

Burying Libor

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BI Oslo

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Based on joint work with Olav Syrstad

The “Libor Funeral”

July 2017: “The Future of Libor” (Bailey, 2017)

- ▶ Libor publication not guaranteed after 2021

Central Questions:

1. What rates replace Libor?
2. How does the Libor transition affect derivatives markets?
3. Does the Libor transition affect borrowing costs?

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The Alternative Reference Rates

- ▶ Replace Libor with **transaction-based overnight** rates
- ▶ Each currency-region chose different rates
- ▶ Three possible types of transactions:
 - T1* Non-bank to bank lending
 - T2* Bank to bank lending (traditional Libor rate)
 - T3* Bank to non-bank lending

United States: Secured Overnight Financing Rate (SOFR)

- ▶ Collateralized overnight rate (with U.S. Treasuries as collateral)
- ▶ Includes *T1*, *T2*, and *T3*

United Kingdom: Sterling Overnight Index Average (SONIA)

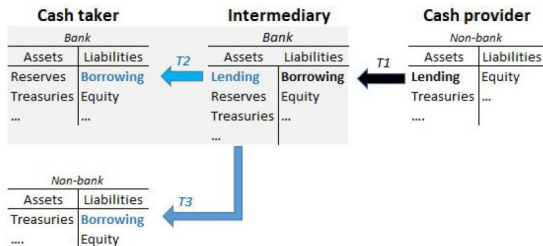
- ▶ Uncollateralized overnight rate (only *T1* and *T2*)

Euro area: Euro Short Term Rate (ESTR)

- ▶ Uncollateralized overnight rates (only *T1* and *T2*)

See Schrimpf and Sushko (2019) for details on other currencies

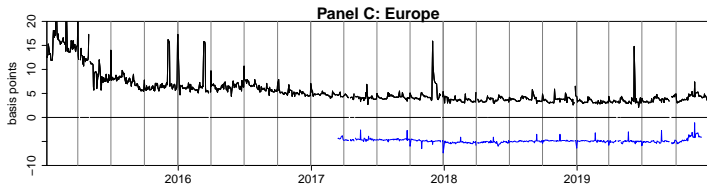
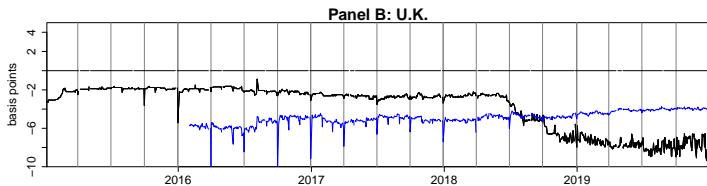
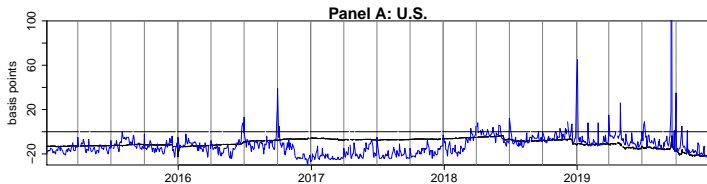
The Alternative Reference Rates



Hypotheses

- Regulatory constraints \uparrow
 - Ample reserves $\Rightarrow T1 \downarrow$ and $T2 \rightarrow$ (banks reluctant to take cash)
 - Banks need cash $\Rightarrow T3 \uparrow$ and $T2 \uparrow$ (banks reluctant to lend)
- Government debt $\uparrow \Rightarrow T1 \uparrow$ (lenders place cash in Treasuries)
 - If rate collateralized: $T1 \uparrow$, $T2 \uparrow$, and $T3 \uparrow$ (more borrowing demand)
- If reserves are not ample
 - Reserves $\downarrow \Rightarrow T1 \uparrow$, $T2 \uparrow$, and $T3 \uparrow$ (more borrowing demand)

The Alternative Reference Rates vs. ON Libor



Differences Between Libor and Alternative Rates

3m Libor is term rate known at time $t = 0$

3-month term rate based on overnight rates:

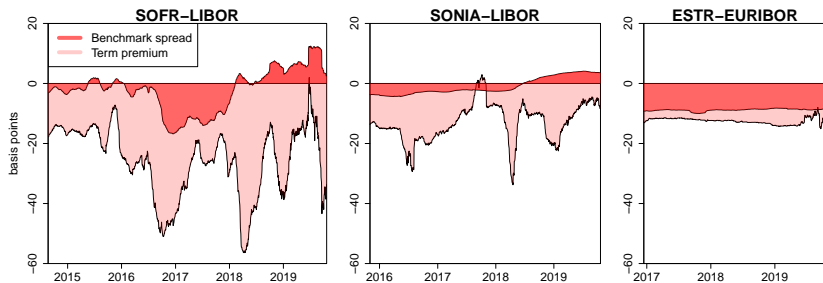
$$r(0, t) = \left[\prod_{i=1}^{d_b} \left(1 + \frac{SOFR_i \times n_i}{360} \right) - 1 \right] \frac{360}{90}$$

- ▶ $SOFR_i$ is rate at date i
- ▶ n_i number of calendar days $SOFR_i$ is applied for
- ▶ d_b number of business days over the past 90 days

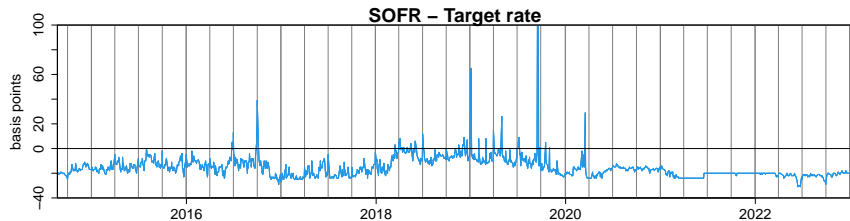
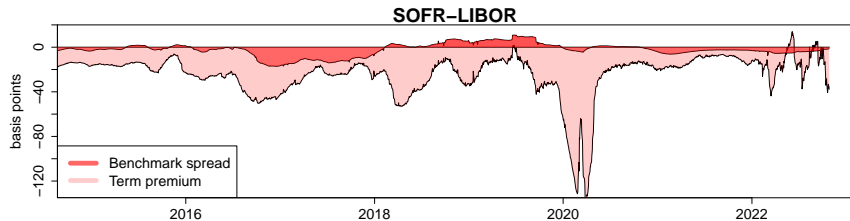
Note: $r(0, t)$ is only known at time t (compounded in arrears)

Differences Between Libor and Alternative Rates

- ▶ Benchmark spread: Alternative rate minus ON Libor (compounded)
- ▶ Term spread: 3m Libor minus compounded ON Libor (in arrears)

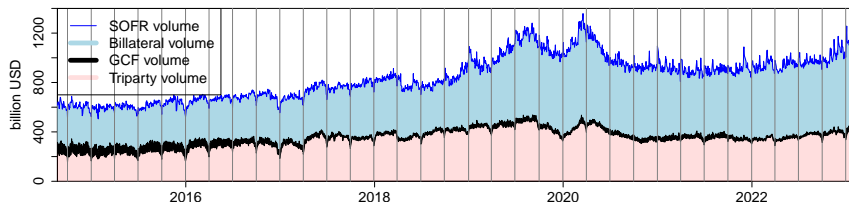


SOFR Over Time



What Makes SOFR Tick?

- ▶ Bilateral repo transactions (similar to $T3$)
- ▶ General collateral financing repos (similar to $T2$)
- ▶ Tri-party repos (similar to $T1$)
 - ▶ MMFs have access to reverse repo facility (RRP)



Fluctuations in SOFR volume mainly due to $T3$ transactions

What Makes SOFR Tick?

Table: Daily Changes in SOFR (excluding QEnds).

	Full Sample		2014 to 2019		2020 to 2023	
	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	-0.00** (-2.36)	-0.00** (-2.52)	-0.00*** (-2.81)	-0.00*** (-2.93)	-0.00 (-0.99)	-0.00 (-1.13)
$\Delta \log(\text{Debt})$	4.12*** (5.80)	4.42*** (6.07)	9.46*** (10.21)	9.92*** (10.79)	1.73** (2.51)	1.91*** (2.61)
$\Delta \log(\text{Transact. Volume})$	0.08*** (3.49)		0.09** (2.48)		0.06** (2.10)	
$\Delta \log\left(\frac{TPV}{SOFRV}\right)$		-0.13*** (-2.81)		-0.17*** (-2.85)		-0.06 (-0.96)
Adj. R ²	0.06	0.05	0.13	0.12	0.02	0.02
Num. obs.	1, 778	1, 778	1, 136	1, 136	642	642

- ▶ *Debt*: US Treasury debt outstanding
- ▶ *Transact. Volume*: All SOFR transactions (variance driven by *T3*)
- ▶ $\frac{TPV}{SOFRV}$: Fraction of *T1* in SOFR

The “Libor Funeral”

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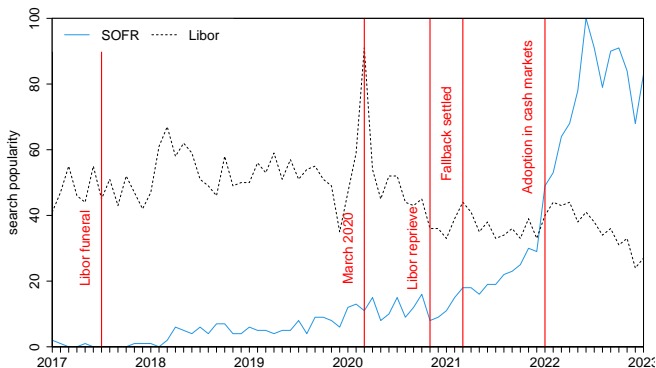
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Central Questions:

1. What rates replace Libor?
 - ▶ Klingler and Syrstad (2021): Life after Libor
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Who Cares About SOFR?

Google trends for Libor and SOFR (restricted US financial)



Libor reprieve: US Libor continued until July 2023

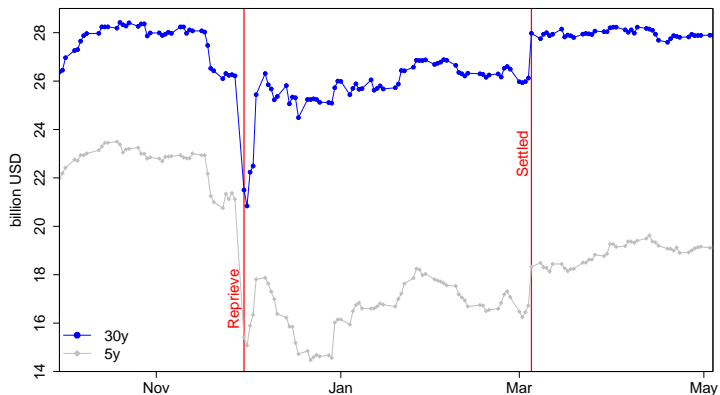
Fallback settled: Replace Libor with term SOFR plus spread

- ▶ Spread based on historic median

Speculation on the End of Libor

Libor tenor basis spreads:

- ▶ Exchange 1-month and 6-month Libor payments
- ▶ Speculate on Libor fallback



Speculation on the End of Libor

	Tenor basis			Euro-dollar futures	
	1m/6m (1)	1m/3m (2)	3m/6m (3)	All (4)	<i>TTM</i> < 48m (5)
$\mathbb{1}(\text{Relieve}) \times \mathbb{1}(\text{Affected})$	-4.60*** (-22.92)	-2.70*** (-11.77)	-1.90*** (-17.55)	-2.20*** (-7.74)	-3.29*** (-11.00)
$\mathbb{1}(\text{Settled}) \times \mathbb{1}(\text{Affected})$	1.49*** (13.01)	1.58*** (8.70)	-0.09 (-0.86)	0.96*** (3.82)	0.68** (2.64)
$\mathbb{1}(\text{Relieve})$	-0.37*** (-9.73)	-0.16*** (-6.08)	-0.21 (-1.89)	-0.50*** (-3.28)	-0.50*** (-3.25)
$\mathbb{1}(\text{Settled})$	0.02 (0.16)	-0.77*** (-4.73)	0.80*** (6.66)	0.13 (0.85)	0.13 (0.84)
YQ FE	Yes	Yes	Yes	Yes	Yes
Type FE	Yes	Yes	Yes	Yes	Yes
Adj. R ²	0.48	0.32	0.27	0.01	0.06
Num. obs.	1, 077	1, 078	1, 090	2, 716	2, 114

Tenor swaps:

- ▶ Affected: (2y,) 3y, 5y, 10y, 30y
- ▶ Not affected: 6m, 12m (and 2y)

Affected Instruments

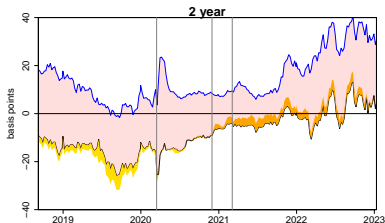
Instruments	Impact
<i>Derivatives markets</i>	
Interest rate swaps	Swap spreads
Currency derivatives & swaps	CIP deviations
STIRs	Converted to SOFR
FRA's	Discontinued
Swaptions	Non-linear effects
 <i>Cash products</i>	
Loans	Issue with loan supply?
FRNs	Issue with lending supply?

Effect of Swap Spreads

$$\text{Swap spread} = \text{Swap rate} - \text{Treasury yield}$$

Traditionally three components (e.g., Feldhütter and Lando, 2008)

1. Convenience premium of Treasuries
More recently “inconvenience premium” (Klingler and Sundaresan, 2022)
2. Risk premium in Libor (not present in SOFR!)
3. Swap-specific (supply-demand) factor

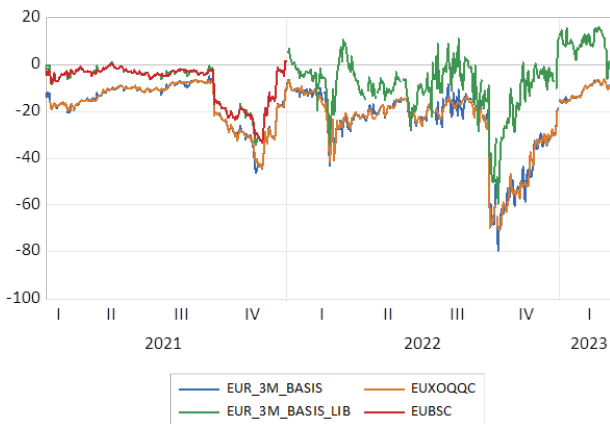


Note: OIS based on effective fed funds rate (“old rate”)

CIP Deviations

Covered interest rate parity:

$$CIP = (fx^{a/b} - fwd^{a/b}) + (r^a - r^b)$$



- ▶ EUBSC: 3m CIP deviation using Libor
- ▶ EUXOQQC: 3m CIP deviation using ESTR and SOFR

Affected Instruments

Instruments	Impact
<i>Derivatives markets</i>	
Interest rate swaps	Swap spreads
Currency derivatives & swaps	CIP deviations
STIRs	Converted to SOFR
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 - ▶ Klingler and Syrstad (2022): The SOFR Discount

Central Issue:

Disconnect Between Alternative Rates and Banks' Funding Costs

The invention of Libor in the 1970s (Vaughan and Finch, 2017):

Banks perform liquidity & maturity transformation

- ▶ Borrow short-term
- ▶ Give long-term loans and charge:

Fixed credit spread + variable interest rate

- ▶ Variable interest rate should reflect banks' funding costs

Issue: *SOFR does not reflect banks' funding costs*

Central Issue:

Disconnect Between Alternative Rates and Banks' Funding Costs

- ▶ Jermann (2019): “Is SOFR Better than Libor?”
- ▶ Jermann (2021): Interest income during GFC
- ▶ Berndt, Duffie, and Zhu (2020): Construct a “credit add on”
Great overview: “Pick a rate: Pitfalls and prizes in the post-Libor world” (Risk.net)
- ▶ Cooperman, Duffie, Luck, Wang, and Yang (2022):
SOFR-benchmark poses issue for credit lines

Big question: *Does benchmark rate affect borrowing costs?*

- ▶ Klingler and Syrstad (2022) study this question

Converting Libor FRN to SOFR FRN using swaps

	0	t_1	...	t_N
<i>Cashflow from investing in Libor FRN</i>				
	-1	$YS^L + \ell_0$	...	$1 + YS^L + \ell_{N-1}$
<i>Pay fixed in SOFR swap</i>				
Pay fixed rate S_0	0	$-S_0$	...	$-S_0$
Receive average SOFR	0	δ_1	...	δ_N
<i>Receive fixed in Libor swap</i>				
Receive fixed rate L_0	0	L_0	...	L_0
Pay Libor	0	$-\ell_0$	...	$-\ell_{N-1}$
<i>Adjusted FRN cash flow</i>	-1	$YS^L + (L_0 - S_0) + \delta_1$	...	$1 + YS^L + (L_0 - S_0) + \delta_N$
<i>Cashflow from investing in SOFR FRN</i>				
	-1	$YS^S + \delta_1$	...	$1 + YS^S + \delta_N$

Conclusion: $YS^S = YS^L + (L_0 - S_0)$

Adjustment procedure

To ensure exact cashflow matching, we proceed in three steps:

1. Determine payment schedule of FRN
2. Bootstrap Libor, Libor swap, and SOFR OIS
 - ▶ Forward rate for each FRN payment
 - ▶ Discount rate for each FRN payment (based on OIS)
3. Construct basis term:

$$b(0, N) = \frac{\sum_{i=1}^N n_i d(0, t_i) \times (f_i^{Libor} - f_i^{SOFR})}{\sum_{i=1}^N n_i d(0, t_i)}$$

- ▶ n_i is daycount between payments
- ▶ f_i is short-hand for $f(0, t_{i-1}, t_i)$

Subtract this basis from SOFR FRNs

FRN Data

Collect FRN data from Bloomberg's fixed income database

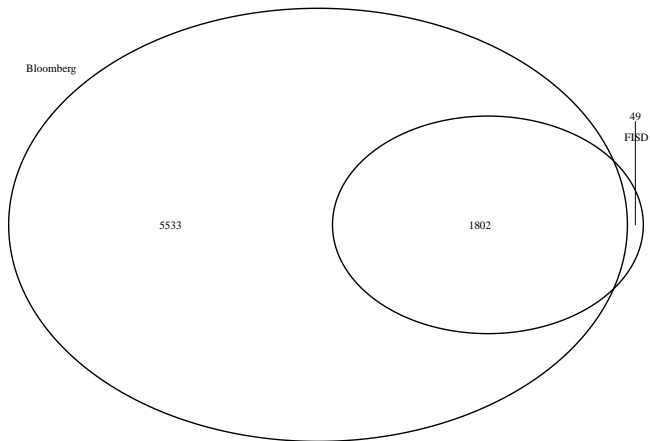
- ▶ Non-exotic FRNs that pay at maturity
- ▶ Benchmark rate: 1m Libor, 3m Libor, SOFR (daycount: ACT/360)
- ▶ Maturity between 6m and 11 years
- ▶ Focus on July 2018 to December 2021
- ▶ Only include issuers with at least one Libor and one SOFR issuance

Key variable: Yield spread (YS) at issuance

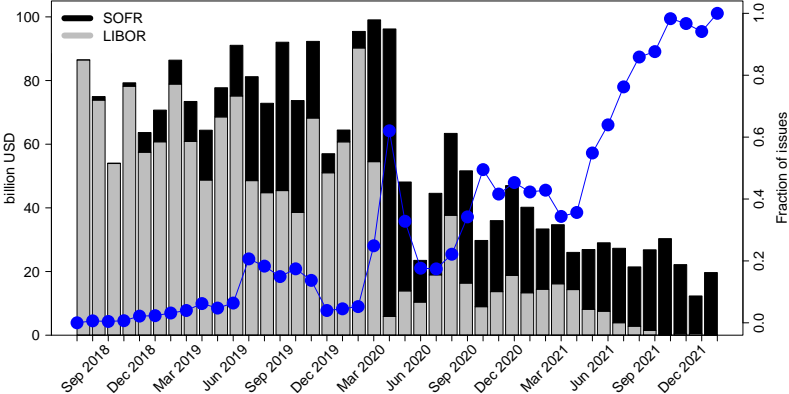
- ▶ YS for SOFR FRNs: Subtract maturity-matched Libor-SOFR spread
- ▶ YS for 1m FRNs: Subtract maturity-matched Libor tenor basis

Repeat collection in Mergent Fixed Income Securities Database (FISD)

FISD is Small Subsample



FRN Issuance Volumes



The SOFR Discount in FRNs

$$YS_{t,j}^{Adj} = \alpha_{SOFR} + \alpha_{1m} + \sum_{t \in YMs} (\beta_{a,t} \log(a)_{t,j} + \beta_{ttm,t} ttm_{t,j} + \beta_{ttm^2,t} ttm^2_{t,j} + FE_i \times FE_t) + \varepsilon_{t,j}$$

	All			Bloomberg	FISD
	(1)	(2)	(3)	(4)	(5)
<i>SOFR</i>	-8.31*** (-5.32)	-6.23*** (-4.81)	-4.73*** (-3.42)	-4.57*** (-3.26)	-3.54** (-2.29)
<i>1m</i>	-4.00*** (-3.84)	-1.42*** (-4.63)	-0.71* (-1.77)	-0.77* (-1.81)	0.73** (2.20)
Add. contr.	<i>ttm</i> <i>ttm</i> ² log(<i>a</i>)	<i>ttm</i> <i>ttm</i> ² log(<i>a</i>)	<i>ttm</i> × <i>ym</i> <i>ttm</i> ² × <i>ym</i> log(<i>a</i>) × <i>ym</i>	<i>ttm</i> × <i>ym</i> <i>ttm</i> ² × <i>ym</i> log(<i>a</i>) × <i>ym</i>	<i>ttm</i> × <i>ym</i> <i>ttm</i> ² × <i>ym</i> log(<i>a</i>) × <i>ym</i>
Rating × YM FEs	✓	-	-	-	-
Issuer × YM FEs	-	✓	✓	✓	✓
Adj. R ²	0.80	0.93	0.95	0.95	0.95
Num. obs.	7,384	7,384	7,384	7,335	1,851

Potential Explanations?

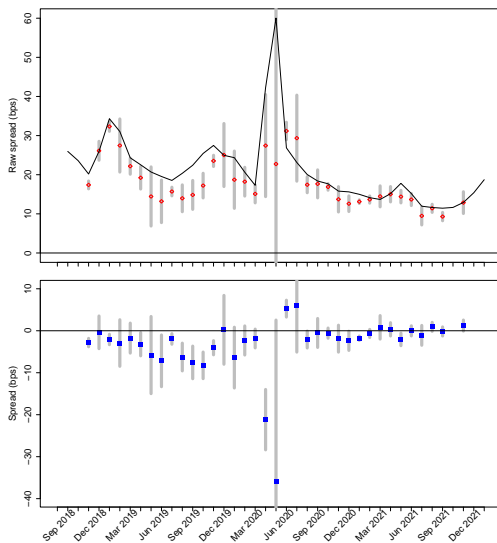
- ▶ *Legal risk*: Discount stronger for FRNs maturing after Libor cessation
- ▶ *Novelty discount*: Discount diminishes over time
- ▶ *Safe asset discount*: Discount stronger for safer issuers
- ▶ *Investor attention*: Discount less pronounced for yield-sensitive investors
- ▶ Alternative spread adjustments

Potential Explanations?

	(1)	(2)	(3)	(4)	(5)	(6)
<i>SOFR</i>	-4.23*** (-3.21)	-4.43*** (-3.15)	-2.97** (-2.13)	-4.58*** (-2.96)	-4.79*** (-3.12)	-3.55*** (-4.12)
<i>SOFR</i> × <i>Mature Post</i>	-5.21** (-2.15)					
<i>SOFR</i> × $\mathbb{1}_{t > Apr\ 2020}$		2.09 (1.39)				
<i>SOFR</i> × $\mathbb{1}_{t \in [03/20, 04/20]}$		-21.36*** (-3.04)				
<i>SOFR</i> × $\mathbb{1}_{US\ GSE}$			-4.02** (-2.50)			
<i>SOFR</i> × $\mathbb{1}_{MMF\ inv.}$				-0.24 (-0.28)		
$\mathbb{1}_{MMF\ inv.}$			-0.40 (-1.13)	-0.33 (-0.87)		
D.1m	-0.67 (-1.61)	-0.92** (-2.14)	-0.86** (-2.12)	-0.73* (-1.81)	-0.67* (-1.73)	-0.85** (-2.03)
Adj. R ²	0.95	0.95	0.95	0.95	0.94	0.95
Num. obs.	7,384	7,384	7,384	7,384	7,384	7,384

- ▶ Column (5): Use cubic spline interpolation (without cf matching)
- ▶ Column (6): Use futures instead of swaps up to 2y

The SOFR Discount Over Time



Based on monthly matrix pricing approach

Loan Data

- ▶ Use the new version of LPC Dealscan (launched in August 2021)
- ▶ Focus on term loans and credit lines
- ▶ Exploit: Loan amendments

Key variables:

- ▶ Indicator: Amendment changes benchmark rate from Libor to SOFR
- ▶ All-in spread drawn (AISD)

Less obvious how to adjust this spread:

- ▶ Use raw AISD
- ▶ Subtract maturity-matched 1m Libor-SOFR spread

The SOFR Discount in Syndicated Loans

	Δ Adjusted AISD		Δ Raw AISD	
	(1)	(2)	(3)	(4)
1 (<i>Benchmark Chg.</i>)	-16.30*** (-5.40)	-19.26*** (-2.91)	-1.84 (-0.61)	-4.71 (-0.71)
$\Delta \#$ <i>Lenders</i>	0.39 (1.43)	-0.16 (-0.36)	0.37 (1.36)	-0.19 (-0.44)
$\Delta \log$ (<i>Amt</i>)	-2.76 (-0.96)	0.52 (0.07)	-2.62 (-0.90)	0.89 (0.13)
Δ <i>TTM</i>	-2.61*** (-3.09)	-2.05 (-1.13)	-3.29*** (-3.86)	-2.62 (-1.43)
$\Delta \mathbb{1}$ (<i>Covenants</i>)	5.20 (1.36)	8.68 (0.99)	5.52 (1.47)	8.99 (1.04)
Loan Type FE	Yes	-	Yes	-
YM FE	Yes	Yes	Yes	Yes
Age FE	Yes	Yes	Yes	Yes
Tranche FE	-	Yes	-	Yes
Adj. R^2	0.07	0.33	0.05	0.25
Num. obs.	4, 311	4, 311	4, 311	4, 311

Conclusion

Benchmark transition from Libor to alternative reference rates:

- ▶ Affects notional worth trillions of dollars (derivatives & debt)
- ▶ Poses several interesting questions for research

Three key take-aways:

1. Alternative rates (especially SOFR):
 - (a) Affected by micro-structure effects
 - (b) Not representative of banks' marginal funding costs
2. No evidence that borrowers pay a premium for SOFR borrowing
 - ▶ The SOFR discount
3. Transition did not go entirely smooth



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