show in the appendix (Table IA.2), our approach of using continuous values instead of dummy variables leads to more conservative estimates of $\alpha_{SOFR}$. Collapsing the regression into one panel improves the statistical power of estimating

Table 3: **Panel regression analysis.** This table shows the results of regressing the yield spreads for our sample newly-issued FRNs on two indicator variables: $SOFR$ equals one if the benchmark rate is SOFR and zero otherwise. $1m$ equals one if the benchmark rate is the 1-month Libor rate. The baseline case corresponds to FRNs with 3-month Libor as benchmark rate. The control variables include the time to matrutiy ($ttm$), the squared time to maturity ($ttm^2$), and the logarithm of the issuance amount ($\log(a)$). In Column (1) we add rating times year-month fixed effects as control, in Columns (2) to (5), we add issuer times year-month fixed effects. In Columns (3) to (5), $ttm$, $ttm^2$, and $\log(a)$ are interacted with year-month fixed effects to capture unobservable changes in the effect of these controls over time. Columns (4) and (5) show the results for the subsample only including Bloomberg or Mergent FISD data, respectively. The numbers in parantheses are $t$-statistics based on heterogeneity-robust standard errors, clustered at the issuer and year-month level. ***, **, and * indicate significance at a 1%, 5%, and 10% level, respectively.

| | All | | | Bloomberg | FISD |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| $SOFR$ | $-8.27^{***}$ | $-6.32^{***}$ | $-4.70^{***}$ | $-4.56^{***}$ | $-3.35^{**}$ |
| | $(-5.28)$ | $(-4.74)$ | $(-3.38)$ | $(-3.27)$ | $(-2.43)$ |
| $1m$ | $-3.86^{***}$ | $-1.18^{***}$ | $-0.50$ | $-0.56$ | $1.03^{**}$ |
| | $(-3.37)$ | $(-3.01)$ | $(-1.16)$ | $(-1.28)$ | $(2.56)$ |
| Add. contr. | $ttm$ | $ttm$ | $ttm \times ym$ | $ttm \times ym$ | $ttm \times ym$ |
| | $ttm^2$ | $ttm^2$ | $ttm^2 \times ym$ | $ttm^2 \times ym$ | $ttm^2 \times ym$ |
| | $\log(a)$ | $\log(a)$ | $\log(a) \times ym$ | $\log(a) \times ym$ | $\log(a) \times ym$ |
| Rating × YM FEs | ✓ | – | – | – | – |
| Issuer × YM FEs | – | ✓ | ✓ | ✓ | ✓ |
| Adj. $R^2$ | 0.80 | 0.93 | 0.95 | 0.95 | 0.95 |
| Num. obs. | 7,406 | 7,406 | 7,406 | 7,357 | 1,853 |

$\alpha_{SOFR}$ and we further discuss the standard matrix pricing approach in the following section (Figure IA.3). As shown in Column (3), controlling for the additional interaction terms reduces $\alpha_{SOFR}$ to $-4.70$ basis points ($t = -3.38$).

Finally, we separately examine the FRNs obtained from Bloomberg and from FISD. Column (4) shows that the results remain virtually unchanged when relying only on the Bloomberg sample, which is expected because 99.4% of the observations in our sample are available in Bloomberg. More interestingly, Column (5) shows that $\alpha_{SOFR}$ remains quantitatively similar with a discount of $-3.35$ ($t = -2.43$) for the FISD sample, despite the substantially smaller sample size.

Taken together, these tests reveal that the adjusted yield spreads of SOFR-linked FRNs are significantly lower than the yield spreads of LIBOR-linked FRNs. Hence, instead of elevated borrowing costs for SOFR-linked debt, we observe a *SOFR discount* with lower borrowing costs in SOFR linked debt.

While we observe a significant SOFR discount, there is no consistent pattern for the spread between FRNs linked to different LIBOR tenors. While $\alpha_{1m}$ is negative and statistically significant in Columns (1) and (2), it turns insignificant in Columns (3) and (4), and changes sign in Column (5).

**How Does the Spread Vary Over Time?**

We now run monthly cross-sectional regressions of the yield spreads for newly-issued FRNs on $\alpha_{SOFR}$, controlling for issuer-fixed effects, time to maturity, squared time to maturity, the logarithm of the issuance volume, and an indicator that equals one if the FRN is linked to the 1-month LIBOR rate.

As a starting point, we illustrate the results without adjusting the spreads of SOFR-linked FRNs. The top panel of Figure 2 shows the resulting coefficient estimates and 95% confidence bands. As shown in the figure, the unadjusted spreads are generally positive and increase during the market turmoil of March 2020. To examine if this time series pattern is comparable to that of LIBOR-SOFR spreads in the swap market, we average our cash-flow adjustments for SOFR-linked FRNs in each month and plot the maturity-matched LIBOR-SOFR spread. As indicated by the black line, the FRN spreads track the maturity-matched LIBOR-SOFR spread, but the spread obtained from the swap market is typically higher than the FRN spread.

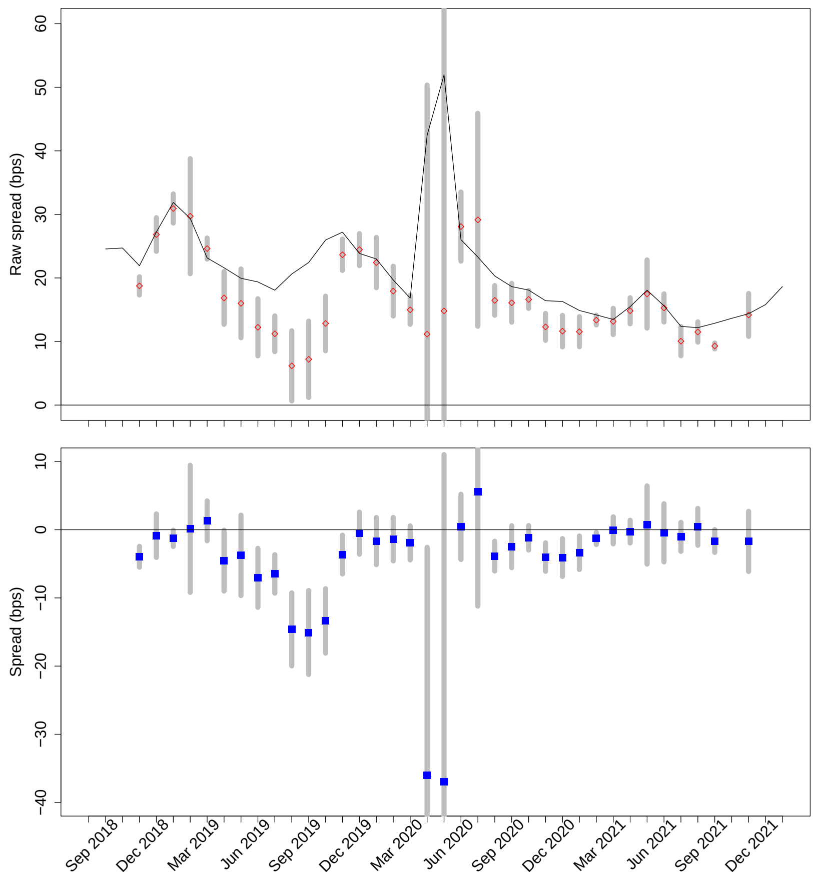


Figure 2: **FRN issuance spreads over time.** The first panel shows the results of monthly cross-sectional regressions of raw FRN spreads on an indicator variable that equals one if the FRN is linked to SOFR. The second panel shows the results for adjusted FRN spreads. In the regressions, we control for issuer fixed effects, time to matruity, squared time to maturity, the logarithm of the issuance amount, and an indicator that equals one if the FRN is linked to 1-month LIBOR. Because we do not include an indicator variable for 3-month Libor, the regression coefficient on $\alpha_j^{SOFR}$ can be interpreted as the spread between FRNs with Libor or SOFR as benchmark. The solid line in the top panel is the spread between Libor swap rates and SOFR OIS with maturity interpolated to match the average maturity of SOFR FRNs in month $t$. The adjusted spreads are obtained by subtracting the maturity-matched Libor-SOFR spread from SOFR FRNs. The grey bars are 95% confidence bars, based on robust standard errors, clustered at the issuer level.

The lower panel of Figure 2 shows the results for using the adjusted yield spreads in SOFR-linked FRNs. In line with the results from Table 3, we observe a *SOFR discount* for most of the sample period. In addition, the figure shows that this discount was most pronounced in March and April 2020 and converged toward zero at the end of our sample period. In Section 4, we further examine how our coefficient estimates vary across time periods and find that excluding March and April 2020 leaves our results largely unchanged.

**Which issuers benefit the most?**

After having examined the spreads over time, we now examine the cross section and investigate which issuers benefited the most from transitioning to SOFR. To that end, we proceed in three steps. First, we repeat our main analysis from Equation (5) but now allow $\alpha_{SOFR,j}$ to vary for each of issuer with more than year-month of issuing both LIBOR- and SOFR-linked FRNs. Second, we estimate the amount saved from SOFR-linked debt as percentage of the total notional amount issued:

$$Discount_j^{\%} = \alpha_{SOFR,j} \times \frac{\sum_i [TTM_i \cdot Amt_i \cdot \mathbb{1}(Benchmark_i = SOFR)]}{\sum_i Amt_i}. \tag{6}$$

The numerator in Equation (6) is the maturity-weighted volume of SOFR-linked debt, accounting for the fact that $\alpha_{SOFR}$ is estimated based on annualized yield spreads. Third, we estimate the average yield spread for each of the issuers. Instead of simply using average yield spreads for each issuer (which would give qualitatively similar estimates), we ensure that the yield spreads are comparable by regressing them on issuer-fixed effects, controlling for $\alpha_{SOFR}$, $\alpha_{1m}$, $\log(a)$, $ttm$, and $ttm^2$, all interacted with year-month fixed effects. We refer to those estimates as residual yield spreads ($y_{Resid,j}$) and compute the percentage yield spread:

$$YS_j^{\%} = y_{Resid,j} \times \frac{\sum_i [TTM_i \cdot Amt_i]}{\sum_i Amt_i}, \tag{7}$$

again using maturity-weighted issuance volumes in the nominator.

Using $\alpha_{SOFR,j}$ and $YS_j^{\%}$, Figure 3 puts the SOFR discount into perspective of issuance costs. As we can see from the figure, issuers with the lowest yield spreads benefit the most from issuing SOFR-linked debt. The size of the circles indicates the number of year-months with both LIBOR- and SOFR-linked debt and the three bottom-right circles correspond to three US GSEs (FHLBs, Fed Farm, and Farmer Mac). In dollar terms, the three GSEs saved about $300 million by issuing SOFR-linked debt and the SOFR discount is substantial when compared to the average yield spreads for these issuers.

We further discuss the distribution of the SOFR discount among issuers in 4, where we find that $\alpha_{SOFR}$ drops to $-2.97$ if we exclude US GSEs from the estimation.

## 2.3 Additional Evidence from US GSEs

To conclude, we present an alternative spread estimation based on a simple matching procedure for US GSEs. We focus on the adjusted issuance spreads for the 1973 FRN issuances in our sample that were conducted by GSEs and proceed in three steps. First, for every month with more than 3 LIBOR-linked FRN issuances, we fit a cubic spline to the issuance spreads. Second, for each SOFR-linked FRN within the same month and with a time to maturity within the range of maturities of LIBOR-linked FRNs, we use the spline to interpolate a maturity-matched LIBOR-linked spread. Finally, we repeat these steps for each month with more than 3 SOFR-linked FRN issuances and construct maturity-matched spreads for each LIBOR-linked FRN. [12]

This approach has the advantage that, instead for controlling for the time to maturity,

[12]To avoid large outliers due to fitting errors in our spline interpolation, we drop observations for which the absolute difference between SOFR-linked and LIBOR-linked spreads is above 20 basis points. The effect of excluding these outliers is similar to wincorizing the spreads.

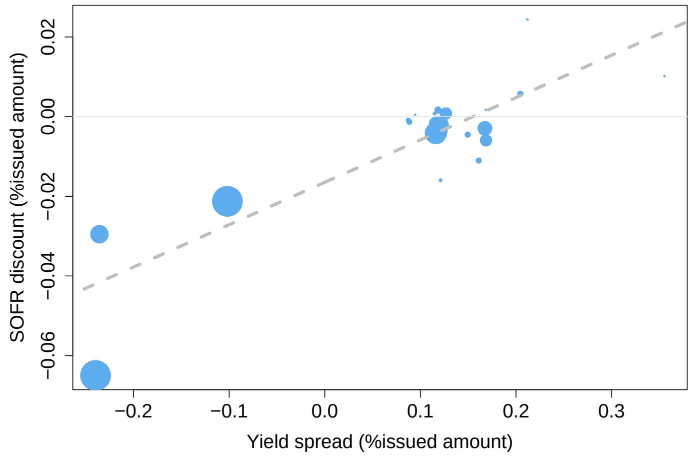


Figure 3: **FRN spreads across issuers.** The y-axis shows the estimated SOFR discount, based estimates of $\alpha_{SOFR,j}$ from Equation (5), allowing for different coefficients across issuers. For each issuer, we multiply this discount with the maturity-weighted issuance amount of SOFR-linked debt and divide by the total issuance volume to observe a percentage discount. The x-axis shows our proxy for the average issuance costs for each of the issuers, again standardized by total issuance volume. The size of the circles indicates the number of year-months with both LIBOR- and SOFR-linked debt and the three bottom-right circles correspond to three US GSEs (FHLBs, Fed Farm, and Farmer Mac).

we construct counterfactual yield spreads with exactly matching maturities. Figure 4 shows the distribution of the SOFR-linked and LIBOR-linked spreads. As shown in the figure, the spread distribution for SOFR-linked FRNs is shifted to the left, compared to the distribution for LIBOR-linked FRNs, suggesting that the SOFR-linked spreads are lower than the LIBOR-linked spreads. In addition, the shaded areas show bootstrapped confidence bands, confirming that the difference is statistically significant. This test provides additional non-parametric evidence confirming the different pricing of SOFR-linked FRNs. We further explore this approach in the appendix, where we show that the results remain intact using weekly instead of monthly matching (Table IA.4).

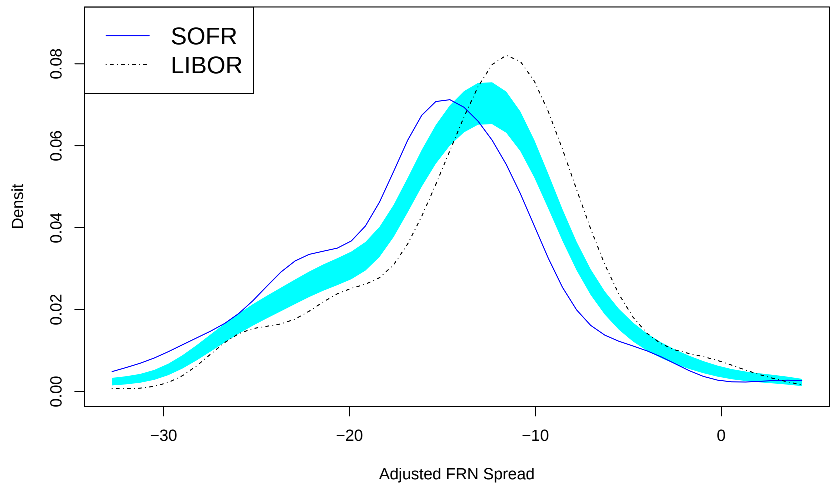


Figure 4: **FRN spreads for maturity-matched sample.** This figure shows the distribution of adjusted FRN yield spreads for SOFR-linked FRNs and LIBOR-linked FRNs, focusing on issuance data of US GSEs. For every month with more than three LIBOR-linked FRN issuances, we we fit a cubic spline to the issuance spreads and, for each SOFR-linked FRN within the same month and with a time to maturity within the range of maturities of LIBOR-linked FRNs, we use the spline to construct a maturity-matched SOFR spread. We repeat this procedure for SOFR-linked FRNs to obtain synthetic LIBOR spreads. The plots show kernel densities and the shaded regions illustrate the bootstrapped standard errors. The solid blue line shows the adjusted spreads for SOFR-linked FRNs. The dashed black line shows the spread of LIBOR-linked FRNs. We can formally reject the hypothesis that these two kernel densities are identical with a $p$-value below 0.1%.

# 3 Borrowing Costs for Syndicated Loans

Because most of the discussion around the benchmark transition focuses on issues with loan supply, it is important to examine if our results generalize to the syndicated loan market. Unfortunately, testing if SOFR-linked loans are priced differently from LIBOR-linked loans is subject to three challenges. First, in contrast to the FRN market, there was virtually no transition period in the syndicated loan market. The first SOFR-linked loan was originated in October 2021 and we observe few LIBOR-linked loan originations after January 2022. Hence, using a similar matrix pricing approach as for FRNs is not feasible. Second, loan prepayments, amortization features, and renegotiations (Roberts and Sufi, 2009) imply that the expected loan maturity is shorter than the contractual loan maturity and therefore not directly comparable to the maturity of interest rate swaps. Third, hidden fees (Berg et al., 2016), loan discounts and floors (Bruche et al., 2020), and the fact that we cannot observe the underlying LIBOR tenor (e.g. 1-month or 3-month) make it challenging to compare the all-in spreads drawn (AISD) commonly reported for syndicated loans.

We now describe the loan data underlying our analysis and our approach to mitigating these issues and distilling the effect of the benchmark rate. Afterwards, we present our estimates of the effect of linking loans to SOFR.

## 3.1 The Data

We obtain information on the syndicated loan market from LPC Dealscan, focusing on term loans and credit lines. Following Berg et al. (2016), we measure borrowing costs with the AISD, which includes loan fees and other costs, and require information on the loan volume, maturity, and AISD for all loans in our sample. In addition, we follow the literature (e.g., Schwert, 2018) by removing financial issuers (SIC between 6000 and 6999) and issuers not headquartered in the US. Because we are interested in the benchmark transition, we further restrict our sample to loans with either LIBOR or SOFR as benchmark rate. Finally, we restrict the sample to the 12-months period between July 2021 and June 2022 when we observe most of the benchmark rate changes.

To address the issues of unobservable loan characteristics we exploit a new feature of LPC Dealscan that was launched in August 2021. This version of the loan database allows us to trace loan amendments over time as Dealscan now keeps the same identifiers after any amendments. The key variables of interest in our analysis are the AISD and the reference rate of the loan tranche.[13] Examining the changes in the AISD after an amendment mitigates the concern that unobservable loan characteristics cloud our analysis.

Restricting the time between loan amendments is critical to avoid biases due to unobservable changes in the underlying issuers' credit quality. However, it is important to balance this consideration with concerns about statistical power, which decreases for narrower times between amendments. We balance these considerations by restricting the time between amendments to 15 months, which allows us to include 75% of the observed amendments. In addition, we control for market-wide changes in credit conditions between amendments by using changes in the weekly National Financial Conditions Index (NFCI) published by the Federal Reserve Bank of Chicago. Hence, the only remaining concern for our analysis is that improvements in the lenders' credit quality could be correlated with amending the loan rates from LIBOR to SOFR. We further discuss this issue and potential solutions to it in Section 3.2.1.

To mitigate the problem with potential prepayments and unobservable LIBOR tenors, we proceed as follows. First, because LIBOR swaps were only traded under excemptions from January 2022, we adjust the AISD of LIBOR-linked loans (which mostly observed in 2021). Second, we adjust the LIBOR swaps by subtracting the 1-3-months LIBOR tenor basis to obtain conservative adjustments (1-month LIBOR are lower than 3- or 6-month LIBOR rates). Third, we divide the contractual time to maturity by two and use this as maturity of the related swaps. We then use the adjusted loan maturity and calculate the spread adjustment using cubic spline interpolation of the spread between synthetic 1-month LIBOR swaps and SOFR OIS.

[13] In the new version, the terminology changed and Dealscan refers to "deals" instead of "packages" and loan "tranches" instead of loan "facilities." As is common in the literature, we focus our analysis on the tranche level.

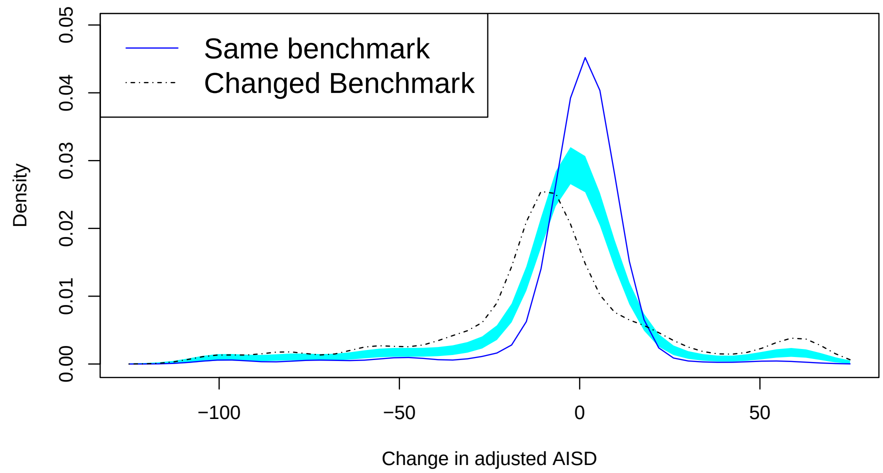


Figure 5: **Changes in adjusted AISD loan spreads.** This figure shows the distribution (kernel density) of changes AISD loan spreads, adjusted for differences in the loan reference rate. The solid blue line shows changes in AISDs for amendments without changes in the reference rate. The dashed black line shows changes in AISDs for amendments wit changes in the reference rate. The shaded regions illustrate bootstrapped standard errors. We can formally reject the hypothesis that these two kernel densities are identical with a $p$-value below 0.1%.

## 3.2 Results

Figure 5 shows the kernel density of changes in the adjusted spreads, illustrating that, similar to the results for FRNs, we tend to observe a *SOFR discount*.

We next test how changes in the benchmark rate from LIBOR to SOFR affect the loan pricing, after controlling for other variables. To that end, we run panel regressions of the following form:

$$\Delta AISD^{Adj}_{j,i,t} = \mathbb{1}(Benchmark\ Chg)_{i,t} + Controls_{i,t} + \varepsilon_{i,t}, \tag{8}$$

where $\mathbb{1}(Benchmark\ Chg)_{i,t}$ is an indicator that equals one if the benchmark rate changed from LIBOR to SOFR and $Controls_{i,t}$ include changes in the number of lenders, loan amount, time to maturity, maturity, covenants, and the NFCI, all measured from the previous amendment (or from origination if it is the first amendment) to the current amendment. In addition, we control for the number of amendments the loan went through already, and add loan type, age and time fixed effects.[14]

Column (1) of Table 4 confirms the intuition from the density plot: The adjusted loan spread decreases when the reference rate is switched from LIBOR to SOFR. The average change when the benchmark rate changes from LIBOR to SOFR is $-11.67$ basis points ($t = -4.15$). In Column (2) we repeat our analysis for the unadjusted AISD and find a positive (as expected) but statistically insignificant increase in unadjusted loan spreads when the benchmark rate changes.

### 3.2.1 Analysis in Levels

We now modify our analysis and focus on the level of loan spreads. Similar to the analysis for FRNs, we run panel regressions of the following form:

$$AISD^{Adj}_{j,i,t} = \alpha_{SOFR} + Controls_{i,t} + FE_j + FE_t + \varepsilon_{i,t}. \tag{9}$$

Controls include the number of lenders in the syndicate, loan size, contractual time to maturity, an indicator capturing if loan covenants are attached, as well as loan type, year-month, and issuer fixed effects. As before, we limit the sample period to July 2021 to June 2022 to reduce the time between loan observations. Because we control for time-fixed effects, we drop NFCI as control. This specification has the drawback that we do not examine spread

[14] We present detailed summary statistics of these control variables and our loan data in the appendix (Table IA.1).

Table 4: **Analysis of changes in AISD loan spreads.** This table shows the results of regressing changes in either the adjusted all-in-spread drawn (AISD) [Column (1)] or the unadjusted AISD [Column (2)] on an indicator variable $\mathbb{1}(\textit{Benchmark Chg.})_i$ that equals one if the benchmark rate of loan $i$ changes from LIBOR to SOFR. The changes are calculated from one tranche amendment to the next. In Column (1), the AISD is adjusted by adding the maturity-matched LIBOR-SOFR spread (with one-month Libor rate and using half the contractual loan maturity) to LIBOR-benchmarked loans. The sample period is July 2021 to June 2022. All specifications include issuance-month, loan-age (measured as quarters from loan origination) and loan-type fixed effects. The numbers in parantheses are $t$-statistics based on heterogeneity-robust standard errors clustered at issuer and year-month level. ***, **, and * indicate significance at a 1%, 5%, and 10% level, respectively.

| | $\Delta$ Adjusted AISD | $\Delta$ Raw AISD |
|---|---|---|
| | (1) | (2) |
| $\mathbb{1}(\textit{Benchmark Chg.})$ | $-11.24^{***}$ | 3.64 |
| | $(-3.66)$ | (1.07) |
| $\Delta \log(\textit{Amt})$ | $-3.71$ | $-3.74$ |
| | $(-0.78)$ | $(-0.76)$ |
| $\Delta TTM$ | $-2.24$ | $-0.73$ |
| | $(-0.82)$ | $(-0.26)$ |
| $\Delta \textit{Maturity}$ | $-3.11$ | $-5.13^{*}$ |
| | $(-1.16)$ | $(-1.83)$ |
| $\Delta \#\textit{Lenders}$ | 0.47 | $0.44^{*}$ |
| | (1.79) | (1.81) |
| $\Delta \mathbb{1}(\textit{Covenants})$ | 2.24 | 2.29 |
| | (0.42) | (0.46) |
| $\Delta NFCI$ | $34.72^{***}$ | $22.77^{**}$ |
| | (5.50) | (2.99) |
| $\#\textit{Amend}$ | 0.41 | 0.42 |
| | (1.50) | (1.27) |
| Loan Type FE | ✓ | ✓ |
| YM FE | ✓ | ✓ |
| Age FE | ✓ | ✓ |
| Adj. $R^2$ | 0.13 | 0.09 |
| Num. obs. | 1,246 | 1,246 |

fluctuations at the individual loan level, which could bias our results due to unobservable characteristics.

Table 5 shows that our results remain qualitatively similar to the analysis in changes.

Starting with the full sample, we first note that 215 issuers in our sample have at least one LIBOR and one SOFR linked observation during the sample period. Column (1) shows the estimate of the SOFR discount in the full sample increases to $-30.1$ basis points. In addition, all control variables have the expected signs—loans with more lenders, larger loan amounts, or shorter times to maturity tend to have lower spreads. We next exploit the fact that we have 107 borrower-months during which we observe LIBOR- and SOFR-linked loans from the same issuer. Despite this smaller sample, Column (2) shows that the coefficient estimats remain largely unchanged when we control for borrower times year-month fixed effects.

To conclude, we repeat our analysis for three different subsamples of the loan database. First, because most research on syndicated loans focuses on public firms, we remove borrowers that are not publicly traded from our sample.[15] Second, we focus on the subsample of loan originations, dropping any loan amendments. Finally, we focus on the subsample of loan amendments, dropping any loan originations. As we can see from Columns (3), (4). and (5), the results remain qualitatively similar for all subsamples with SOFR-linked loans having significantly lower spreads than LIBOR-linked loans.

Taken together, it is worth noting that the economic magnitude of the SOFR coefficient is around three times larger than for our analysis of loan amendments. Hence, the estimates from loan amendments can be interpreted as a conservative estimate of the SOFR discount.

[15] Instead of relying on the most recent matching table between Dealscan and Compustat, provided by Chava and Roberts (2008), we exploit another new feature of the Dealscan database which now provides firm identifiers from Eikon (Thomson Reuters). For each borrower in our sample, we use Eikon to find the ultimate parent of the borrower and check if the borrower reports outstanding stocks to determine if it is a publicly traded company. This approach has the advantage that we do not need to update the most recent matching table for new borrowers.

Table 5: **Panel regression of AISD loan spreads.** This table shows the results of regressing adjusted all-in-spread drawn (AISD) on an indicator variable $SOFR_i$ that equals one if the interest payments of loan $i$ are linked to SOFR and zero otherwise. The AISD is adjusted by adding the maturity-matched LIBOR-SOFR spread (with one-month Libor rate and using half the contractual time to maturity) to LIBOR-benchmarked loans. The sample period is July 2021 to June 2022. All specifications include borrower, issuance month, and loan type fixed effects. Columns (2) shows the results including interactions between borrower and year-month fixed effects. Column (3) shows the results for the subsample of non-private borrowers. Column (4) shows the results for the subsample of loan originations. Column (5) shows the results for the subsample of loan amendments. The numbers in parantheses are $t$-statistics based on heterogeneity-robust standard errors, clustered at the issuer and year-month level. ***, **, and * indicate significance at a 1%, 5%, and 10% level, respectively.

| | All Obs. | | Only publ. | Only orig. | Only amend. |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| $\mathbb{1}(SOFR)$ | $-30.12^{***}$ | $-36.42^{**}$ | $-33.67^{***}$ | $-61.36^{**}$ | $-27.24^{**}$ |
| | $(-3.29)$ | $(-2.91)$ | $(-3.95)$ | $(-2.31)$ | $(-2.85)$ |
| $\#Lenders$ | $-2.76^{***}$ | $-3.97^{***}$ | $1.53$ | $-4.54^{***}$ | $-2.59^{**}$ |
| | $(-3.59)$ | $(-3.16)$ | $(1.78)$ | $(-3.22)$ | $(-2.35)$ |
| $\log(Amt)$ | $-4.18^{**}$ | $-4.42^{**}$ | $-7.66^{*}$ | $-10.79^{**}$ | $-1.91$ |
| | $(-2.47)$ | $(-2.49)$ | $(-2.11)$ | $(-2.58)$ | $(-1.03)$ |
| $TTM$ | $19.31^{***}$ | $16.89^{***}$ | $10.87^{**}$ | $38.75^{***}$ | $8.04^{**}$ |
| | $(6.19)$ | $(4.58)$ | $(2.57)$ | $(4.38)$ | $(2.30)$ |
| Covenant FE | ✓ | ✓ | ✓ | ✓ | ✓ |
| Loan Type FE | ✓ | ✓ | ✓ | ✓ | ✓ |
| YM FE | ✓ | – | ✓ | ✓ | ✓ |
| Issuer FE | ✓ | – | ✓ | ✓ | ✓ |
| Issuer × YM FE | – | ✓ | – | – | – |
| Adj. $R^2$ | 0.87 | 0.86 | 0.84 | 0.87 | 0.88 |
| Num. obs. | 4,390 | 4,390 | 832 | 1,511 | 2,879 |

# 4 Interpretation and Discussion

The goal of our study is to investigate if SOFR-linked debt costs borrowers more than LIBOR-linked debt. Our results answer this question with a clear no— if anything, issuing SOFR-linked debt costs borrowers *less* than issuing LIBOR-linked debt, at least after adjusting for the differences in variable rates. From a theoretical perspictive, this "SOFR discount" is surprising because, as outlined by, among others, Jermann (2019) and Cooperman et al. (2022), lenders in SOFR-linked debt lose the hedging properties inherent in LIBOR. Hence, it is important to discuss the interpretation and limitations of our findings.

First, to compare the borrowing costs of LIBOR- and SOFR-linked debt, it is a necessary evil to focus on a sample period in which we observe debt instruments linked to both benchmark rates. Hence, we focus on the three-year period between January 2019 and December 2021 for FRNs and the one-year period between July 2021 and June 2022 for syndicated loans. While this sample period allows for a clean comparison between floating rate debt with different benchmark rates, it is plausible that our results are driven by idiosyncratic factors that are special to the transition period. One such factor are legal concerns and transition risks, which we further discuss in the following subsections. However, while the SOFR discount might diminish over time, the central takeaway from our study is that we find no evidence of elevated borrowing costs for SOFR-linked debt.

Second, we cannot interpret the SOFR discount as an arbitrage opportunity. To see this point, consider the hypothetical situation in which an arbitrageur could invest in a two-year LIBOR-linked FRN and take a short position in a two-year SOFR-linked FRN from the same issuer. To ensure matching cashflows, this strategy would require paying the fixed rate in a SOFR OIS and receiving the fixed rate in a LIBOR swap. With an average SOFR discount of 5 basis points, it is plausible that hedging costs in the interest rate swap market combined with transaction costs for the FRNs diminish any arbitrage profit. However, if investors have a preference for LIBOR-linked debt, the hedging argument outlined in Table 1 suggests that we would observe higher yield spreads for SOFR-linked debt. Hence, our results can be interpreted as evidence against elevated funding costs for SOFR-linked debt.

Finally, most of the theoretical arguments around investors' preference for credit sensitive benchmark rates are for the loan market and specific to bank lenders. For FRNs, banks are unlikely the marginal investors and it is important to acknowledge the data limitation that we do not observe all investors in these instruments. Instead, money market mutual funds (MMFs) are the largest investors and we examine their role in further detail in the following subsection. For syndicated loans, our main results are based on loan amendments and it is plausible that the arranging banks sell (part of) their loan shares to other investors over time. Hence, our results do not contradict the arguments discussed by Jermann (2019) and Cooperman et al. (2022)—it is still plausible that the benchmark transition has an adverse effect on loan supply. However, quantifying this effect is an empirical challenge and our paper is the first systematic study examining the link between borrowing costs and the benchmark transition.

## 4.1 Explanations for FRNs

We now examine various potential explanations of the SOFR discount for FRNs. Throughout this section, we focus on modifications of the most stringent regression specification from Equation (5).

### 4.1.1 A Covid Discount?

The results shown in Figure 2 suggest that the SOFR discount is most pronounced in March and April 2020 and diminishes toward the end of our sample period. To test if the SOFR discount is simply a "Covid discount" we interact $\alpha_{SOFR}$ with an indicator variable that equals one in March and April 2020 and zero otherwise. In addition, we add an interaction with an indicator variable that equals one after April 2020. As shown in Column (1) of Table 6, we observe a significantly larger SOFR discount during the COVID crisis but a qualitatively similar discount before and after the market turmoil of 2020. Hence, our results are not simply driven by this sub-period.

### 4.1.2 Safe Asset Discount

The results in Figure 3 suggest that the SOFR discount is most pronounced for US GSEs. To examine if our results simply reflect a safe asset discount, we add an interaction between $\alpha_{SOFR}$ and an indicator variable that equals one if the issuer is one of the three US GSEs in our sample and zero otherwise. As shown in Column (2) of Table 6, $\alpha_{SOFR}$ reduces to $-2.96$ basis points ($t = -2.10$) for non-GSEs and is significantly larger for US GSEs. Hence, the SOFR discount remains significant for other issuers.

### 4.1.3 Legal Risks

Because LIBOR-linked FRNs that mature after the LIBOR cessation date need to fall back to an alternative reference rate, it is plausible that investors are concerned about legal risks. While these concerns are mitigated by the fallback protocol discussed in Section 1, it is plausible that frictions in implementing the fallbacks could still cause some investor concerns. To test if these risks affect the SOFR discount, we define an indicator variable $\mathbb{1}_{Mat.post}$ that equals one if the maturity of the FRN is after the LIBOR cessation date, which, until November 2020 was December 2021 and June 2023 afterwards. As shown in Column (3) of Table 6, FRNs maturing after the LIBOR cessation date are subject to a larger SOFR discount than FRNs maturing before.

We further examine the role of legal risks by separately studying $\alpha_{SOFR}$ for securities with less than one year to maturity (which never cross the cessation date in our sample), securities with more than three years to maturity (which always cross the cessation date in

Table 6: **Dissecting the SOFR discount for FRNs.** This table shows the results of regressing the yield spread of newly-issued FRNs on two indicator variables: $SOFR$ equals one if the benchmark rate is SOFR and zero otherwise. $1m$ equals one if the benchmark rate is the 1-month Libor rate. The baseline case corresponds to FRNs with 3-month Libor as benchmark rate. $\mathbb{1}_{t\in[03/20,04/20]}$ and $\mathbb{1}_{t>Apr\ 2020}$ are indicator variables that equal one in March and April 2020 and after April 2020, respectively. $\mathbb{1}_{US\ GSE}$ is an indicator variable that equals one if the issuer is one of the three US GSEs in our sample. $\mathbb{1}_{Mat.post}$ is an indicator variable that equals one if the maturity of the FRN is after the Libor cessation date, which, until November 2020 was December 2021 and June 2023 afterwards. $\mathbb{1}_{MMF\ inv.}$ is an indicator variable that equals one if a MMF invested in the FRN within the first month of issuance (as reported in monthly MMF reports). The control variables include the time to matrutiy ($ttm$), the squared time to maturity ($ttm^2$), and the logarithm of the issuance amount ($\log(a)$), and issuer fixed effects, all interacted with year-month fixed effects to capture unobservable changes in the effect of these controls over time. The numbers in parantheses are $t$-statistics based on heterogeneity-robust standard errors, clustered at the issuer and year-month level. ***, **, and * indicate significance at a 1%, 5%, and 10% level, respectively.

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| $SOFR$ | $-4.41^{***}$ | $-2.96^{**}$ | $-4.35^{***}$ | $-4.60^{***}$ |
| | $(-3.38)$ | $(-2.10)$ | $(-3.13)$ | $(-2.99)$ |
| $SOFR \times \mathbb{1}_{t\in[03/20,04/20]}$ | $-22.34^{***}$ | | | |
| | $(-3.19)$ | | | |
| $SOFR \times \mathbb{1}_{t>Apr\ 2020}$ | 2.21 | | | |
| | (1.59) | | | |
| $SOFR \times \mathbb{1}_{US\ GSE}$ | | $-3.98^{**}$ | | |
| | | $(-2.68)$ | | |
| $SOFR \times \mathbb{1}_{Mat.post}$ | | | $-6.00^{***}$ | |
| | | | $(-2.88)$ | |
| $SOFR \times \mathbb{1}_{MMF\ inv.}$ | | | | $-0.16$ |
| | | | | $(-0.18)$ |
| $\mathbb{1}_{MMF\ inv.}$ | | $-0.34$ | | $-0.28$ |
| | | $(-0.98)$ | | $(-0.77)$ |
| D.1m | $-0.72$ | $-0.65$ | $-0.47$ | $-0.51$ |
| | $(-1.54)$ | $(-1.44)$ | $(-1.08)$ | $(-1.16)$ |
| Controls | $ttm \times ym$ | $ttm \times ym$ | $ttm \times ym$ | $ttm \times ym$ |
| | $ttm^2 \times ym$ | $ttm^2 \times ym$ | $ttm^2 \times ym$ | $ttm^2 \times ym$ |
| | $\log(a) \times ym$ | $\log(a) \times ym$ | $\log(a) \times ym$ | $\log(a) \times ym$ |
| Issuer × YM FEs | ✓ | ✓ | ✓ | ✓ |
| Adj. $R^2$ | 0.95 | 0.95 | 0.95 | 0.95 |
| Num. obs. | 7,406 | 7,406 | 7,406 | 7,406 |

our sample) and securities with maturities between one and three years, separating those that mature before and after the cessation date. As shown in Figure 6, we find a substantial difference between FRNs crossing the cessation date and other FRNs, even after conditioning on the maturity structure.

#### 4.1.4 Investor Basis

One limitation of our FRN data is that we do not observe who invests in the issuances as holdings data for FRNs are scarce. For MMFs, we observe monthly portfolio holdings from their regulatory filings and use the first monthly filing after FRN issuance to estimate the percentage of the issuance sold to MMFs. Matching the FRN CUSIPs with monthly MMF holdings data obtained from Crane data, we first note that MMFs hold 55% of the notional of all FRNs in our sample. This fraction increases to 83% for US GSEs and drops to 26% for other issuers. Further, for 51% of the FRNs in our sample, MMFs are holding at least a fraction of the issuance.

To test if the SOFR discount differs for FRNs held by MMFs, we interact $\alpha_{SOFR}$ with a dummy variable that equals one if MMFs hold a part of the notional. Because MMFs are highly sensitive to the yields of their investments, it would be plausible to observe a less pronounced SOFR discount for those FRNs. However, Column (4) of Table 6 shows no evidence of a significant difference between FRNs held by MMFs and other FRNs.

#### 4.1.5 Alternative specifications

In the appendix we conduct four additional robustness checks. First, we use a spread adjustment based on cubic spline interpolation instead of exact cashflow matching. Second, we replace swap rates up to five years with Euro-dollar and SOFR futures contracts. Third, we add an interaction term between $\alpha_{1m}$ and time fixed effects. Finally, we repeat our analysis

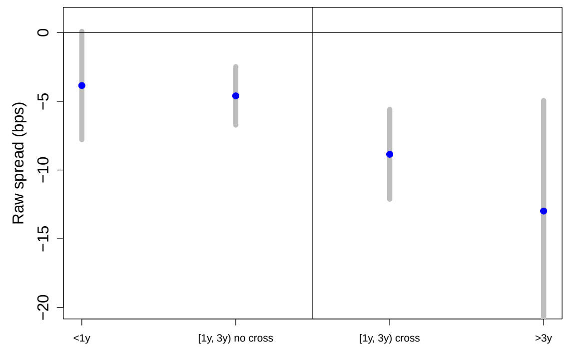


Figure 6: **FRN spreads across maturities.** This figure illustrates the coefficient $\alpha_{SOFR}$ from Specification 5, allowing for different coefficients depending on the maturity of the FRN. $< 1y$ captures all FRNs with less than one year to maturity and $\geq 3y$ captures all FRNs with more than three years to maturity. For FRNs with maturities between one and three years, we separate two cases. "no cross" captures all FRNs that mature before the LIBOR cessation date (which, until November 2020, was December 2021 and June 2023 afterwards) and "cross" captures all FRNs that mature after the LIBOR cessation date. The grey bars are 95% confidence bars, based on robust standard errors, clustered at the issuer level.

for the more common matrix pricing approach and control for different indicators capturing the time to maturity and issuance amount. The SOFR discount remains quantitatively similar in all specifications (see Table IA.2).

## 4.2 Explanations for Loans

Directly repeating our analysis for syndicated loans is not possible. First, the benchmark transition was contained in a relatively short time period (which did not include March 2020) and we therefore do not consider different time subsamples. Second, focusing on "safe" issuers is not obvious because US GSEs do not borrow in the loan market and the majority of loans are to non-public firms. Table 5 shows that conducting the analysis separately for public firms gives qualitatively similar results. Third, we cannot test for legal risks because the transition was condensed in end-2021 and most loan maturities exceed three years. Finally, the large spread makes it less sensitive to small adjustments in derivatives.

Instead, we first examine how the amendments vary with loan age. The idea behind this test is that loans further away from origination are more likely held by non-bank investors. Column (1) of Table 7 shows that loan amendments for loans that are more than one year old tend to correspond with larger SOFR discounts. However, the difference between older and younger loans is not statistically significant. Second, we examine if small loans are subject to a similar discount as larger loans. As shown in Column (2) of Table 7, there is no significant difference between the SOFR discount for smaller and larger loans. Finally, we examine the role of lenders and separate loans with less than four lenders in the syndicate (corresponding to the median) face a different SOFR discount than loans with more lenders. Column (3) shows that loans with fewer lenders tend to be subject to a higher SOFR discount. However, the difference between loans with fewer lenders and other loans is not statistically significant.

# 5 Conclusion

We examine how the transition from LIBOR as benchmark rate in floating rate debt to SOFR as alternative benchmark rate affects affects borrowing costs. The central concern about this transition is that lenders lose the hedging benefits inherent in LIBOR floating rate payments when transitioning to SOFR. This loss of hedging benefits could make lending with the alternative benchmark rate less attractive and therefore increase borrowing costs. Contrasting with this concern, we find a small, but statistically significant SOFR discount when examining FRNs benchmarked against SOFR and LIBOR. After adjusting for the risk-neutral expectations about LIBOR-SOFR spreads, obtained from the swap market, borrowing with SOFR floating rate debt is *cheaper*.

Table 7: **Analysis of changes in loan spreads.** This table shows the results of regressing changes in the adjusted all-in-spread drawn (AISD) on an indicator variable $\mathbb{1}(Benchmark\ Chg.)_i$ that equals one if the benchmark rate of loan $i$ changes from Libor to SOFR. The changes are calculated from one tranche amendment to the next. The AISD is adjusted by adding the maturity-matched Libor-SOFR spread (with one-month Libor rate) to Libor-benchmarked loans. The sample period is July 2021 to June 2022. $1y\ later$ is an indicator variable that equals one if the amendment is more than one year after the origination. $Small$ is an indicator variable that equals one if the loan size is below the median size. $FewLenders$ is an indicator that equals one if the syndicate comprises less than four lenders (the median). All specifications include issuance month, distance from issue (in quarters) and loan type fixed effects. The numbers in parantheses are $t$-statistics based on heterogeneity-robust standard errors clustered at issuer and year-month level. ***, **, and * indicate significance at a 1%, 5%, and 10% level, respectively.

| | (1) | (2) | (3) |
|---|---|---|---|
| $\mathbb{1}(Benchmark\ Chg.)$ | $-6.86$ | $-10.77^{**}$ | $-9.73^{**}$ |
| | $(-0.68)$ | $(-2.31)$ | $(-2.41)$ |
| $\mathbb{1}(Benchmark\ Chg.) \times 1y\ later$ | $-5.75$ | | |
| | $(-0.45)$ | | |
| $\mathbb{1}(Benchmark\ Chg.) \times Small$ | | $-2.61$ | |
| | | $(-0.40)$ | |
| $\mathbb{1}(Benchmark\ Chg.) \times FewLenders$ | | | $-8.81$ |
| | | | $(-1.37)$ |
| $\Delta \#Lenders$ | $0.54^{**}$ | $0.55^{**}$ | $0.51^{*}$ |
| | $(2.23)$ | $(2.22)$ | $(2.14)$ |
| $\Delta \log(Amt)$ | $-2.78$ | $-2.84$ | $-2.61$ |
| | $(-0.86)$ | $(-0.89)$ | $(-0.80)$ |
| $\Delta TTM$ | $-5.27^{*}$ | $-5.34^{*}$ | $-5.46^{*}$ |
| | $(-2.14)$ | $(-2.15)$ | $(-2.18)$ |
| $\Delta \mathbb{1}(Covenants)$ | $-0.12$ | $0.21$ | $-0.55$ |
| | $(-0.02)$ | $(0.03)$ | $(-0.09)$ |
| Loan Type FE | ✓ | ✓ | ✓ |
| YM FE | ✓ | ✓ | ✓ |
| Age FE | ✓ | ✓ | ✓ |
| Adj. $R^2$ | 0.08 | 0.08 | 0.08 |
| Num. obs. | 1,246 | 1,246 | 1,246 |

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# Internet Appendix

(Not for publication)

## A Additional Details

### A.1 Additional Descriptive Statistics

Figure IA.1 shows a Venn diagram, illustrating how many of the FRN issuances in our sample are obtained from Bloomberg and how many are from FISD

**[Insert Figure IA.1 near here]**

#### A.1.1 Loan Summaries

Table IA.1 contains summary statistics for the other variables. We have $1,246$ amendments in our sample and 14% of these amendments were a change (partly) due to a change in benchmark rate. Further, the time-to-maturity of the loans in our sample tends to decrease from one amendment to the next, which is due to passing of time, not due to changes in the maturity (which stays unchanged for the majority of observations). The majority of amendments do not entail a change in the amount or number of lenders and only 2% experience a change in covenants. The NFCI index tends to increase, suggesting that average credit conditions tightened over the amendment window. Finally, the average loan in our sample experienced, on average, 3.27 amendments and 26% of the loans in our sample are revolving credit (the rest are term loans).

**[Insert Table IA.1 near here]**

### A.1.2 LIBOR-SOFR Spreads in Derivatives Markets

Figure IA.2 shows the spread between LIBOR swap rates and SOFR OIS rates for contracts with 2, 5, and 10 years to maturity. As shown in the figure, during quiet times, LIBOR-SOFR spreads are higher for longer maturities, while the pattern inverts during times of financial distress, as illustrated during the market turmoil of March 2020. Generally speaking, the LIBOR-SOFR spread is qualitatively similar to the spread between LIBOR swap rates and OIS rates with the effective FED funds rate as benchmark.[1] Moreover, the LIBOR fallback spread was settled in March 2021 and equals 26.1 basis points for 3-month LIBOR-SOFR spreads (ARRC, 2021). The solid line in Figure IA.2 shows the fallback spread. Because LIBOR will cease to exist in June 2023, standard contracts referencing LIBOR will fall back to $SOFR + 26.1$ basis points after that date.

**[Insert Figure IA.2 near here]**

## A.2 Matrix Pricing approach

We now closely follow Liao (2020) and using a matrix pricing approach to examine the link between yield spreads and benchmark rates over time. In contrast to Liao (2020), who studies the role of the currency denomination for secondary market bond prices, we apply the matrix pricing approach to yield spreads in the primary market. Every month, we run cross-sectional regressions of the yield spreads for newly-issued FRNs on $\alpha_{SOFR}$, controlling for issuer-fixed effects, maturity buckets, and issuance volumes. We introduce indicators $\delta_j^{[t_i,t_{i+1})}$ and $\delta_j^{[a_k,a_{k+1})}$, which equal one if the maturity of FRN $j$ is in the interval $[t_i, t_{i+1})$ or the issuance amount of FRN $j$ is in the interval $[a_i, a_{i+1})$. We use intervals $[0, 1)$, $[1, 3)$,

[1]Filipović and Trolle (2013) is an important example studying those spreads.

$[3, 7)$, and $> 7$ for the time to maturity and $[\$0m, \$75m)$, $[\$75m, \$200m)$, $[\$200m, \$400m)$, and $> \$400m$ for the issuance volumes.

As a starting point, we illustrate the results without adjusting the spreads of SOFR-linked FRNs. The top panel of Figure IA.3 shows the resulting coefficient estimates and 95% confidence bands. As shown in the figure, the unadjusted spreads are generally positive and increase during the market turmoil of March 2020. To examine if this time series pattern is comparable to that of LIBOR-SOFR spreads in the swap market, we average our cash-flow adjustments for SOFR-linked FRNs in each month and plot the maturity-matched LIBOR-SOFR spread. As indicated by the black line, the FRN spreads track the maturity-matched LIBOR-SOFR spread, but the spread obtained from the swap market is typically higher than the FRN spread.

[**Insert Figure IA.3 near here**]

The lower panel of Figure IA.3 shows the results for using the adjusted yield spreads in SOFR-linked FRNs. In line with the results from Table 3, we observe a *SOFR discount* for most of the sample period. In addition, the figure shows that this discount was most pronounced in March and April 2020 and converged toward zero at the end of our sample period. In Section 4, we further examine how our coefficient estimates vary across time periods and find that excluding March and April 2020 leaves our results largely unchanged.

## A.3 Additional Robustness Checks

We now compare our baseline estimate to alternative specifications. Column (1) of Table IA.2 shows using cubic-spline interpolation of the spread instead of cash-flow matching leads to virtually identical results. Column (2) shows that replacing the rate instruments with less than five years to maturity with rates extracted from Euro-dollar and SOFR futures contracts leads to a small drop $\alpha_{SOFR}$. Column (3) shows that adding more granular controls for 1-month-LIBOR-linked FRNs (interacting $\alpha_{1m}$ with time fixed effects) leads to virtually identical results. Finally, Column (4) shows that using the matrix pricing approach with indicator variables for time to maturity categories and issuance size categories leads to marginally stronger results.

[**Insert Table IA.2 near here**]

Figure IA.4 shows the results of repeating our non-parametric tests for FRNs issued by US GSEs (Section **??**) with weekly instead of monthly matching. As we can see from the figure, despite the smaller sample, the results remain qualitatively similar with lower adjusted yield spreads for SOFR-linked FRNs.

[**Insert Figure IA.4 near here**]

## A.4 Detailed Data Cleaning Procedure

In this appendix, we provide detailed steps for cleaning the FRN and loan data used in our analysis.

### A.4.1 Loan Data

We proceed as follows:

- We restrict the sample to include only term loans and revolving credit (i.e., credit lines)

- Following Berg et al. (2016), we require the following key loan characteristics: Loan amount, maturity date, and AISD. In addition, for revolving credits, we also require the all-in spread undrawn (AISU).
- We drop loans with missing active dates and the few loans with less than 3 months to maturity
- We collapse the loan information using the following identifiers: "Lender Id", "LPC Deal ID", "Deal Input Date", "Deal Active Date", "LPC Tranche ID", "Tranche Active Date"
- We only include loans with benchmark rate "LIBOR" or "Term SOFR" (dropping the few observations of simple SOFR and SOFR (undisclosed))
- After computing amendment changes, we only include observations from the July 2021 to June 2022 period.

### A.4.2 FISD Data

After focusing on bonds with variable interest rates (coupon_type = V), we apply the following filters to the FISD data:

- convertible = N
- foreign_currency = N
- settlement_type = S
- asset_backed = N
- enhancement = N
- covenants = N
- redeemable = N
- putable = N

- offering_price = 100
- no cap and no floor (there are virtually no FRNs with zero floor in the FISD data)
- Variable rate on of the following: LIBOR_one_month, LIBOR_three_month or SECURED_OVERNIGHT_FINANCING_RATE
- day_count_basis = ACT/360
- coupon_change_indicator = F

We then extract the yield spread from the FRN formula and remove the few observations with multiplicative spreads.

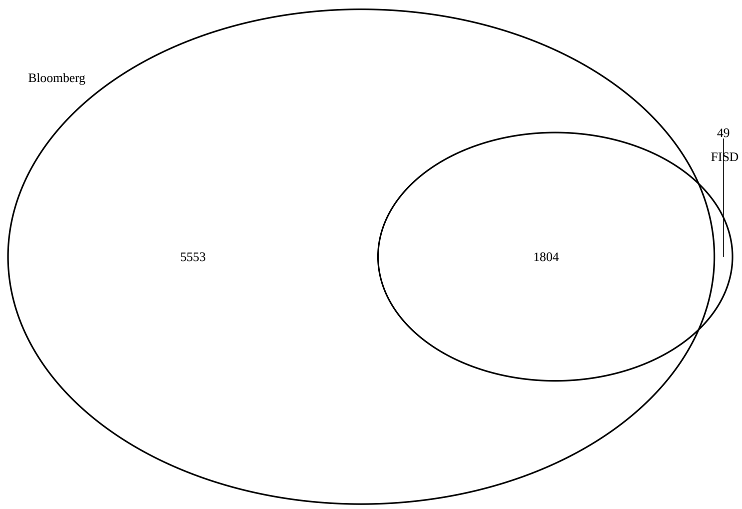


Figure IA.1: **Overview of data sources.** This figure gives an overview of the data sources. The majority of FRNs in our sample is not covered by Mergent FISD

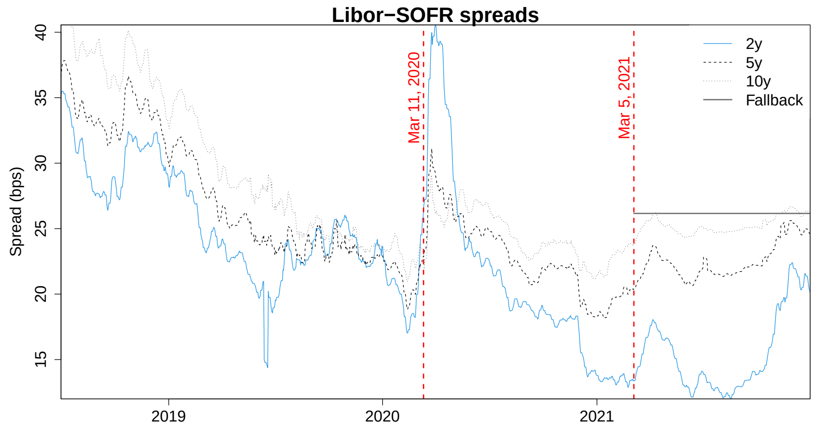


Figure IA.2: **Libor-SOFR spreads in swap markets.** This figure shows seven-day rolling averages of the spread between LIBOR swap rates and SOFR OIS rates for swaps with 2, 5, and 10 years to maturity. The black line shows fallback adjustment (estimated on March 5, 2021), which captures the 5-year historic median of the spread between 3-month LIBOR and 3-month (historical average) SOFR. The dashed vertical lines mark March, 11 2020 (the date when the WHO declared COVID-19 to a global pandemic) and March 5, 2021 (the date when LIBOR fallback was announced).

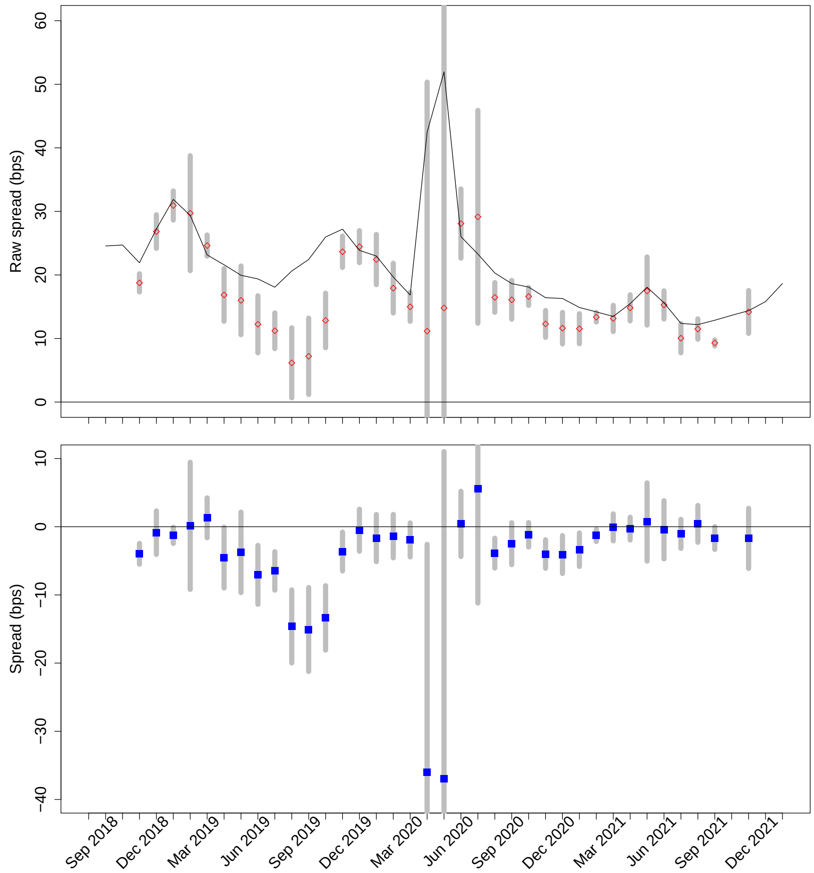


Figure IA.3: **Issuance spreads of FRNs.** The top panel shows the results of monthly cross-sectional regressions of raw FRN spreads on a set of indicator variables. The bottom panel repeats the analysis for adjusted FRN spreads. For each FRN $j$, the indicator variables include $\alpha_j^{SOFR}$, which equals one if the benchmark rate of FRN $j$ is SOFR; $\delta_j^{[t_i,t_{i+1})}$, which equals one if the maturity of FRN $j$ is in the interval $[t_i, t_{i+1})$, using $[0,1)$, $[1,3)$, $[3,7)$, and $> 7$ as intervals; $\delta_j^{[a_k,a_{k+1})}$, which equals one if the issuance amount of FRN $j$ is in the interval $[a_i, a_{i+1})$, using $[\$0m, \$75m)$, $[\$75m, \$200m)$, $[\$200m, \$400m)$, and $> \$400m$ as cut-offs; and $\gamma_{j,i}$, capturing issuer fixed effects. Because we do not include an indicator variable for LIBOR bencharks, the regression coefficient on $\alpha_j^{SOFR}$ can be interpreted as the spread between FRNs with LIBOR or SOFR as benchmark. In both panels the spreads of FRNs linked to 1-month LIBOR are adjusted by adding the maturity-matched LIBOR tenor basis. The solid line in the top panel is the spread between LIBOR swap rates and SOFR OIS with maturity interpolated to match the average maturity of SOFR FRNs in month $t$. The adjusted spreads are obtained by subtracting the maturity-matched LIBOR-SOFR spread from SOFR FRNs. The grey bars are 95% confidence bars, based on robust standard errors, clustered at the issuer level.

Table IA.1: **Loan summary statistics.** This table contains summary statistics of the changes in loan characteristics after amendments in our sample. $\mathbb{1}(Benchmark\ Chg.)$ is an indicator variable that equals one if the benchmark rate changes from LIBOR to SOFR. $\Delta TTM$ and $\Delta Maturity$ capture changes in the contractual loan time to maturity and the contractual loan maturity, respectively. $\Delta \log(Amt)$ captures changes in the loan amount. $\Delta \#Lenders$ captures changes in the number of lenders. $\Delta NFCI$ captures changes in the NFCI credit conditions index. $\#Amendments$ is the number of amendments a given loan has been through. $\mathbb{1}(Revolver)$ is an indicator variable that equals one if a given loan is revolving credit.

| | Mean | SD | 5% | 25% | Median | 75% | 95% | $N$ |
|---|---|---|---|---|---|---|---|---|
| $\mathbb{1}(Benchmark\ Chg.)$ | 0.14 | 0.35 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | 1,246 |
| $\Delta TTM$ | -0.33 | 0.77 | -1.13 | -0.77 | -0.43 | -0.18 | 1.50 | 1,246 |
| $\Delta Maturity$ | 0.29 | 0.79 | 0.00 | 0.00 | 0.00 | 0.00 | 2.23 | 1,246 |
| $\Delta \log(Amt)$ | 0.03 | 0.17 | -0.03 | 0.00 | 0.00 | 0.00 | 0.36 | 1,246 |
| $\Delta \#Lenders$ | -0.33 | 2.26 | -4.00 | 0.00 | 0.00 | 0.00 | 3.00 | 1,246 |
| $\Delta \mathbb{1}(Covenants)$ | 0.02 | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1,246 |
| $\Delta NFCI$ | 0.10 | 0.17 | -0.18 | 0.00 | 0.07 | 0.22 | 0.42 | 1,246 |
| $\#Amendments$ | 3.27 | 2.32 | 1.00 | 1.00 | 3.00 | 4.00 | 8.00 | 1,246 |
| $\mathbb{1}(Revolver)$ | 0.26 | 0.44 | 0.00 | 0.00 | 0.00 | 1.00 | 1.00 | 1,246 |

Table IA.2: **Robustness checks for FRNs.** This table shows the results of regressing the yield spread of newly-issued FRNs on two indicator variables: $SOFR$ equals one if the benchmark rate is SOFR and zero otherwise. $1m$ equals one if the benchmark rate is the 1-month Libor rate. The baseline case corresponds to FRNs with 3-month Libor as benchmark rate. The differences to our baseline regression are as follows. Column (1) shows the results for using a different adjustment term based on cubic spline interpolation instead of exact cash-flow matching. Column (2) shows the results for using a different adjustment term, using euro-dollar futures and SOFR futures for maturities up to five years. Column (3) corresponds to the baseline specification, adding an interaction term between $\alpha_{1m}$ and time-fixed effects as control. Column (4) shows the results using the traditional matrix pricing approach controlling for maturity categories and issuance volume categories. The numbers in parantheses are $t$-statistics based on heterogeneity-robust standard errors, clustered at the issuer and year-month level. ***, **, and * indicate significance at a 1%, 5%, and 10% level, respectively.

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| $SOFR$ | $-4.82^{**}$ | $-3.65^{***}$ | $-4.42^{***}$ | $-4.84^{***}$ |
| | $(-2.58)$ | $(-4.30)$ | $(-3.53)$ | $(-3.85)$ |
| $1m$ | $-0.44$ | $-0.60$ | | |
| | $(-0.99)$ | $(-1.35)$ | | |
| Alternative adj | Spline | Futures | – | – |
| Add. contr. | $ttm \times ym$ | $ttm \times ym$ | $ttm \times ym$ | |
| | $ttm^2 \times ym$ | $ttm^2 \times ym$ | $ttm^2 \times ym$ | |
| | $\log(a) \times ym$ | $\log(a) \times ym$ | $\log(a) \times ym$ | |
| | | | $\alpha_{1m} \times ym$ | $\alpha_{1m} \times ym$ |
| | | | | $\mathbb{1}_{ttm<1y} \times ym$ |
| | | | | $\mathbb{1}_{ttm\in[1,3)} \times ym$ |
| | | | | $\mathbb{1}_{ttm\in[3,7)} \times ym$ |
| | | | | $\mathbb{1}_{ttm>7y} \times ym$ |
| | | | | $\mathbb{1}_{a<75} \times ym$ |
| | | | | $\mathbb{1}_{a\in[75,200)} \times ym$ |
| | | | | $\mathbb{1}_{a\in[200,400)} \times ym$ |
| | | | | $\mathbb{1}_{a>400} \times ym$ |
| Issuer × YM FEs | ✓ | ✓ | ✓ | ✓ |
| Adj. $R^2$ | 0.94 | 0.95 | 0.95 | 0.93 |
| Num. obs. | 7,406 | 7,406 | 7,406 | 7,406 |

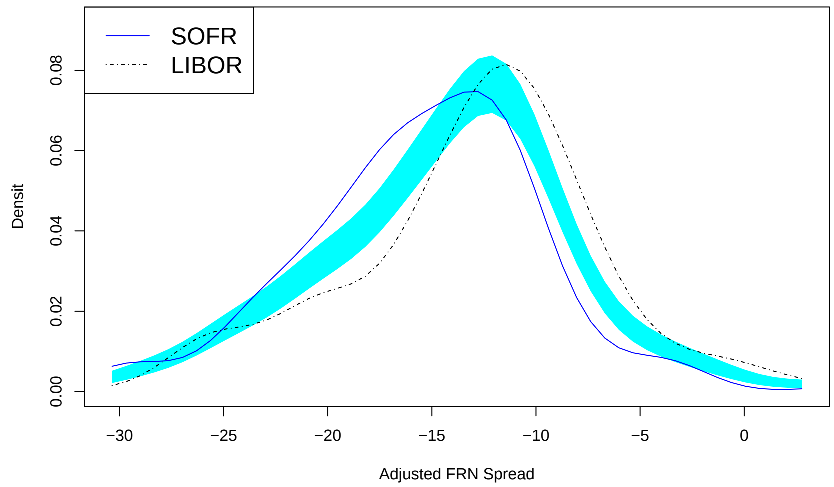


Figure IA.4: **FRN spreads for maturity-matched sample (weekly matching).** This figure shows the distribution of adjusted FRN yield spreads for SOFR-linked FRNs and LIBOR-linked FRNs, focusing on issuance data of US GSEs. For every *week* with more than three LIBOR-linked FRN issuances, we we fit a cubic spline to the issuance spreads and, for each SOFR-linked FRN within the same month and with a time to maturity within the range of maturities of LIBOR-linked FRNs, we use the spline to construct a maturity-matched SOFR spread. We repeat this procedure for SOFR-linked FRNs to obtain synthetic LIBOR spreads. The plots show kernel densities and the shaded regions illustrate the bootstrapped standard errors. The solid blue line shows the adjusted spreads for SOFR-linked FRNs. The dashed black line shows the spread of LIBOR-linked FRNs. We can formally reject the hypothesis that these two kernel densities are identical with a $p$-value below 0.1%.