Management Science

Publication details, including instructions for authors and subscription information:
http://pubsonline.informs.org

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To cite this article:
Jeong-Bon Kim; , Chong Wang; , Feng (Harry) Wu (2025) LIBOR Discontinuation and the Cost of Bank Loans. Management Science 71(5):4413-4432. https://doi.org/10.1287/mnsc.2022.03133

https://pubsonline.informs.org/journal/mnsc

MANAGEMENT SCIENCE
Vol. 71, No. 5, May 2025, pp. 4413–4432
ISSN 0025-1909 (print), ISSN 1526-5501 (online)

LIBOR Discontinuation and the Cost of Bank Loans

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Received: April 21, 2021
Revised: October 7, 2022; December 20, 2023
Accepted: January 30, 2024
Published Online in Articles in Advance: September 12, 2024

https://doi.org/10.1287/mnsc.2022.03133

Abstract. With the London Interbank Offered Rate (LIBOR) being replaced by risk-free rate (RFR)-based alternative reference rates, the fundamental differences between the two benchmarking frameworks impose significant risks on banks. Exploiting the Financial Conduct Authority (FCA)'s announcement of the phase-out of LIBOR, we conduct a difference-in-differences analysis based on banks' reliance on LIBOR and show that LIBOR discontinuation entails higher interest rate spread of bank loans. The result implies that banks tend to compensate for the LIBOR-to-RFR risks by passing on the transition costs to borrowers. This effect is attenuated if multiple benchmarks are already in use, for relationship lending, and among banks operating in a competitive environment. We further find that LIBOR discontinuation leads to more collateral and covenant requirements in loan terms. After the FCA announcement, banks are inclined to switch away from LIBOR dependence by referencing alternative rates.

History: Accepted by Victoria Ivashina, finance.
Funding: J.-B. Kim acknowledges support from City University of Hong Kong; C. Wang acknowledges support from Hong Kong Polytechnic University and the National Natural Science Foundation of China [No. 71932003]; F. (H.) Wu acknowledges support from the General Research Fund [No. 13500820] from the University Grants Committee of Hong Kong.
Supplemental Material: The data files are available at https://doi.org/10.1287/mnsc.2022.03133.

Keywords: LIBOR discontinuation • cost of bank loans • alternative reference rates • loan contracting

1. Introduction

The London Interbank Offered Rate (LIBOR) was arguably "the most important number" in the financial world (Klingler and Syrstad 2021, p. 783) that served as the major benchmark rate in various financial markets throughout the globe. As of mid-2018, LIBOR underpinned approximately USD 400 trillion of notional value of contracts (Schrimpf and Sushko 2019). However, LIBOR suffered from a lack of actual transactions and liquid markets on which a viable benchmark rate should be grounded, which led to LIBOR largely based on the judgments of a few panel banks. This fundamental flaw made LIBOR susceptible to manipulation, which impelled regulatory bodies to replace it with alternative, transaction-based reference rates, mostly overnight risk-free rates (RFRs), to provide robust and credible benchmarking. Nevertheless, LIBOR- and RFR-based benchmarking schemes are fundamentally different in that RFRs do not involve credit and term premia as captured by LIBOR. It is therefore imperative to understand the consequences of the LIBOR–RFR difference for financial market participants. In this paper, we address an important consequence—bank lending; in particular, we examine whether any systematic change in the cost of bank loans occurs in response to the transition away from LIBOR.

Given the prevalent use of LIBOR in money and derivatives markets, banks are especially vulnerable to LIBOR demise because they hold the greatest portion of financial instruments tied to LIBOR.[1] Banks also actively trade in derivatives benchmarked to LIBOR, through which they manage interest rate risk exposure in the loan business. The transition from LIBOR to RFRs presents challenges to banks due to the absence of a reference rate to capture lenders' marginal funding cost, which exposes banks to significant basis risk in asset-liability management. The cessation of LIBOR also delivers a substantial shock to the derivatives market, thus the related risk may not be adequately hedged. For legacy loan contracts linked to LIBOR, setting RFR-based fallback provisions imposes additional risk. Banks may pass on these risks, at least partially, to borrowers. In line with this notion, some banks have explicitly warned their clients of possible changes in the price of loan products or contracts due to impending benchmark reforms.[2]

To address this issue, we exploit a milestone event on July 27, 2017 when the U.K.'s Financial Conduct Authority (FCA), the regulating body of LIBOR, announced that LIBOR would cease to exist by the end of 2021. The FCA announcement is deemed the "LIBOR funeral," which "caused a transition toward transaction-based overnight rates (that are) virtually risk-free" (Klingler and Syrstad 2021, p. 783). The discontinuation of LIBOR is considered one of the most significant events in global financial history (Amamiya 2019). Against this backdrop, we conduct an empirical analysis of LIBOR discontinuation's impact on the cost of bank loans. In a difference-in-differences (DiD) setting, we compare the changes in loan spreads during the five-year period surrounding the FCA's announcement of LIBOR phase-out between banks with higher and lower vulnerabilities to LIBOR discontinuation. We identify the level of vulnerability using banks' status of referencing LIBOR in loan issuance *prior to* the FCA announcement, which is unlikely to be endogenously influenced by LIBOR's later cessation. We verify that when measured this way, greater LIBOR dependence indicates greater exposure to risk from the LIBOR-to-RFR transition, as disclosed in banks' 10-K filings. We then show that loans issued by treatment banks exposed to larger LIBOR transition risk exhibit a significant increase in interest rate spread subsequent to the FCA announcement. This evidence supports the view that borrowers share (at least part of) the risks from LIBOR discontinuation.

To ensure that our main result is not due to influences of omitted variables, we control for borrower (firm), lender (bank), and time (year) fixed effects in our baseline DiD design and validate its parallel trend assumption. We conduct falsification tests by randomizing treatment and control groups and adopting a pseudo FCA announcement date, and find that the spread-increasing effect disappears in these cases. We use propensity score matching (PSM) to further control for observable firm, bank, and macroeconomic characteristics, and we employ an impact threshold of a confounding variable (ITCV) method to show that unobservable variables do not drive the loan spread effect. In addition, we find no evidence that borrowing firms' fundamental risk changes with LIBOR transition, suggesting that the documented loan spread increase is unlikely to be driven by heightened borrower risk.

In further analyses, we examine factors that could mitigate banks' willingness and ability to pass on LIBOR transition costs to borrowers. We find that the impact of LIBOR discontinuation on loan spread is weaker if multiple rates are already used in bank funding, if banks are engaged in relationship lending, and if banks operate in a more competitive loan market. These findings are consistent with the cushioning effect of a multireference scheme, the reduced information asymmetry and renegotiation cost in relationship lending facilitating LIBOR transition, and the market competition pressure hindering the risk-transferring mechanism, respectively. We also find that after the FCA announcement of LIBOR discontinuation, LIBOR-referenced loans are more likely to include collateral and covenant requirements. These results imply that banks proactively secure collateral protection for potential losses (especially during distress when RFRs are likely pressured downward) and enhance the flexibility of loan renegotiation during the process of a benchmark rate change. Lastly, we examine banks' switch from LIBOR to alternative non-LIBOR benchmarking and find that they increase the use of non-LIBOR reference rates in loan contracts following the announcement of the LIBOR phase-out. We interpret this outcome as banks' understanding the evolution of the system to replace LIBOR as an outlet for addressing the problem of LIBOR transition. However, the trend of switching to alternative rates had not yet altered the status of LIBOR as the dominating reference rate during our sample period, which echoes the significant difference between LIBOR and RFRs as well as the challenges in the benchmark rate transition.

Our study contributes to the literature by providing early evidence on the economic consequences of LIBOR discontinuation, an aspect relatively underexplored by academics. Existing studies of LIBOR problems focus on scandals in the interbank money markets (Abrantes-Metz et al. 2012, Fouquau and Spieser 2015, Gandhi et al. 2019), LIBOR reform (Hou and Skeie 2014, Duffie and Stein 2015, Perkins and Mortby 2015, Coulter et al. 2018), and alternative rates (Kuo et al. 2018; Duffie and Dworczak 2021; Klingler and Syrstad 2021, 2023). Our paper produces initial evidence on the real impacts of LIBOR cessation on banks' operations, particularly their lending behaviors. The evidence highlights an important implication of the fundamental difference between LIBOR and the replacing RFR-based benchmark rates. More generally, our study leverages the rare research opportunity provided by LIBOR discontinuation to explore the role of benchmarking in economic transactions, as proposed in various economic theories (e.g., Duffie et al. 2017, Muto 2017, Aquilina and Pirrone 2020, Cooperman et al. 2023).

Our study differs from prior literature examining how the level or uncertainty of a government-oriented benchmark rate affects the behaviors of economic agents (see, e.g., Bernanke and Gertler 1995, Jimenez et al. 2012, Ippolito et al. 2018). The phase-out of a primary benchmarking scheme is likely to have implications that are distinctive from the adjustment of the rate for an existing benchmark. The FCA's decision to discontinue LIBOR is largely exogenous to individual banks, which is unlike previous monetary policy changes in which setting the reference rate is a response to prevailing cyclical conditions and thus endogenous to economic behaviors (English et al. 2018). Our study thus helps better identify

a benchmark reform as the source of observed changes in economic activities.

We also contribute new insights about the determinants of contract design and loan costs by examining lending behaviors from an angle not confined to the conventional framework (e.g., credit risk exposure). The novelty of our analysis hinges on the fact that the disappearance of a widely accepted benchmark is characterized by significant frictions and risks. The changes in interest rate spread and other loan terms in our setting are thus driven by a fresh concern regarding the erosion of the basis for loan contracting that has not been studied in prior research.

The findings in our study should provide benchmark regulators with useful information for the shift from LIBOR to alternative rates. To the extent that LIBOR is replaced to improve the benchmarking system that reduces transaction costs and facilitates risk management, the increase in loan spread during LIBOR transition is an unintended outcome of the reform. Our results call for regulators to acknowledge the importance of securing a resilient, workable new benchmarking system that has minimal burdens on market participants if the LIBOR transition to RFRs warps normal bank loan pricing behaviors. Switching from LIBOR to replacement benchmarks is likely to move banking behaviors to a new equilibrium, and our study can serve as an inference for and path to that equilibrium.

2. Institutional Background and Conceptual Discussion

2.1. Institutional Background

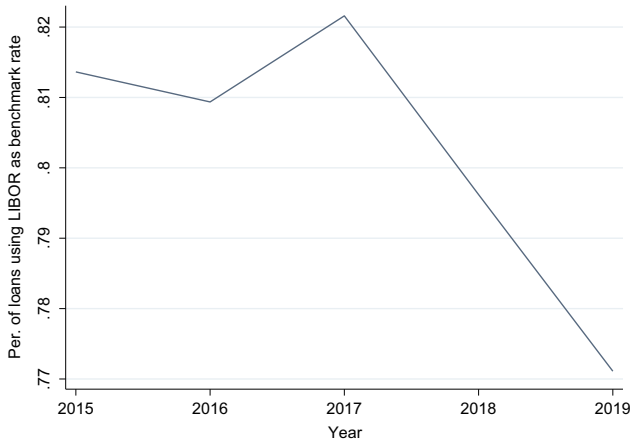
LIBOR represented the cost of unsecured, interbank wholesale funds for various terms in various currencies. Its determination was based on quote submissions from a limited number of, normally large, panel banks (refer to Hou and Skeie (2014) for details of LIBOR formation mechanisms). Yet, in recent years, there was an increasing trend that very few of these submissions were underpinned by actual transactions, especially for longer tenors (Schrimpf and Sushko 2019). In this case, as detailed in Appendix A, LIBOR formation depended largely on the judgments of panel banks, making it subject to potential bias and even manipulation.

Recognizing the diminished reliability of LIBOR and the fundamental deficiency in its construction, global efforts, led by the Financial Stability Board (FSB) and the International Organization of Securities Commissions (IOSCO), were taken to address LIBOR's shortcomings (IOSCO 2013, FSB 2014). These LIBOR reforms had a shared principle to base benchmarks on observable, actual transactions rather than estimates. In response, the Alternative Reference Rates Committee (ARRC) in the U.S. was convened by the Federal Reserve and the New York Fed in 2014 to identify alternative reference rates for USD LIBOR. In 2017, the ARRC recommended a new rate as proposed by the New York Fed—the Secured Overnight Financing Rate (SOFR), which measures the cost of overnight borrowings through repo transactions collateralized with U.S. Treasury securities. Parallel work was taken in other jurisdictions and various benchmark supervising bodies endorsed different alternative reference rates (FSB 2018).[3] These alternative rates are all overnight rates; that is, they do not feature term risk, interest is paid in arrears (i.e., rates are backward-looking), and many are backed by secured transactions with no credit risk. The initial intension of these efforts was to improve LIBOR's integrity and sustainability with the expectation that it could continue to be used, alongside the program to identify alternatives (Held 2019).

While the global efforts were underway, Andrew Bailey, Chief Executive of the FCA, which supervises the production of LIBOR, announced in July 2017 that after 2021, the FCA would no longer compel banks to furnish data to support the determination of LIBOR. The FCA's decision to discontinue LIBOR changed the nature of the ongoing LIBOR reforms because, as indicated above, at the outset of those reforms, the idea was not to completely abandon LIBOR. Bailey's announcement thus presented an unexpected shock to LIBOR users.[4] Following the FCA's setting of the secular deadline for ending LIBOR, replacing it became a priority for benchmark working groups around the globe. For example, the ARRC was reconstituted in 2018 with an expanded membership to help address the increased risk that LIBOR may no longer be usable beyond 2021 and initiate paced transition from LIBOR to SOFR, and the New York Fed has started to publish SOFR since April of 2018.[5]

Nevertheless, there was significant market inertia in transitioning to the proposed LIBOR replacement rates. According to the estimate by The Economist (2018), by September 27, 2018 (i.e., more than one year after the FCA announced LIBOR discontinuation), only seven or eight bonds had been sold using SOFR as reference price. The Economist (2019, p. 74) states that "LIBOR-based contracts are still being entered into at a rate little reduced from 2017" and "Little has been done to move existing contracts, of which many last beyond 2021, off LIBOR." Our evidence presented in Figure 1 (as detailed later) echoes this claim. Meanwhile, regulators and various working groups proposed fallback provisions for legacy or newly initiated LIBOR-referenced loans.[6] In fact, with alternative rates being slow to gain sufficient liquidity or wide acceptance, ICE Benchmark Administration Limited (IBA), the authorized and regulated administrator of LIBOR, extended the deadline of the cessation of USD LIBOR to the end of June 2023 in order to support the transition of existing products, whereas the GBP, CHF, JPY, and EURO LIBOR settings ceased on December 31, 2021.[7]

Figure 1. (Color online) Percentage of Loans Using LIBOR as the Benchmark Rate



Note. This figure plots the percentage of loans referencing LIBOR for each year during the sample period of 2015–2019.

2.2. LIBOR Discontinuation and the Cost of Bank Loans: Conceptual Discussion

The transition from LIBOR to RFRs is not a simple substitution. There are inherent differences between the two benchmarking schemes, which poses significant challenges to market participants, especially banks. Initially introduced to facilitate bank lending (Reuters 2012, Duffie and Stein 2015), LIBOR had for decades served as a key benchmark interest rate for unsecured borrowing and been hardwired into many financial processes, including derivatives trading and risk management. Given LIBOR's ubiquitous acceptance among a broad range of financial instruments and commercial agreements, transition away from LIBOR affects both cash and derivatives markets, which in turn blurs banks' vision of risk prospective and hinders their management of relevant risk.

One important challenge of LIBOR replacement is potential basis risk in banks' asset-liability management. In the U.S. loan market, the proposed new benchmark (i.e., SOFR) cannot adequately capture banks' marginal term lending cost because it is overnight, secured, and backward-looking. These features are especially problematic for bank lending because they conflict with LIBOR as a base rate that reflects lenders' funding cost as determined by credit and term liquidity risks and that is known at loan initiation. Without these mechanisms, a margin squeeze arises in which the interest rate earned on bank assets benchmarked to the new RFR diverges from banks' cost of refinancing, especially during financial distress when the RFR tends to decrease due to flight-to-safety; in contrast, banks' funding cost tends to increase due to enhanced credit risk. The margin squeeze may be further exacerbated if banks engage in maturity transformation in which they fund illiquid, long-tenor assets with instruments of shorter duration. In this case, the refinancing cost is subject to uncertainty in the benchmark transition as market-wide compensations for credit and term liquidity risks evolve (Schrimpf and Sushko 2019). Moreover, transaction-based overnight rates like SOFR are associated with significantly larger volatility than LIBOR, adding another layer of uncertainty (Klingler and Syrstad 2021).[8]

Basis risk also arises from the lack of appropriate instruments in the derivatives market to hedge the interest rate risk in the loan market. For instance, for a long-term fixed rate loan that is funded by short-term variable rate funding instruments, a bank could utilize interest rate swaps as a fixed rate payer and thus receive floating rate payments determined by a benchmark reflecting the bank's funding cost. In the LIBOR era, such swaps were readily available. With RFRs replacing LIBOR, the swaps are based on risk-free overnight rates that cannot capture the bank's funding cost in the term loan, leading to reduced efficiency in interest rate risk hedging and giving rise to diverged asset and liability exposures.[9]

The global practices of transitioning LIBOR to various RFRs entail the risk of market fragmentation. For bank lending and risk hedging, LIBOR provided an all-in-one solution within a harmonized framework that facilitated market liquidity and reduced transaction costs. The enforced benchmark transitions away from LIBOR generate a plethora of alternative reference rates as each financial system chooses its own rate for its own currency, thereby eliminating the network effect of LIBOR. One manifestation is the possible decoupling of reference rates in loan and derivatives markets. Consider an international banking scenario in which banks entering into financial derivatives contracts for the purpose of hedging risks embedded in their cash products. If the hedged derivatives and cash products transition to different alternative reference rates associated with different currencies, it induces risk related to benchmark mismatches and thus insufficient hedging. In this case, new instruments need to emerge in order to manage the ensuing basis risk, which creates extra complexity. Relatedly, with fragmented markets referencing to different alternative benchmark rates, synchronization is required to address the emerging frictions for efficient asset-liability management and hedging. Yet, synchronizing activities are difficult to conduct when different products are administered by different institutions and transitions are conducted in different jurisdictions.

The risk imposed on banks by LIBOR discontinuation also manifests in legacy contracts. Transitioning from LIBOR to a replacement rate requires amending the terms and conditions of loans, which normally is associated with significant costs due to the difference between LIBOR and fallback RFRs. Failure to reach unanimous agreement regarding compensation to either contracting party can lead to costly litigation. Such a challenge is especially prominent in loan market because, unlike

derivative contracts for which a standardized process can be coordinated by institutes like the International Swaps and Derivatives Association (ISDA), handling legacy positions in bank loans requires negotiations on a contract-by-contract basis (EFRAG 2019, ARRC 2021). Moreover, the expenses incurred by the underlying legal documentation for all relevant transactions are unlikely to be trivial. Existing and upcoming regulatory requirements also may present compliance costs and other obstacles. In addition, banks can face risks generated from accounting and tax shocks because benchmark replacement could induce fair value changes and impact hedge accounting and interaffiliate accounting structures, which may result in unexpected losses.[10]

All of these risks are unique to LIBOR transition and inherent in the LIBOR–RFR differences, and thus difficult to manage. Economic theories suggest that banks should not assume risks that are not diversifiable unless they have special advantages in managing them (Diamond 1984, 1991). To achieve this, banks in the LIBOR era usually resorted to the derivatives markets to hedge unsystematic interest rate risk using LIBOR-pegged products, thanks to the prevalence of LIBOR benchmarking in financial derivatives. With the demise of LIBOR, however, this traditional hedging mechanism tends not to function properly, for reasons previously mentioned. These challenges make it imperative for banks to seek other ways to manage the risks from the LIBOR-to-RFR transition. In particular, banks may exert their influence on loan pricing and increase interest charges to compensate for their risk exposure induced by the cessation of LIBOR. Jermann (2019) shows that, as loans indexed to LIBOR can offer insurance to lenders against adverse funding shock but loans indexed to SOFR do not, banks may need to change their risk management practices that increase funding spreads. Schrimpf and Sushko (2019) argue that if LIBOR transition-induced risks cannot be adequately hedged, it is likely they will be passed on to clients. More generally, Deshmukh et al. (1983) posit that financial intermediaries minimize their risk exposure by setting stricter credit standards. This rationale is consistent with the theoretical prediction that, for banks exposed to interest rate risk, optimal contracting involves borrowing firms bearing the risk of the loan (Arvan and Brueckner 1986, Froot and Stein 1998, Edelstein and Urosevic 2003, Vickery 2008). Therefore, we propose that interest rate spreads in loan contracts increase in response to LIBOR discontinuation, and this adjustment serves as a de facto risk transfer mechanism by which banks pass on (at least part of) their LIBOR transition costs to borrowers.

3. Empirical Framework

3.1. Baseline Research Design

We exploit the mid-2017 FCA announcement of the LIBOR phase-out as our setting for a quasi-natural experiment in which to apply a DiD framework. We construct the treatment (control) group by including banks that more (less) extensively rely on LIBOR *prior to* the FCA announcement. Specifically, we compute the ratio of the number of loans referencing LIBOR to a bank's total number of loans. We calculate such a LIBOR ratio for each bank based on all of its loans issued before the announcement of LIBOR discontinuation, and define an indicator variable, *Treatment*, that equals one if the LIBOR ratio exceeds the sample median, and zero otherwise. We construct another indicator variable, *Post*, to differentiate the periods before and after the FCA announcement in July 2017. Specifically, we consider January 2015 through June 2017 to be the preannouncement period and code *Post* to be zero; *Post* is set to one for the postannouncement period from July 2017 through December 2019.

The main dependent variable is loan spread, that is, the difference between loan interest rate and a benchmark rate. Because our methodology is to compare loan spreads before and after the FCA announcement, it is important to ensure that the loan spreads are based on the *same* benchmark. In choosing this common benchmark, we note the extensive adoption of LIBOR as the reference rate in bank lending, even after the FCA announced its forthcoming discontinuation. As shown in Figure 1, more than 80% of loans reference LIBOR in 2015–2017, the years before the announcement of LIBOR phase-out. Even in the postannouncement period of 2018–2019, the proportion of LIBOR-referenced loans still exceeds 77%, reflecting that banks continue to use LIBOR as the benchmark rate despite its planned replacement by RFRs. This result underscores the fundamental differences between LIBOR and alternative reference rates and banks' difficulties in replacing LIBOR with other benchmarks (The Economist 2018, 2019; Reuters 2019). It also implies that banks face a nonnegligible risk in the inevitable demise of LIBOR because the transition risk is mostly embedded in transactions that still reference LIBOR, for which the associated costs during the reference changing process are especially burdensome. Our analysis thus focuses on LIBOR-referenced loans.[11]

Specifically, we estimate the following standard DiD model:

$$\begin{aligned} &\textit{Loan Spread} \\ &= \beta_0 + \beta_1 \textit{Treatment} \times \textit{Post} + \beta_2 \textit{Loan Size} \\ &\quad + \beta_3 \textit{Loan Maturity} + \beta_4 \textit{Firm Size} + \beta_5 \textit{Leverage} \\ &\quad + \beta_6 \textit{ROA} + \beta_7 \textit{Operational Risk} + \beta_8 \textit{Tangibility} \\ &\quad + \beta_9 \textit{Z-score} + \beta_{10} \textit{Markt-to-Book Ratio} + \beta_{11} \textit{Bank Size} \\ &\quad + \beta_{12} \textit{Bank ROA} + \beta_{13} \textit{Bank Capital Ratio} \\ &\quad + \beta_{14} \textit{Bank PPE} + \beta_{15} \textit{Bank Derivatives Exposure} \\ &\quad + \beta_{16} \textit{Credit Spread} + \beta_{17} \textit{Term Spread} \\ &\quad + \textit{Firm Fixed Effects} + \textit{Bank Fixed Effects} \\ &\quad + \textit{Year Fixed Effects} + \varepsilon. \end{aligned} \tag{1}$$

The dependent variable *Loan Spread* refers to the natural logarithmic value of loan spread, measured by the amount that borrowers pay in basis points (bps) over LIBOR for each dollar drawn down. Among the independent variables, the key variable of interest is the interaction between *Treatment* and *Post*, which captures the DiD effect in conjunction with the bank and year fixed effects. Specifically, bank fixed effects differentiate treatment banks from control banks; they "fully control for fixed differences between (them)" (Bertrand and Mullainathan 2003, p. 1056) and account for the time-invariant bank characteristics that may influence loan pricing. Year fixed effects identify the periods prior and subsequent to the FCA announcement and control for sample-wide time-series dynamics. As such, a positive β_1 can be interpreted in such a way that treatment banks, relative to control banks, impose larger loan spreads on borrowers in the period following the LIBOR phase-out announcement.

Following prior bank loan contracting studies (e.g., Graham et al. 2008, Kim et al. 2011, Valta 2012, Huang et al. 2018), we control for loan-level characteristics including loan amount and maturity, borrower-level characteristics (firm size, leverage, profitability, operational risk, tangibility, credit risk, and market-to-book ratio), lender-level characteristics (bank size, bank profitability, bank capital ratio, bank property, plant and equipment, and banks' exposure in the derivatives market), as well as macroeconomic level term spread and credit spread. Appendix B details the definition and construction for each variable. We also control for firm fixed effects to address potential differences in unobservable static borrower characteristics, along with the bank and year fixed effects. Our baseline model thus includes comprehensive controls over borrowers, lenders, and dynamic trends.

3.2. Descriptive Statistics

We select a sample period of 2015–2019, which covers 2.5 years before and 2.5 years after the FCA announced the phase-out of LIBOR in July 2017. From this sample period, we identify 819 loan observations (including term loans and credit lines) in DealScan. For firm- and bank-level variables, we obtain relevant information from Compustat;[12] for macroeconomic level variables, we obtain data from the Federal Reserve Bank of St. Louis. Table 1 shows that the mean and median of *Loan Spread* are 5.242 and 5.165, respectively, corresponding to the nonlogarithm values of 189.048 and 175.038 bps, respectively, for loan spreads over LIBOR. *Treatment* has a mean value of 0.422, indicating that about 42.2% of the loans in our sample are issued by banks that rely heavily on LIBOR as the benchmark rate in the period before the FCA announcement of LIBOR phase-out. *Post* carries a mean value of 0.414 (i.e., 41.4% of loans are initiated after the FCA announcement).

Table 1. Descriptive Statistics of Baseline Regression Variables

Variable	Mean	Std. dev.	P25	Median	P75
Loan Spread	5.242	0.500	4.868	5.165	5.521
Treatment	0.422	0.494	0.000	0.000	1.000
Post	0.414	0.493	0.000	0.000	1.000
Loan Size	0.233	0.242	0.072	0.140	0.332
Loan Maturity	3.842	0.526	3.761	4.094	4.094
Firm Size	7.305	1.623	6.118	7.149	8.272
Leverage	0.454	0.194	0.325	0.433	0.579
ROA	0.118	0.090	0.076	0.113	0.156
Operational Risk	0.041	0.034	0.019	0.033	0.050
Tangibility	0.603	0.473	0.223	0.481	0.911
Z-score	3.749	3.557	1.718	2.876	4.582
Market-to-Book Ratio	3.114	3.770	1.415	2.169	3.702
Bank Size	14.089	0.932	14.183	14.542	14.671
Bank ROA	0.921	0.372	0.741	0.993	1.195
Bank Capital Ratio	10.362	2.183	10.092	10.854	11.569
Bank PPE	0.693	0.380	0.442	0.569	0.927
Bank Derivatives Exposure	0.209	1.167	0.004	0.028	0.068
Credit Spread	0.966	0.213	0.830	0.910	1.050
Term Spread	0.839	0.477	0.410	0.880	1.270

Notes. This table reports full-sample descriptive statistics of testing variables in the baseline model of Equation (1). Details about the variable definitions are provided in Appendix B.

3.3. Validation of the DiD Setting

Although we use the quasi-natural experiment arising from the FCA's announcement of the phase-out of LIBOR, our interest is not in the announcement event per se. Instead, we use the announcement event as an exogenous shock to banks' exposure to benchmark transition risk. In Table 2, we confirm that treatment banks (i.e., those that rely more heavily on LIBOR in the preannouncement period) are indeed exposed to more risks related to the transition away from LIBOR. In so doing, we retrieve information about the relevant risks from banks' 10-K reports filed with the Securities and Exchange Commission (SEC). Starting in 2005, the SEC mandates all publicly listed firms to disclose "information about the most significant risks" (SEC 2021, np) in Item 1A of their 10-K filings, which has been shown to effectively reveal firms' material risk exposures in various areas, especially when the risks are clearly specified (Campbell et al. 2014, Hope et al. 2016, Chiu et al. 2018, Chiu et al. 2019). With the LIBOR transition risk being specific and salient, we expect it to be disclosed in 10-Ks filed by banks after they become aware of the planned phase-out of LIBOR. Appendix C presents selected relevant excerpts from Item 1A in the 10-K reports of several banks.

After extracting risk information regarding LIBOR transition from 10-K disclosures via a textual analysis algorithm (see Appendix D for details), we define a variable *Transition Risk* that represents the counts of LIBOR

Table 2. Validation of the Identification for Bank Exposure to LIBOR Transition Risk

Dependent variable	(1) *Transition risk*
Treatment × Post	3.194***
	(2.75)
Bank Size	6.388**
	(2.44)
Bank Growth	−0.119***
	(−4.83)
Bank Market-to-Book Ratio	−2.145*
	(−1.87)
Bank ROA	−2.082
	(−0.84)
Bank Capital Ratio	0.398
	(1.09)
Bank/year fixed effects	Included
Number of observations	275
R^2	0.769

Notes. This table reports the regression estimation results for Equation (2). The dependent variable is *Transition Risk*. The key independent variable is *Treatment × Post*. Bank characteristic variables are controlled as in Equation (2). Details about the variable definitions are provided in Appendix B. The regression coefficients on independent variables are reported, followed by the *t*-values (in the parentheses) based on standard errors clustered by bank. The intercept is not reported for brevity.

*, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

risk-related keywords as identified by the algorithm (i.e., those in Table A.1). We regress this variable on *Treatment × Post* and several bank characteristic variables (with definitions detailed in Appendix B), controlling for bank and year fixed effects, as in Equation (2) below:[13]

$$\begin{aligned} &Transition\ Risk \\ &= \gamma_0 + \gamma_1 Treatment \times Post + \gamma_2 Bank\ Size \\ &\quad + \gamma_3 Bank\ Growth + \gamma_4 Bank\ Market\text{-}to\text{-}Book\ Ratio \\ &\quad + \gamma_5 Bank\ ROA + \gamma_6 Bank\ Capital\ Ratio \\ &\quad + Bank\ Fixed\ Effects + Year\ Fixed\ Effects + \varepsilon. \end{aligned} \tag{2}$$

As shown in Table 2, the regression generates a significantly positive coefficient of 3.194 (*t*-statistic = 2.75) on *Treatment×Post*, suggesting that banks tend to disclose LIBOR transition risk as a material risk factor more frequently in the post period after the FCA announcement than in the pre period, and this effect manifests more significantly among treatment banks than control banks. This result confirms that banks with heavier reliance on LIBOR as the reference rate have higher exposure to LIBOR transition risk, thus verifying the validity of our DiD scheme.

4. Influence of LIBOR Discontinuation on the Cost of Bank Loans

4.1. Baseline Result

Table 3 reports the result of our estimates from the baseline model in Equation (1), which shows that

Table 3. The Impact of LIBOR Discontinuation on the Cost of Bank Loans: Baseline Result

Dependent variable	(1) *Loan spread*
Treatment × Post	0.123***
	(2.72)
Loan Size	−0.129
	(−1.53)
Loan Maturity	0.077
	(1.44)
Firm Size	−0.103
	(−1.61)
Leverage	0.717***
	(3.35)
ROA	−1.411***
	(−2.89)
Operational Risk	−1.724
	(−1.53)
Tangibility	0.445***
	(3.13)
Z-score	0.022
	(1.59)
Market-to-Book Ratio	−0.002
	(−0.40)
Bank Size	0.062
	(0.11)
Bank ROA	−0.269***
	(−3.97)
Bank Capital Ratio	0.150**
	(2.29)
Bank PPE	−0.522***
	(−4.28)
Bank Derivatives Exposure	0.068
	(0.70)
Credit Spread	0.090
	(1.36)
Term Spread	−0.002
	(−0.15)
Firm/bank/year fixed effects	Included
Number of observations	819
R^2	0.776

Notes. This table reports the estimation result for the baseline model of Equation (1). The dependent variable is *Loan Spread*. The key independent variable is the interaction term between the treatment bank indicator *Treatment* and the indicator *Post* for the period of July 2017 through December 2019, representing the period after the FCA announcement of LIBOR phase-out. Loan-, firm-, bank-, and macroeconomic level control variables, as well as firm, bank, year fixed effects are controlled as in Equation (1). Details about the variable definitions are provided in Appendix B. The regression coefficients on independent variables are reported, followed by the *t*-values (in the parentheses) based on standard errors clustered by firm and bank. The intercept is not reported for brevity.

*, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Treatment×Post has a positive coefficient of 0.123 and a *t*-statistic of 2.72. The coefficient indicates an average change of 23.25 bps in loan spread (= 189.048 × 0.123).[14] This evidence suggests that banks with a greater exposure to LIBOR transition risk apply larger spreads over LIBOR in their loans initiated after the FCA announcement than banks with a lower exposure to LIBOR risk. In other words, facing heightened risks from LIBOR

discontinuation, banks adjust their lending behaviors by charging a higher interest rate in excess of LIBOR. The finding supports the view that lenders pass on the LIBOR transition risks to borrowing firms, or at least share with them, which serves as a strategy to manage risk in an environment lacking effective traditional ways to do so.

4.2. Robustness Checks

We conduct several tests to confirm the robustness of our baseline result and to show that the documented loan spread effect is due to LIBOR discontinuation.

4.2.1. Parallel Trend Test. We first validate the parallel trend assumption underlying our DiD design. To this end, we introduce a set of indicator variables to refer to different subperiods surrounding the FCA announcement of LIBOR phase-out in July 2017. Specifically, we indicate the second half (July through December) of 2017 as $T+0$, which represents the first subperiod following the FCA announcement. According to this base period, we define $T-1$ as the first half of 2017 that precedes the FCA announcement, that is, $T-1$ equals one for observations belonging to the subperiod of January through June of 2017, and zero otherwise. Similarly, we use $T-2$ and $T-3$ to indicate the second and first half of 2016, respectively, which are in the preannouncement period. We define $T+1^+$ to refer to the subperiod in the postannouncement era beyond 2017 (i.e., $T+1^+$ is coded as one for loans issued in 2018 and 2019, and zero otherwise). We interact *Treatment* with these subperiod indicators and use the resulting interaction terms to replace *Treatment*×*Post* in Equation (1), in which the unspecified year (i.e., 2015) serves as the reference subperiod.

Panel A of Table 4 shows that, relative to the reference year, which is part of the preannouncement period, other preannouncement subperiods represented by $T-3$, $T-2$, and $T-1$ do not exhibit any difference in the treatment–control gap because the coefficients on their interaction terms with *Treatment* are insignificant. This finding confirms that the parallel trend between the treatment and control groups holds prior to the FCA announcement event. Following the event, the coefficients on *Treatment*×$T+0$ and *Treatment*×$T+1^+$ are both significantly positive, suggesting that the difference in loan costs between treatment and control banks starts to show a significant deviation from the pre-event trend, consistent with the LIBOR transition risk exposure being different between them.

4.2.2. Falsification Tests. To buttress our conclusion that LIBOR discontinuation entails the increasing effect of loan costs, we conduct two falsification tests to show that if we interrupt the proper identifications of

Table 4. The Impact of LIBOR Discontinuation on the Cost of Bank Loans: Robustness Tests

Panel A. Parallel trend test

Dependent variable	(1) *Loan Spread*
Treatment × $T-3$	0.172
	(1.33)
Treatment × $T-2$	0.062
	(0.62)
Treatment × $T-1$	0.145
	(1.47)
Treatment × $T+0$	0.349**
	(2.57)
Treatment × $T+1^+$	0.168**
	(2.03)
Controls	Included
Firm/bank/year fixed effects	Included
Number of observations	819
R^2	0.811

Panel B. Falsification test: Pseudo *Treatment*

Dependent variable	(1) *Loan Spread*
Pseudo-Treatment × *Post*	0.004
	(0.12)
Controls	Included
Firm/bank/year fixed effects	Included
Number of observations	819
R^2	0.774

Panel C. Falsification test: Pseudo *Post*

Dependent variable	(1) *Loan Spread*
Treatment × *Pseudo-Post*	0.178
	(0.87)
Controls	Included
Firm/bank/year fixed effects	Included
Number of observations	479
R^2	0.558

Panel D. Propensity score matching (PSM) analysis

Dependent variable	(1) *Loan Spread*
Treatment × *Post*	0.376***
	(2.86)
Controls	Included
Firm/bank/year fixed effects	Included
Number of observations	310
R^2	0.283

Panel E. Analysis of impact threshold of a confounding variable (ITCV)

	Loan Spread	
	(1) *ITCV*	(2) *Impact*
Treatment × *Post*	0.029	
Loan Size		0.001
Loan Maturity		0.005

Table 4. (Continued)

Panel E. Analysis of impact threshold of a confounding variable (ITCV)

	Loan Spread	
	(1) *ITCV*	(2) *Impact*
Firm Size		0.021
Leverage		0.014
ROA		−0.008
Operational Risk		0.012
Tangibility		−0.001
Z-score		−0.003
Market-to-Book Ratio		−0.003
Bank Size		0.025
Bank ROA		−0.030
Bank Capital Ratio		−0.008
Bank PPE		0.014
Bank Derivatives Exposure		−0.006
Credit Spread		0.011
Term Spread		−0.048

Panel F. Analysis of firm fundamental risk

Dependent variable	(1) *ROA*	(2) *Operational Risk*	(3) *Leverage*
Treatment × *Post*	−0.014	−0.001	0.003
	(−1.28)	(−0.33)	(0.16)
Controls	Included	Included	Included
Firm/bank/year fixed effects	Included	Included	Included
Number of observations	819	819	819
R^2	0.904	0.928	0.946

Notes. In Panel A, the dependent variable is *Loan Spread*, the key independent variables are the interaction terms between the treatment bank indicator *Treatment* and the indicators for the various subperiods before and after the FCA announcement of LIBOR discontinuation. In Panel B, the dependent variable is *Loan Spread*, the key independent variable is the interaction term between a randomly determined indicator variable *Pseudo-Treatment* and the indicator variable *Post*. In Panel C, the dependent variable is *Loan Spread*, the key independent variable is the interaction term between *Treatment* and an indicator variable *Pseudo-Post* that equals one if the loan is initiated between April 2016 and June 2017 and zero if the loan is initiated between January 2015 and March 2016. In Panel D, the baseline regression of Equation (1) is re-estimated using a PSM-screened sample. Panel E reports the results of an analysis of ITCV. In Panel F, firm fundamental risk measures are regressed on the independent variables of Equation (1). In all panels but Panel E, loan-, firm-, bank-, and macroeconomic level control variables, collectively denoted by *Controls*, as well as firm, bank, year fixed effects are controlled as in Equation (1). Details about the variable definitions are provided in Appendix B. The regression coefficients on the key independent variables are reported, followed by the *t*-values (in the parentheses) based on standard errors clustered by firm and bank. The intercept is not reported for brevity.

*, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

treatment and control groups or of the time of FCA announcement, our baseline result ceases to hold.

For the first falsification test, we randomly assign a bank to the treatment group or control group, regardless of its LIBOR transition risk exposure. We define a variable *Pseudo-Treatment*, which indicates the randomized treatment banks, to replace *Treatment* in the baseline regression of Equation (1). We repeat this randomization exercise 1,000 times and report the average coefficient on *Pseudo-Treatment*×*Post* for the re-estimated regressions in Panel B of Table 4. The result shows no significant DiD effect because the coefficient on *Pseudo-Treatment*×*Post* has a small average value (0.004) and a small *t*-statistic (0.12). This finding suggests that along with the disappearance of correct identification of the LIBOR discontinuation shock on banks, the spread-increasing effect also disappears, thus confirming LIBOR discontinuation as a cause for the loan spread change documented in our baseline result.

In the second falsification test, we select a pseudo FCA announcement time that differs from the actual announcement time of July 2017. This incorrect identification of the shock event for LIBOR discontinuation allows us to examine the DiD effect surrounding this pseudo-event. Specifically, we consider the beginning of April 2016, which represents the middle of the pre-announcement period, as the pseudo-event time and define a variable, *Pseudo-Post*, to equal one for the period from April 2016 to June 2017 and zero for the period from January 2015 to March 2016. To exclude the effect from the actual FCA announcement, we do not consider the period beyond June 2017. As such, in the current falsification setting, our DiD analysis (after replacing *Post* with *Pseudo-Post* in Equation (1)) compares the loan spread changes from the pseudo-pre to pseudo-post periods for treatment banks relative to control banks. As neither of the two types of banks are subject to any actual LIBOR discontinuation shock, we expect no result on loan costs. The result reported in Panel C of Table 4 is consistent with our expectation, showing an insignificant coefficient on *Treatment* × *Pseudo-Post*. This result confirms the loan spread effect of LIBOR discontinuation announced in 2017 and helps alleviate the concern that some other macroeconomic events (e.g., the downturn in the energy market in 2015–2016, which could affect loan costs) confound our finding of LIBOR discontinuation changing loan spread.

4.2.3. PSM Analysis. To address the concern that potential differences in observable (loan, firm, bank, and macroeconomic) characteristics between treatment and control groups may confound our baseline result, we conduct a PSM analysis. As the first step, we estimate a Probit model in which the indicator variable *Treatment* is regressed on the same set of control variables included in Equation (1) and industry and year fixed effects. We then use the estimated coefficients to compute the propensity scores for all observations in the treatment and control groups, and match each treatment loan with a control loan using the nearest neighbor propensity score. In the second step, we re-estimate

Equation (1) using this PSM-screened sample, and report the result in Panel D of Table 4. We find that the coefficient on *Treatment*×*Post* remains positive and highly significant, suggesting that our main result is robust to the intergroup differences in observable characteristics of control variables.

4.2.4. ITCV Analysis. To further address potential confounding effects arising from unobserved (and thus omitted) variables, we adopt the approach in Frank (2000) to assess how large the confounding effect (if any) would have to be to overturn the result documented in our baseline regression. Specifically, we calculate the ITCV for the LIBOR discontinuation DiD variable (i.e., *Treatment*×*Post*), which is defined as the lowest product of two correlations that makes the coefficient on *Treatment*×*Post* statistically insignificant: the partial correlation between the dependent variable (loan spread) and a confounding variable and the partial correlation between the independent variable (*Treatment*×*Post*) and the confounding variable. A high value of ITCV indicates that the result from the tested regression is robust to omitted variable concerns.

Column (1) in Panel E, Table 4 shows that the ITCV for *Treatment*×*Post* is 0.029, implying that each correlation (between the LIBOR discontinuation variable and the unobserved confounding variable and between loan spread and the confounding variable) needs to be about 0.170 (= $\sqrt{0.029}$) for our baseline result to be overturned. We follow prior literature (Larcker and Rusticus 2010, Badertscher et al. 2013) and develop a benchmark to assess the level of this ITCV by computing the impact of the inclusion of each control variable on the coefficient on *Treatment*×*Post*.[15] The impact is defined as the product of the partial correlations between the control variable and *Treatment*×*Post* and between the control variable and loan spread. As shown in column (2), *Bank Size* has the largest impact with a value of 0.025, which is lower than the ITCV for *Treatment*×*Post*. This implies that the confounding variable would need to have a substantially larger impact on loan spread than *Bank Size* (and any other control variable) to make the coefficient on *Treatment*×*Post* insignificant. The potential confounding factor problems are thus unlikely to overturn the observed impact of LIBOR discontinuation on loan spread.

4.2.5. Analysis of the Fundamental Risk of Borrowing Firms. As the last robustness check, we address the concern that the increasing effect on loan spread during LIBOR phase-out could be due to increased fundamental risk of borrowing firms. After all, borrower risk is a major consideration of loan pricing for lending banks. To conclude that that LIBOR discontinuation brings about the loan spread effect, it is thus important to show that the effect is not simply due to the change in borrowers' risk level, or more specifically, that the increase in spread is *not* associated with a corresponding increase in borrower fundamental risk. To show this, we regress proxies for borrower fundamental risk on *Treatment*×*Post* and other independent variables in Equation (1), along with firm, bank, and year fixed effects. We use three fundamental risk proxies with detailed definitions provided in Appendix B: *ROA* or return on assets, *Operational Risk* represented by the volatility of cash flow from operations, and *Leverage* measured by the ratio of the sum of current and long-term debts to total assets.[16] The results reported in Panel F of Table 4 show that none of the regressions with these firm fundamental risk measures as the dependent variables has a significant coefficient on *Treatment*×*Post*, suggesting no difference in borrower risk change between the treatment and control banks during LIBOR transition. Therefore, we find no evidence that our baseline loan spread effect is driven by banks' exposure to different borrower fundamental risks.

5. Further Analyses

5.1. Cross-Sectional Variation in the Impact of LIBOR Discontinuation on the Cost of Bank Loan

The mechanism by which lending banks pass on LIBOR transition costs to borrowers hinges on banks' level of exposure to benchmark risk (which incentivizes them to shift the risk), the cost of contract renegotiation, and the market environment that facilitates or limits banks' cost transfer. In this subsection, we delve into these issues by focusing on the factors that are deemed to affect the cross-sectional variation in the effect of LIBOR discontinuation on loan spread.

5.1.1. Level of Exposure to LIBOR Transition Risk: Use of Other Benchmarks in Addition to LIBOR. The abandonment of LIBOR is more likely to disturb bank funding if LIBOR is the only benchmark rate used in loan referencing. Jerome Powell, the Chair of the U.S. Federal Reserve, claimed in 2017 that "The big … risk here is that you have contracts citing a rate that goes out of publication … and you don't have a backup" (Powell 2017, np). Nevertheless, some LIBOR-referenced loans specify extra benchmark rates in addition to LIBOR. For example, DealScan identifies non-LIBOR reference rates, which, in our sample, include the prime rate, Canadian prime, rate of bankers' acceptance, Euribor, and Fed funds rate. Although these additional benchmarks may not be suitable replacements for LIBOR, their existence is likely to provide a cushion for the collapse of LIBOR, especially in the absence of a viable replacement rate. During the LIBOR phase-out, these benchmarks could serve as temporary backups to sustain bank credits without an abrupt disruption. In this way, the shock (and

thus risk) from LIBOR discontinuation tends to be less severe for loans with multiple benchmarks. Accordingly, the impact of LIBOR discontinuation on loan costs should be attenuated for these loans.

We address this issue by identifying firms' bank loans referencing multiple benchmarks including LIBOR. We re-estimate our baseline regression of Equation (1) among this subsample of loans and compare the result with that from the subsample including firms' loans benchmarked exclusively to LIBOR (on which the abandonment of LIBOR triggers a more acute shock). As shown in Panel A of Table 5, in the multibenchmarking subsample, the coefficient on *Treatment*×*Post* is −0.077, which is insignificant (*t*-statistic = −1.23). In contrast, the result in the LIBOR-only subsample is stronger: *Treatment*×*Post* has a significantly positive coefficient of 0.167 (*t*-statistic = 3.72). The *p*-value in the bottom row shows that the difference in *Treatment*×*Post* coefficient between the two subsamples is statistically significant. These results support the argument that the availability of

Table 5. Cross-Sectional Variation in the Impact of LIBOR Discontinuation on Bank Loan Costs

Panel A. Use of other benchmarks in addition to LIBOR

	Using multiple rates as benchmarks	Using LIBOR as the only benchmark
	(1)	(2)
Dependent variable	*Loan Spread*	*Loan Spread*
Treatment×*Post*	−0.077	0.167***
	(−1.22)	(3.72)
Controls	Included	Included
Firm/bank/year fixed effects	Included	Included
Number of observations	243	576
R^2	0.941	0.724
p-value for the difference in the coefficient on *Treatment*×*Post*		0.00***

Panel B. Lending relationship

	With prior lending relationship	Without prior lending relationship
	(1)	(2)
Dependent variable	*Loan Spread*	*Loan Spread*
Treatment×*Post*	0.172**	0.678**
	(2.37)	(2.09)
Controls	Included	Included
Firm/bank/year fixed effects	Included	Included
Number of observations	415	404
R^2	0.853	0.465
p-value for the difference in the coefficient on *Treatment*×*Post*		0.00***

Panel C. Loan market competition

	High loan market competition	Low loan market competition
	(1)	(2)
Dependent variable	*Loan Spread*	*Loan Spread*
Treatment×*Post*	0.101***	1.683***
	(2.36)	(22.73)
Controls	Included	Included
Firm/bank/year fixed effects	Included	Included
Number of observations	618	201
R^2	0.796	0.292
p-value for the difference in the coefficient on *Treatment*×*Post*		0.00***

Notes. In Panels A, B, and C, the baseline model of Equation (1) is estimated in subsamples partitioned by the use of non-LIBOR benchmarks, prior lending relationship, and the level of loan market competition, respectively. The dependent variable is *Loan Spread*. The key independent variable is the interaction term between the treatment bank indicator *Treatment* and the indicator *Post* for the period of July 2017 through December 2019. Loan-, firm-, bank-, and macroeconomic level control variables, collectively denoted by *Controls*, as well as firm, bank, year fixed effects are controlled as in Equation (1). Details about the variable definitions are provided in Appendix B. The regression coefficients on the key DiD independent variables are reported, followed by the *t*-values (in the parentheses) based on standard errors clustered by firm and bank. The bottom row of each panel presents the *p*-value for the difference test of the coefficients on *Treatment*×*Post* between the two subsamples. The intercept is not reported for brevity.

*, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

additional reference rates plays a nontrivial role in absorbing the shock from LIBOR cessation.

5.1.2. The Moderating Role of Prior Lending Relationship. Loan contracting reflects a process of negotiation between lenders and borrowers; on top of conventional frictions, changing the benchmark rate adds another layer of complexity that increases the cost of contracting, especially when the uncertainty surrounding the cessation of LIBOR is entangled with information risk regarding the creditworthiness of borrowers. The literature has shown that information risk in loan contracting is lower for relationship lending in which the contract parties have developed continuous contacts (Elyasiani and Goldberg 2004). Less information asymmetry between lenders and borrowers tends to facilitate mutual agreement and ease the negotiation burden for both parties, thus alleviating the overall cost of loan contracting (Fama 1985). Stiglitz and Greenwald (2003, p. 26) contend that "Interest rates are not like conventional prices and the capital market is not like an auction market," and Stenfors and Lindo (2018, p. 187) posit that "Prices and benchmarks related to borrowing and lending are ultimately dependent on trust and relationships." These arguments are especially applicable to our study because a smooth LIBOR transition hinges greatly on whether the agreement on replacement rate, spread adjustment, value transfer, and other fallback arrangements can be reached without excessive costs. Such an agreement is likely to be more easily established between loan contracting parties with prior relationships as they better understand the implications of the benchmark-changing situation for both sides, and the contract revision terms are more likely to be acceptable to them. In addition, the exogenous uncertainty about LIBOR discontinuation leaves out a large number of unforeseen contingencies, making loan contracts especially incomplete a priori (Hart 1995). Therefore, future contract renegotiations could be triggered in response to ex post progress in the LIBOR transition. A reliable existing lending relationship tends to lubricate this process. In sum, for relationship lending, lower levels of information opaqueness and renegotiation cost help curb the overall costs associated with the transition away from LIBOR, which, in turn, reduces the likelihood that lending banks pass on these costs to borrowing firms.

We test the above conjecture in Panel B of Table 5, where we construct a subsample of loans with prior bank–borrower contracting experience at the time of loan initiation and one of loans without a previous lending relationship. The re-estimated baseline regression results show that, for relationship lending, the coefficient on *Treatment*×*Post* is 0.172. The DiD effect becomes greater in the subsample of loans without a prior contracting relationship with the coefficient on *Treatment*×*Post* being 0.678. As shown at the bottom of the panel, the difference in the coefficients on *Treatment*×*Post* across the two subsamples is statistically significant. These findings support our conjecture about the lower LIBOR transition costs for relationship lending and the consequent weaker cost transfer effect.

5.1.3. The Constraint of Loan Market Competition. Whether lenders can pass on LIBOR transition costs to borrowers and to what extent the costs are transferred depend on the bargaining power of banks. Borrowers may not accept higher funding costs imposed on them by lenders. We examine a condition that may affect banks' bargaining power—loan market competition. The rationale is that if fewer banks compete for lending business from a certain group of borrowers, then lenders have more bargaining power and thus are more likely to require larger loan spreads because they have less worry that doing so may drive the borrowers to (the limited number of) competing lenders. Previous banking studies (e.g., Rice and Strahan 2010) find that lack of competition in the loan markets forces firms to borrow at higher interest rates. Following similar logic, we expect that banks can more easily transfer LIBOR transition costs to borrowers in less competitive loan markets; stated another way, in these circumstances, borrowing firms must bear a greater proportion of the costs induced by LIBOR discontinuation, making bank loan spread more sensitive to the LIBOR cessation shock.

We find supporting evidence for the above argument in Panel C of Table 5, where we estimate the baseline regression, separately, for the two subsamples with low and high levels of loan market competition. We identify the level of loan market competition by the competitiveness among lenders in a borrower's industry. Lender competitiveness is measured by the Herfindahl–Hirschman Index (HHI) of the dollar amounts of loans issued by different banks, with a higher HHI indicating a less heterogeneous lending amount and thus weaker loan market competition. We consider loans granted to borrowers associated with the top-quartile HHIs as those issued in low-competition loan markets and consider others as from loan markets with a relatively higher level of competition. The results show that, in the high-competition subsample, *Treatment*×*Post* has a coefficient of 0.101, which is significantly smaller than the corresponding value (1.683) in the low-competition subsample, suggesting that weakened loan market competition enhances the ability of banks to pass on LIBOR transition costs to borrowers, consistent with our expectation.

5.2. Impacts of LIBOR Discontinuation on Non-Price Loan Terms

In addition to passing on LIBOR transition costs to borrowers via increasing interest rate spread (i.e., the price term of a loan contract), banks may also seek other ways to reduce the costs, which could be realized

through changing nonprice terms, in particular, loan collateralization and loan covenants. First, banks are likely to rely on collateral protection because they are exceptionally vulnerable to default losses given the extraordinary burdens engendered by LIBOR transition. This consideration is especially pertinent in the scenario of USD-dominated LIBOR being replaced by SOFR because overnight repo-based SOFR is collateralized and tends to be pressured downward by financial distress (Schrimpf and Sushko 2019). Benchmarks based on repo rates reflect the supply and demand conditions not only in funding markets but also in markets for securities that serve as collateral. In flight-to-safety episodes, collateral is in high demand, causing repo rates to fall, which happens at precisely the same time when the liquidity and credit premia demanded by lenders are likely to rise. Therefore, a secured alternative reference rate makes it particularly valuable for a bank to secure its loans with collateral.

Second, banks could also enhance the flexibility for amending loan contracts during the phase-out of LIBOR by setting more covenant provisions. LIBOR transition is an uncertain process complicated by the handling of LIBOR-referenced legacy or new contracts, which could require fallback benchmarking arrangements (and related value transfers) that have to be updated in accordance with the evolvement of the LIBOR replacement rates. On a theoretical basis, as mentioned in the preceding subsection, private loan contracts are inherently incomplete because of the lack of clear a priori information regarding payoffs to the contracting parties that are critical to loan values (e.g., Hart and Moore 1988). The incomplete nature of loan contracts manifests prominently during the transition process from LIBOR to alternative rates. It is thus essential to have flexible arrangements for contract renegotiations to accommodate the dynamics of benchmark changing. Prior studies (e.g., Denis and Wang 2014, Roberts 2015, Prilmeier 2017, Nikolaev 2018) show that covenants are an important channel for loan renegotiations. To the extent that covenants (and the induced contract renegotiations) provide banks with more options to flexibly make necessary adjustments to benchmarking condition, they help reduce the risk of value loss and cost of possible litigation. This rationale is also consistent with financial contracting theories emphasizing that renegotiation is an important mechanism for dynamically completing contracts (Roberts 2015).

Based on the above arguments, we conjecture that LIBOR discontinuation entails a higher likelihood of collateral requirement and more covenant provisions in loan contracts. To test this conjecture, we construct an indicator variable *Secured* as the measure of collateral requirement; specifically, *Secured* equals one if the loan involves collateral, and zero otherwise. We use the variable *Covenants* to measure the number of covenants (in natural logarithm) involved in the loan. We regress *Secured* and *Covenants* on the independent variables in Equation (1) as well as loan spread, after controlling for firm, bank, and year fixed effects. The estimation results are reported in Table 6. Column (1) shows that for the

Table 6. The Impacts of LIBOR Discontinuation on Non-Price Loan Terms

Dependent variable	(1) *Secured*	(2) *Covenants*
Treatment×Post	0.163***	0.194**
	(2.84)	(2.07)
Loan Size	0.343***	0.097
	(3.03)	(1.21)
Loan Maturity	0.037	−0.162
	(1.34)	(−1.55)
Loan Spread	−0.051	−0.232**
	(−1.48)	(−2.56)
Firm Size	−0.057	0.0410
	(−1.31)	(0.27)
Leverage	0.377**	0.549
	(2.41)	(1.25)
ROA	−0.898***	−2.200***
	(−2.71)	(−3.18)
Operational Risk	1.103	1.609
	(1.33)	(0.74)
Tangibility	−0.104	−0.256
	(−0.97)	(−1.01)
Z-score	0.012*	0.026*
	(1.89)	(1.78)
Market-to-Book Ratio	−0.000	0.0130
	(−0.07)	(1.18)
Bank Size	−0.852	−1.836**
	(−1.31)	(−2.11)
Bank ROA	−0.049	0.309
	(−0.48)	(1.67)
Bank Capital Ratio	−0.000	−0.300***
	(−0.00)	(−3.02)
Bank PPE	0.108	0.034
	(0.72)	(0.10)
Bank Derivatives Exposure	0.032	0.056*
	(1.37)	(1.97)
Credit Spread	0.235***	−0.060
	(2.69)	(−0.36)
Term Spread	0.217***	0.367*
	(2.98)	(1.90)
Firm/bank/year fixed effects	Included	Included
Number of observations	819	819
R^2	0.881	0.877

Notes. This table reports the estimation results for the effects of LIBOR discontinuation on the likelihood of loan collateralization and covenants. The dependent variables are the indicator variable *Secured* in column (1) and *Covenants* in column (2). The key independent variable is the interaction term between the treatment bank indicator *Treatment* and the indicator *Post* for the period of July 2017 through December 2019. Loan-, firm-, bank-, and macroeconomic level control variables in Equation (1), as well as loan spread and firm, bank, year fixed effects are controlled. Details about the variable definitions are provided in Appendix B. The regression coefficients on independent variables are reported, followed by the *t*-values (in the parentheses) based on standard errors clustered by firm and bank. The intercept is not reported for brevity.

*, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Secured regression, the coefficient on *Treatment*×*Post* is 0.163 with a *t*-statistic of 2.84, and column (2) reports that with *Covenants* as the dependent variable, *Treatment*×*Post* has a significantly positive coefficient of 0.194 (*t*-statistic = 2.07). These results suggest that, facing heightened risks from LIBOR discontinuation, banks adjust nonprice loan terms to secure a higher level of protection through collateral requirement and covenant restrictions.

5.3. LIBOR Discontinuation and the Shift in Benchmark Rate

Arguably, the ultimate solution to the LIBOR transition problem is to switch to a non-LIBOR benchmarking system. However, in the absence of a viable and widely accepted new reference rate in the market, abruptly abandoning LIBOR and benchmarking to an alternative rate cannot address all the challenges associated with LIBOR discontinuation. Although there is no future trouble in negotiating the benchmark-changing issue for a non-LIBOR-referenced loan, immediately switching to another benchmark may incur other costs, which include, but are not limited to, the selection of an alternative reference rate and associated spread adjustment, the loss of efficiency in risk hedging if the new rate is not as widely used as LIBOR, the loss of customers if they still prefer LIBOR-referenced loans due to similar concerns regarding the alternative benchmarking scheme, and the concurrent operational expenses.

On the one hand, an early switch to a new benchmark represents an early realization of possible LIBOR transition costs, which may not always be a wise decision, especially when the new benchmarking system is not fully mature. On the other hand, as the demise of LIBOR appears to be an inevitable event, indefinitely delaying the actions needed to replace LIBOR could exacerbate the problem, along with the lapse of time for adequate adaptation to a new regime. Akin to the concept of "benchmark tipping" (McCauley 2001), a new benchmarking operation is a self-fulfilling process: the more the market participants accept and use it, the more effectively it works as a reference rate, which further boosts its broader adoption. However, this process is also self-fulfilling in the opposite direction, with less acceptance in the market and less effective benchmarking function reinforcing each other. Overall, transitioning to an alternative benchmarking scheme is a dynamic process closely related to the evolution of a new reference rate. Ultimately, whether banks adopt a wait-and-see approach, a do-it-now strategy, or something in between is an empirical issue that merits further investigation.

To shed light on this issue, we investigate how banks shift benchmark rates as a result of the FCA announcement of LIBOR discontinuation. Specifically, we assess the adoption of non-LIBOR benchmarks in future bank loan contracting by the number of non-LIBOR reference rates (denoted by *Number of Non-LIBOR Rates*) used in the next new loan issuance as well as the proportion of these non-LIBOR rates (denoted by *Non-LIBOR Ratio*). We then conduct a regression analysis within our baseline DiD framework in Equation (1). Because non-LIBOR rates have already been used for some bank loans even before the LIBOR discontinuation shock, it is

Table 7. LIBOR Discontinuation and Benchmark Shift

Dependent variable	(1) *Number of Non-LIBOR Rates*	(2) *Non-LIBOR Ratio*
Treatment×*Post*	0.161***	0.073**
	(3.61)	(2.42)
Loan Size	0.093	0.013
	(0.98)	(0.25)
Loan Maturity	0.049	0.003
	(0.57)	(0.06)
Firm Size	−0.026	−0.004
	(−0.27)	(−0.07)
Leverage	−0.091	−0.141
	(−0.27)	(−0.65)
ROA	−0.420	−0.750
	(−0.39)	(−1.29)
Operational Risk	0.344	1.732*
	(0.25)	(1.71)
Tangibility	0.102	0.027
	(1.39)	(0.20)
Z-score	0.029**	0.011
	(2.58)	(1.11)
Market-to-Book Ratio	0.000	0.004
	(0.03)	(0.74)
Bank Size	−1.431*	0.881
	(−1.77)	(1.41)
Bank ROA	0.220*	0.117
	(1.79)	(1.42)
Bank Capital Ratio	−0.166**	0.041
	(−2.45)	(0.70)
Bank PPE	0.491**	0.180
	(2.30)	(1.20)
Bank Derivatives Exposure	−0.009	−0.052*
	(−0.20)	(−1.80)
Credit Spread	0.088	−0.047
	(0.50)	(−0.58)
Term Spread	0.381**	0.170
	(2.47)	(1.63)
Firm/bank/year fixed effects	Included	Included
Number of observations	735	735
R^2	0.751	0.681

Notes. This table reports the estimation results for the effect of LIBOR discontinuation on the benchmark shift from LIBOR to other non-LIBOR rates. The dependent variables are *Number of Non-LIBOR Rates* and *Non-LIBOR Ratio* in columns (1) and (2), respectively. The key independent variable is the interaction term between the treatment bank indicator *Treatment* and the indicator *Post* for the period of July 2017 through December 2019. Loan-, firm-, bank-, and macroeconomic level control variables, as well as firm, bank, year fixed effects are controlled as in Equation (1). Details about the variable definitions are provided in Appendix B. The regression coefficients on independent variables are reported, followed by the *t*-values (in the parentheses) based on standard errors clustered by firm and bank. The intercept is not reported for brevity.

*, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

meaningful to examine the change in the use of non-LIBOR rates from the pre- to the postannouncement period; our purpose here is to check whether there is any difference in this change over time between treatment banks with more exposure to LIBOR transition risk and control banks with less exposure.

In Table 7, columns (1) and (2) present the regression results using *Number of Non-LIBOR Rates* and *Non-LIBOR Ratio*, respectively, as the dependent variable. The coefficients on *Treatment*×*Post* are significantly positive in both columns, suggesting that the FCA announcement leads to an increase in the use of non-LIBOR rates in loan contracts from the pre- to the post-period. These results are consistent with the notion that banks relying more heavily on LIBOR as the reference rate in the preannouncement period, and thus facing a higher level of LIBOR transition risk, are pressured to act further to change benchmarks, as compared with banks with less reliance on LIBOR. In conjunction with the evidence from Figure 1 that most banks still make reference to LIBOR in their lending, the findings in Table 7 show a statistically significant trend in benchmark shifting, even if it has not overthrown the dominant status of LIBOR for at least two and a half years (as shown in our sample period) following the FCA announcement of LIBOR discontinuation.

6. Conclusion

The financial systems around the world have undergone a significant shift from LIBOR to various RFRs as the benchmark rate. The benchmark transition features a new set of overnight rates rooted in actual transactions. Nevertheless, for the bank loan market, the new benchmarking paradigm achieves its robustness and reliability at the expense of not capturing banks' marginal term funding costs, which poses significant challenges to banks' asset-liability management, liquidity generation, and hedging strategies. We examine whether banks transfer these LIBOR transition-induced risks to borrowing firms via charging a higher spread for bank loans and adjusting other nonprice terms of collateral and covenants.

We conduct our analysis in the context of the FCA's announcement of the gradual phase-out of LIBOR, which we show generates a significant enhancement in banks' concern about the risks associated with LIBOR-to-RFR transition. In a baseline DiD framework, we examine the changes in loan spread over a five-year period surrounding the FCA's announcement of LIBOR discontinuation. We compare such changes between treatment banks that depend more heavily on LIBOR as the benchmark in the preannouncement period to control banks with loans less benchmarked to LIBOR. We find that treatment banks exhibit a larger increase in loan spread from the pre- to the postannouncement period, compared with control banks. This effect is mitigated if non-LIBOR benchmarks are already used in bank funding, if banks are engaged in relationship lending, and if banks operate in more competitive lending markets. These findings suggest that the impact of LIBOR discontinuation hinges on the cushioning effect of backup reference rates, the cost of contract renegotiations, and the bargaining power of banks in loan contracting. We also find that treatment banks are more likely to require collateral and covenants in loan contracts, consistent with banks seeking the additional protection provided by these nonprice terms. The transition to alternative benchmark rates appears to be slow because most bank loans still use LIBOR as the reference rate; nevertheless, we observe more benchmark shifting behaviors among treatment banks than among control banks.

Our study provides initial evidence for the consequences on real economic behaviors from the transition away from LIBOR to alternative RFRs, "arguably one of the biggest challenges facing the financial industry" (Burgess 2020, p. 4). Our findings that the discontinuation of LIBOR induces significantly higher loan prices (and nonprice requirements) have important implications for the overall economy, given banks' extensive connections with firm operations via their lending activities. It is, of course, a matter for further study to investigate in detail the influences of LIBOR cessation on corporations in general (such as the cost of capital, capital structure, firm performance, and firm value); our current study is nevertheless suggestive in this regard. This study is also informative for benchmark-regulating bodies aiming at introducing a replacement rate that is subject to minimal business interruption or value redistribution.

Acknowledgments

The authors thank Victoria Ivashina (the Department Editor), an anonymous Associate Editor, three anonymous referees, Aurelius Aaron, Yangyang Chen, Ying Mao, Jeff Ng, Nancy Su, Rui Wang, Yue Zhang, and workshop participants at Hong Kong Polytechnic University and Lingnan University for valuable comments.

Appendix A. Pitfalls of LIBOR During and After the 2007–2009 Global Financial Crisis

Despite its prevalence as a reference rate, LIBOR was sparsely discussed and largely taken for granted (Bailey 2017) until the global financial crisis (GFC) of 2007–2009, during which panel banks submitted artificially biased rates to avoid signaling financial weakness and to profit from related derivatives positions (Abrantes-Metz et al. 2012, Duffie and Stein 2015). In 2012, several LIBOR panel banks were investigated by regulating authorities, resulting in significant penalties (Abrantes-Metz et al. 2012, Duffie and Stein 2015, Fouquau and Spieser 2015).

Table A.1. Keywords Relevant to LIBOR Transition Risk

administrator of LIBOR	LIBOR ceases	regulate(s) LIBOR
alternative benchmark rate	LIBOR cessation	reliability of LIBOR
alternative rate	LIBOR reform(s)	replace(s) LIBOR
alternative(s) to LIBOR	LIBOR submissions	replacement of LIBOR
away from LIBOR	LIBOR transition	replacing LIBOR
based on LIBOR	LIBOR will cease	sterling LIBOR
calculation of LIBOR	LIBOR-based	submit LIBOR
continuation of LIBOR	LIBOR-linked	support LIBOR
continuing LIBOR	Phase-out (or phaseout) of LIBOR	sustainability of LIBOR
determining LIBOR	phasing out LIBOR	tied to LIBOR
discontinuance in LIBOR	provide(s) LIBOR	transition from LIBOR
discontinuation of LIBOR	published LIBOR	use of LIBOR
future of LIBOR	reconsideration of LIBOR	version of LIBOR
LIBOR after 2021	referencing LIBOR	
LIBOR as a benchmark	reforms to LIBOR	

Note. This table lists the 43 keywords (phrases) relevant to LIBOR transition risk identified from Item 1A of 10-K.

Appendix B. Variable Definitions

Variable name	Variable definition and construction
Cost of bank loans variable	
Loan Spread	Natural logarithm of interest rate the borrower pays in bps over LIBOR for each dollar drawn down. Source: DealScan.
DiD variables	
Treatment	Indicator variable that equals one if a bank's LIBOR ratio (i.e., the ratio of the number of loans referencing LIBOR to a bank's total number of loans) is above the median value among all sample banks in the period prior to the FCA announcement of LIBOR discontinuation, and zero otherwise. Source: DealScan.
Post	Indicator variable that equals one if the loan is initiated in the period of July 2017 through December 2019, and zero if the loan initiation date falls between January 2015 and June 2017. Source: DealScan.
Baseline model control variables	
Loan Size	Natural logarithm of one plus the loan amount of the facility in billion USD. Source: DealScan.
Loan Maturity	Natural logarithm of number of months to maturity. Source: DealScan.
Firm Size	Natural logarithm of the firm's total assets. Source: Compustat.
Leverage	Sum of current debt and long-term debt scaled by total assets of the firm. Source: Compustat.
ROA	Earnings before interest, taxes, depreciation, and amortization scaled by total assets of the firm. Source: Compustat.
Operational Risk	Standard deviation of yearly cash flows from operations of the firm divided by its total assets over the previous five fiscal years. Source: Compustat.
Tangibility	Gross property, plant and equipment scaled by total assets of the firm. Source: Compustat.
Z-score	Modified Altman (1968) *Z*-score of the firm = (1.2 × working capital + 1.4 × retained earnings + 3.3 × income before extraordinary items + 1.0 × sales) ÷ total assets. Source: Compustat.
Market-to-Book Ratio	Market-to-book ratio of the firm. Source: Compustat.
Bank Size	Natural logarithm of the bank's total assets. Source: Compustat Bank.
Bank ROA	Income before tax scaled by total assets (in percentage) of the bank. Source: Compustat Bank.
Bank Capital Ratio	Total equity scaled by total assets (in percentage) of the bank. Source: Compustat Bank.
Bank PPE	Property, plant and equipment scaled by total assets (in percentage) of the bank. Source: Compustat Bank.
Bank Derivatives Exposure	Absolute value of unrealized gain/loss from derivatives scaled by absolute value of income before tax. Source: Compustat Bank.
Credit Spread	Difference in yield between BAA- and AAA-rated corporate bonds. Source: Federal Reserve Bank of St. Louis.
Term Spread	Difference in yield between ten-year and two-year U.S. Treasury bonds. Source: Federal Reserve Bank of St. Louis.
Validation test variables	
Transition Risk	Total number of keywords (in Table A.1) related to LIBOR transition-related risks as disclosed in Item 1A (Risk Factors) of a bank's 10-Ks. Source: EDGAR.
Bank Growth	Yearly growth rate in sales of the bank. Source: Compustat Bank.
Bank Market-to-Book Ratio	Market-to-book ratio of the bank. Source: Compustat Bank.
Robustness tests variables	
T−3	Indicator variable that equals one if the loan is initiated in the subperiod of January–June of 2016, and zero otherwise. Source: DealScan.

Appendix B. (Continued)

Variable name	Variable definition and construction
T−2	Indicator variable that equals one if the loan is initiated in the subperiod of July–December of 2016, and zero otherwise. Source: DealScan.
T−1	Indicator variable that equals one if the loan is initiated in the subperiod of January–June of 2017, and zero otherwise. Source: DealScan.
T+0	Indicator variable that equals one if the loan is initiated in the subperiod of July–December of 2017, and zero otherwise. Source: DealScan.
$T+1^{+}$	Indicator variable that equals one if the loan is initiated in the subperiod of January 2018 to December 2019, and zero otherwise. Source: DealScan.
Pseudo-Treatment	Indicator variable that equals one if banks are in the randomly assigned treatment group, and zero otherwise.
Pseudo-Post	Indicator variable that equals one if the loan is initiated during April 2016–June 2017, and zero if the loan initiation date falls in January 2015–March 2016. Source: DealScan.
Further analyses variables	
Secured	Indicator variable that equals one if the loan involves collateral, and zero otherwise. Source: DealScan.
Covenants	Natural Logarithm of one plus the number of covenants included in the loan. Source: DealScan.
Number of Non-LIBOR Rates	Number of non-LIBOR benchmark rates used in the next loan. Source: DealScan.
Non-LIBOR Ratio	Number of non-LIBOR benchmark rates scaled by the total number of benchmark (including LIBOR and non-LIBOR) rates used in the next loan. Source: DealScan.

The dwindling liquidity in interbank transactions continued to prevail after the GFC, especially in the unsecured segment (Schrimpf and Sushko 2019), for several reasons, including central banks' post-crisis monetary policies (Bech and Monnet 2016), banks' application of tighter risk management (which increases balance sheet costs), and regulatory reforms favoring banks holding reserves deposited at central banks (BCBS 2014, BIS 2018). Banks' tendency to turn to non-bank sources for term funding also exacerbated the dispersion of individual bank credit risk, which undermined LIBOR's function of capturing common bank risk (BIS 2013). The lack of an active and liquid interbank lending market highlighted a design flaw of LIBOR in that it was constructed from a survey of a small set of panel banks and thus failed to be a robust and accurate representation of interest rates in core money markets and for financial contracts beyond the money markets. This posed a significant threat to the efficiency of economic activities because viable benchmarking is essential to reduce search costs, improve matching, facilitate participation, and enhance liquidity (Duffie and Stein 2015).

Appendix C. Sample Excerpts of LIBOR Transition Risk Disclosed in Item 1A of 10-K

Comerica, Inc., 10-K for Fiscal Year of 2018, Filed on February 12, 2019

Interest rates on Comerica's outstanding financial instruments might be subject to change based on developments related to LIBOR, which could adversely affect its revenue, expenses, and the value of those financial instruments. … Comerica's loan composition at December 31, 2018 was 62% 30-day LIBOR, 13% other LIBOR (primarily 60-day), 16% prime and 9% fixed rate. The market transition away from LIBOR to an alternative reference rate, including SOFR, is complex and could have a range of adverse effects on our business, financial condition and results of operations. In particular, any such transition could adversely affect the interest rates paid or received on, and the revenue and expenses associate with, Comerica's floating rate obligations, loans, deposits, derivatives, and other financial instruments tied to LIBOR rates, or other securities or financial arrangements given LIBOR's role in determining market interest rates globally. Prompt inquiries or other actions from regulators in respect of Comerica's preparation and readiness for the replacement of LIBOR with an alternative reference rate result in disputes, litigation or other actions with counterparties regarding the interpretation and enforceability of certain fallback language in LIBOR-based securities, and require the transition to or development of appropriate systems and analytics to effectively transition Comerica's risk management processes from LIBOR-based products to those based on the applicable alternative pricing benchmark, such as SOFR. The manner and impact of this transition, as well as the effect of these developments on Comerica's funding costs, loan and investment and trading securities portfolios, asset-liability management, and business, is uncertain.

HSBC (USA), Inc., 10-K for Fiscal Year of 2018, Filed on February 19, 2019

We may not manage risks associated with the replacement of benchmark rates effectively. The expected replacement of benchmarks, including the key London Interbank Offered Rate ("LIBOR") with alternative benchmark rates introduces a number of risks for us, our clients, and the financial services industry more widely. This includes, but is not limited to: legal risks, as changes required to documentation for new and existing transactions may be required; financial risks, arising from any changes in the valuation of financial instruments linked to benchmark rates; pricing risks, as changes to benchmark indices could impact pricing mechanisms on some instruments; operational risks, due to the potential requirement to adapt IT systems, trade reporting infrastructure, operational processes and controls; and

conduct risks, through potential material, adverse impact on customers or financial markets, and engagement during the transition period. The benchmark specifications together with the timetable and mechanisms for implementation have not yet been agreed across the industry and regulatory authorities. Accordingly, it is not currently possible to determine whether, or to what extent, any such changes would affect us. However, the implementation of alternative benchmark rates may have a material adverse effect on our financial condition, customers and operations.

PNC Financial Services Group, Inc., 10-K for Fiscal Year of 2018, Filed on March 1, 2019

The planned discontinuance of the requirement that banks submit rates for the calculation of LIBOR presents risks to the financial instruments originated or held by PNC that use LIBOR as a reference rate. LIBOR is used as a reference rate for many of our transactions, which means it is the base on which relevant interest rates are determined. Transactions include those in which we lend and borrow money, issue, purchase and sell securities, and enter into derivatives to manage our or our customers' risk. … Those risks arise in connection with transitioning those instruments to a new reference rate and the corresponding value transfer that may occur in connection with that transition. That is because a new reference rate likely will not exactly mimic LIBOR. As a result, for example, over the life of a transaction that transitions from LIBOR to a new reference rate, our monetary obligations to our counterparties and our yield from transactions with clients may change, potentially adversely to us. For some instruments, the method of transitioning to a new reference rate may be challenging, especially if parties to an instrument cannot agree as to how to effect that transition. If a contract is not transitioned to a new reference rate and LIBOR ceases to exist, the impact on our obligations is likely to vary by asset class and contract. In addition, prior to LIBOR cessation, instruments that continue to refer to LIBOR may be impacted if there is a change in the availability or calculation of LIBOR. Risks related to transitioning instruments to a new reference rate or to how LIBOR is calculated and its availability include impacts on the yield on loans or securities held by us, amounts paid on securities we have issued, or amounts received and paid on derivative instruments we have entered into.

Appendix D. Algorithm for Retrieving Information About LIBOR Transition Risk from 10-K Reports

We download all 10-K reports filed with the SEC during our sample period for all sample banks (SIC codes 6000–6999) from the EDGAR database and use specific HTML tags to identify LIBOR transition risk-related information from Item 1A, following the methods of Campbell et al. (2014) and Hope et al. (2016). To assess the nature of LIBOR transition risk clauses, we hand-collect and read 100 randomly selected 10-K reports for 2018 and 2019. Based on this process, we identify 43 keywords (phrases) relevant to firm disclosure of LIBOR transition risk, as listed in Table A.1, to automate our search.

We develop a textual analysis algorithm to facilitate the automatic search. We first validate the reliability of this algorithm. Specifically, we randomly choose 50 banks each year during 2018–2019 and manually collect LIBOR transition risk information in their risk factor disclosures in 10-K. At the same time, we employ our textual analysis algorithm to extract similar disclosures. We then compare the algorithm extraction with the manual collection and find that our algorithm extracts only and the correct information from the 10-K reports in 98% of the selected cases.

Based on the above validation, we apply our textual analysis algorithm to scan the full text of the risk factor portion of 10-K to search for the LIBOR risk keywords in Table A.1, for all SEC filings during 2015 and 2019. This procedure generates a comprehensive extraction of LIBOR transition risk for all sample banks.

Endnotes

[1] The Market Participants Group on Reforming Interest Rate Benchmarks (2014) reports that over 97% of syndicated loans are indexed to LIBOR.

[2] As examples, see, among others, the special reports regarding LIBOR transition issued by HSBC (https://www.gbm.hsbc.com/financial-regulation/market-structure/ibor), Deutsche Bank (https://www.db.com/company/en/media/How-Deutsche-Bank-is-preparing-for-IBOR-transition-and-Benchmark-Reform.pdf), and Barclays (https://www.barclayscorporate.com/insights/funding/transitioning-to-risk-free-rates/#loanstradeandworkingcapital).

[3] For example, the U.K. advocated the Sterling Overnight Index Average (SONIA) and Japan chose the Tokyo Overnight Average Rate (TONAR). For Swiss Franc, the candidate was the Swiss Average Rate Overnight (SARON); for Euro, the Euro Overnight Index Average (EONIA) was recommended (which was later replaced by the Euro Short-Term Rate (€STR)).

[4] As mentioned by Sean Taor of RBC Capital Markets in the 2019 European Capital Markets Forum, "before July 2017 … very few market participants thought Libor would be going anywhere – no one was prepared for potential transition back then – but since July 2017 the world has changed pretty quickly." See "Roundtable: What does life after Libor look like?" in International Financial Law Review (May 30, 2019), available at https://www.iflr.com/Article/3876328/ROUNDTABLE-What-does-life-after-Libor-looklike.html?ArticleId=3876328.

[5] See https://www.newyorkfed.org/markets/reference-rates/sofr.

[6] For example, the ARRC suggested an amendment approach and hardwired waterfall provisions to identify a replacement rate, with SOFR as the top priority in each waterfall (https://www.newyorkfed.org/arrc/announcements.html). The Loan Market Association (LMA) published "replacement of screen rate wording" intended to facilitate the amendments to be made, including exposure drafts of facilities agreements for SOFR compounded in arrears (https://www.lma.eu.com/libor).

[7] See https://www.theice.com/publicdocs/ICE_LIBOR_feedback_statement_on_consultation_on_potential_cessation.pdf.

[8] The CME Group introduced Term SOFR Reference Rates (Term SOFR rates hereafter) benchmark that was endorsed by the ARRC in July 2021 (https://www.newyorkfed.org/medialibrary/Microsites/arrc/files/2021/ARRC_Press_Release_Term_SOFR.pdf). However, Term SOFR rates are "engineered" benchmarks calculated based on derivatives products, primarily SOFR futures. In other words, Term SOFR rates are *not* transaction-based as term LIBOR and overnight SOFR. This feature is inconsistent with the principle of LIBOR reform that should be based on actual transactions. Unlike LIBOR that can

serve both derivatives and cash products, Term SOFR rates feature a one-way dependency between the derivative and cash markets, its robustness thus relies heavily on the depth and liquidity of the SOFR derivatives market. As "engineered" benchmarks, Term SOFR rates are also prone to model risk due to complex methodology, data failure, biased market expectations, and potential market manipulations (Liu and Bai 2022). Moreover, Term SOFR rates reflect the market-implied expected path of future overnight rates over the term of the contract, which does not embed premium for term funding risk. Consequently, the interest rate curve constructed under the CME methodology is essentially risk-free and thus resembles the RFR more than it does LIBOR (Schrimpf and Sushko 2019). Realizing these potential pitfalls, the ARRC emphasizes that the use of Term SOFR rates needs to remain limited (ARRC 2023).

[9] Hedging cash products based on Term SOFR rates is also difficult because it is challenging to exactly re-engineer Term SOFR rates to achieve perfect hedge. Also, the fact that Term SOFR rates are constructed based on close dependency between the derivatives and cash markets could reduce the diversification effect of a portfolio and add systematic risk (Liu and Bai 2022).

[10] Costs may also arise from enhancing governance and control procedures to enable smooth transition and ensure compliance, as well as operational and infrastructure updates including technology configuration, risk modeling, portfolio tracking, and trade settlement.

[11] Another important consideration for this benchmarking strategy is that non-LIBOR-based loan spread may have different connotations following the announcement of LIBOR discontinuation because loan contracting parties are more likely to incorporate an additional term or credit risk adjustment as a response to the benchmark change. This could contaminate the economic implications of loan spread for our research purpose of detecting the risk-transfer effect directly induced by the transition away from LIBOR.

[12] Because DealScan does not have the identifier of lenders and borrowers to link with Compustat directly, we obtain the borrower and lender linking tables from the Roberts DealScan-Compustat Linking Database (Chava and Roberts 2008) and Michael Schwert's website https://sites.google.com/site/mwschwert/data-and-code (Schwert 2018), respectively. For a bilateral loan, we identify the lending bank to match the borrowing firm; for a syndicated loan, we identify the lead arranger as it negotiates loan terms with the borrower on behalf of the rest of the syndicate, following prior literature (Schwert 2018, Francis and Wang 2021). We focus on syndicates with a sole lead arranger to avoid matching one borrower with multiple lenders.

[13] 10-Ks are annual reports, we thus delete 2017 (i.e., the FCA announcement year) when defining *Post* to avoid the noise in LIBOR transition risk identification from 2017s 10-Ks.

[14] The dependent variable of loan spread is in natural logarithmic form, thus the coefficient estimate represents the percentage change effect of the independent variable on the dependent variable (Graham et al. 2008, Low 2009).

[15] Larcker and Rusticus (2010) posit that the impact of selected control variables can provide a reasonable benchmark for ITCV.

[16] When using each firm fundamental risk measure as the dependent variable, we exclude the measure from the control variable list.

References

Abrantes-Metz R, Kraten M, Metz A, Seow G (2012) Libor manipulation? *J. Banking Finance* 36:136–150.

Altman E (1968) Financial ratios, discriminant analysis and the prediction of corporate bankruptcy. *J. Finance* 23:589–609.

Amamiya M (2019) Development of Asia's capital markets: Roles and challenges. Accessed August 31, 2024, https://www.boj.or.jp/en/announcements/press/koen_2019/ko191010a.htm/.

Aquilina M, Pirrone A (2020) The effects of regulating benchmarks. *Econom. Lett.* 186:108512.

ARRC (Alternative Reference Rates Committee) (2021) Frequently asked questions. Accessed August 31, 2024, https://www.newyorkfed.org/medialibrary/Microsites/arrc/files/2021/ARRC-Scope-of-Use-FAQ.pdf.

ARRC (Alternative Reference Rates Committee) (2023) Summary and update of the ARRC's term SOFR scope of use best practice recommendations. Accessed August 31, 2024, https://www.newyorkfed.org/medialibrary/Microsites/arrc/files/2023/ARRC-Press-Release-Best-Practice-Recommendations.pdf.

Arvan L, Brueckner J (1986) Efficient contracts in credit markets subject to interest rate risk: An application of Raviv's insurance model. *Amer. Econom. Rev.* 76:259–263.

Badertscher B, Katz S, Rego S (2013) The separation of ownership and control and corporate tax avoidance. *J. Accounting Econom.* 56:228–250.

Bailey A (2017) The future of LIBOR. Accessed August 31, 2024, https://www.fca.org.uk/news/speeches/the-future-of-libor.

BCBS (Basel Committee on Banking Supervision) (2014) Basel III: The new stable funding ratio. Accessed August 31, 2024, https://www.bis.org/publ/bcbs271.pdf.

Bech M, Monnet C (2016) A search-based model of the interbank money market and monetary policy implementation. *J. Econom. Theory* 164:32–67.

Bernanke B, Gertler M (1995) Inside the black box: The credit channel of monetary policy transmission. *J. Econom. Perspect.* 9:27–48.

Bertrand M, Mullainathan S (2003) Enjoying the quiet life? Corporate governance and managerial preferences. *J. Political Econom.* 111:1043–1075.

BIS (Bank of International Settlements) (2013) Toward better reference rate practices: A central bank perspective. Accessed August 31, 2024, https://www.bis.org/publ/othp19.pdf.

BIS (Bank of International Settlements) (2018) Annual economic report. Accessed August 31, 2024, https://www.bis.org/publ/arpdf/ar2018e.pdf.

Burgess N (2020) Libor benchmark reform: An overview of Libor changes and its impact on yield curves, pricing and risk. Working paper, University of Oxford, Oxford, UK.

Campbell J, Chen H, Dhaliwal D, Lu H, Steele L (2014) The information content of mandatory risk factor disclosures in corporate filings. *Rev. Accounting Stud.* 19:396–455.

Chava S, Roberts M (2008) How does financing impact investment? The role of debt covenants. *J. Finance* 63:2085–2121.

Chiu T-T, Guan Y, Kim J-B (2018) The effect of risk factor disclosures on the pricing of credit default swaps. *Contemp. Accounting Res.* 35:2191–2224.

Chiu T-T, Kim J-B, Wang Z (2019) Customers' risk factor disclosures and suppliers' investment efficiency. *Contemp. Accounting Res.* 36:773–804.

Cooperman H, Duffie D, Luck S, Wang Z, Yang Y (2023) Bank funding risk, reference rates, and credit supply. NBER Working Paper No. 30907, National Bureau of Economic Research, Cambridge, MA.

Coulter B, Shapiro J, Zimmerman P (2018) A mechanism for LIBOR. *Rev. Finance* 33:491–520.

Denis D, Wang J (2014) Debt covenant renegotiations and creditor control rights. *J. Financial Econom.* 113:348–367.

Deshmukh S, Greenbaum S, Kanatas G (1983) Interest rate uncertainty and the financial intermediary's choice of exposure. *J. Finance* 38:141–147.

Diamond D (1984) Financial intermediation and delegated monitoring. *Rev. Econom. Stud.* 51:393–414.

Diamond D (1991) Monitoring and reputation: The choice between bank loans and directly placed debt. *J. Political Econom.* 99:689–721.

Duffie D, Dworczak P (2021) Robust benchmark design. *J. Financial Econom.* 142:775–802.

Duffie D, Stein J (2015) Reforming LIBOR and other financial benchmarks. *J. Econom. Perspect.* 29:191–212.

Duffie D, Dworczak P, Zhu H (2017) Benchmarks in search markets. *J. Finance* 72:1983–2044.

Edelstein R, Urosevic B (2003) Optimal loan interest rate contract design. *J. Real Estate Finance Econom.* 26:127–156.

EFRAG (European Financial Reporting Advisory Group) (2019) IBOR reform and effects on financial reporting. Accessed August 31, 2024, https://www.efrag.org/en/projects/ibor-reform-and-its-effects-on-financial-reporting/phase-2-endorsement-consultation.

Elyasiani E, Goldberg L (2004) Relationship lending: A survey of the literature. *J. Econom. Bus.* 56:315–330.

English W, Van den Heuvel S, Zakrajsek E (2018) Interest rate risk and bank equity valuations. *J. Monet. Econom.* 98:80–97.

Fama E (1985) What's different about banks? *J. Monet. Econom.* 15:29–39.

Fouquau J, Spieser P (2015) Statistical evidence about LIBOR manipulation: A "Sherlock Holmes" investigation. *J. Banking Finance* 50:632–643.

Francis J, Wang W (2021) Common auditors and private bank loans. *Contemp. Accounting Res.* 38:793–832.

Frank K (2000) Impact of a confounding variable on a regression coefficient. *Sociol. Methods Res.* 29:147–194.

Froot K, Stein J (1998) Risk management, capital budgeting, and capital structure policy for financial institutions: An integrated approach. *J. Financial Econom.* 47:55–82.

FSB (Financial Stability Board) (2014) Reforming major interest rate benchmarks. Accessed August 31, 2014, https://www.fsb.org/wp-content/uploads/r_140722.pdf.

FSB (Financial Stability Board) (2018) Reforming major interest rate benchmarks: Progress report. Accessed August 31, 2024, https://www.fsb.org/2018/11/reforming-major-interest-rate-benchmarks-progress-report/.

Gandhi P, Golez B, Jackwerth J, Plazzi A (2019) Financial market misconduct and public enforcement: The case of Libor manipulation. *Management Sci.* 65:5268–5289.

Graham J, Li S, Qiu J (2008) Corporate misreporting and bank loan contracting. *J. Financial Econom.* 89:44–61.

Hart O (1995) *Firms, Contracts and Financial Structure* (Clarendon Press, Oxford).

Hart O, Moore J (1988) Incomplete contracts and renegotiation. *Econometrica* 50:755–785.

Held M (2019) SOFR and the transition from LIBOR. Accessed August 31, 2024, https://www.newyorkfed.org/newsevents/speeches/2019/hel190226.

Hope O, Hu D, Lu H (2016) The benefits of specific risk-factor disclosures. *Rev. Accounting Stud.* 21:1005–1045.

Hou D, Skeie D (2014) LIBOR: Origins, economics, crisis, scandal, and reform. FRB of New York Staff Report No. 667, Federal Reserve Bank of New York, New York.

Huang H, Lobo G, Wang C, Zhou J (2018) Do banks price independent directors' attention? *J. Financial Quant. Anal.* 53:1755–1780.

IOSCO (International Organization of Securities Commissions) (2013) Principles for financial benchmarks: Final report. Accessed August 31, 2024, https://www.iosco.org/library/pubdocs/pdf/IOSCOPD415.pdf.

Ippolito F, Ozdagli A, Perez-Orive A (2018) The transmission of monetary policy through bank lending: The floating rate channel. *J. Monet. Econom.* 95:49–71.

Jermann U (2019) Is SOFR better than LIBOR? Working paper, University of Pennsylvania, Philadelphia.

Jimenez G, Ongena S, Peydro L, Saurina J (2012) Credit supply and monetary policy: Identifying the bank balance-sheet channel with loan applications. *Amer. Econom. Rev.* 102:2301–2326.

Kim J-B, Song B, Zhang L (2011) Internal control weakness and bank loan contracting: Evidence from SOX Section 404 disclosures. *Accounting Rev.* 86:1157–1188.

Klingler S, Syrstad O (2021) Life after LIBOR. *J. Financial Econom.* 141:783–801.

Klingler S, Syrstad O (2023) Does SOFR-linked debt cost borrowers more than LIBOR-linked debt? Working paper, BI Norwegian Business School and Norges Bank, Oslo , Norway.

Kuo D, Skeie D, Vickery J (2018) A comparison of Libor to other measures of bank borrowing costs. Working paper, Institute for Defense Analysis, Texas A&M University, and Federal Reserve Bank of New York, New York.

Larcker D, Rusticus T (2010) On the use of instrumental variables in accounting research. *J. Accounting Econom.* 49:186–205.

Liu X, Bai Y (2022) Term risk-free rates: Methodologies, challenges, and the future. *J. Derivatives* (Spring):30–45.

Low A (2009) Managerial risk-taking behavior and equity-based compensation. *J. Financial Econom.* 92:470–490.

Market Participants Group on Reforming Interest Rate Benchmarks (2014) Final report. Accessed August 31, 2024, https://www.fsb.org/wp-content/uploads/r_140722b.pdf?page_moved=1.

McCauley R (2001) Benchmarking tipping in the money and bond markets. *BIS Quart. Rev.* (March):39–45.

Muto I (2017) The role of the reference rate in an interbank market with imperfect information. *Global Finance J.* 34:16–31.

Nikolaev V (2018) Scope of renegotiation in private debt contracts. *J. Accounting Econom.* 65:270–301.

Perkins J, Mortby P (2015) Evolving financial benchmarks: The impact of legacy contracts. *J. Securities Oper. Custody* 7:296–304.

Powell J (2017) Libor death is "big stability risk" – Interview with Risk.net. Accessed August 31, 2024, https://www.risk.net/derivatives/5354301/feds-powell-libor-death-is-big-stability-risk.

Prilmeier R (2017) Why do loans contain covenants? Evidence from lending relationships. *J. Financial Econom.* 123:558–579.

Reuters (2012) Insight: A Greek banker, the Shah and the birth of Libor. Accessed August 31, 2024, https://www.reuters.com/article/business/a-greek-banker-the-shah-and-the-birth-of-libor-idUSBRE877023/.

Reuters (2019) The end of Libor: The biggest banking challenge you've never heard of. Accessed August 31, 2024, https://www.reuters.com/article/economy/the-end-of-libor-the-biggest-banking-challenge-youve-never-heard-of-idUSKBN1WN0H7/.

Rice T, Strahan P (2010) Does credit competition affect small-firm finance? *J. Finance* 65:861–889.

Roberts R (2015) The role of dynamic renegotiation and asymmetric information in financial contracting. *J. Financial Econom.* 116:61–81.

Schrimpf A, Sushko V (2019) Beyond LIBOR: A primer on the new reference rates. *BIS Quart. Rev.* (March):29–52.

Schwert M (2018) Bank capital and lending relationships. *J. Finance* 73:787–830.

SEC (Securities and Exchange Commission) (2021) How to read a 10-K/10-Q. Accessed August 31, 2024, https://www.sec.gov/resources-for-investors/investor-alerts-bulletins/how-read-10-k10-q.

Stenfors A, Lindo D (2018) Libor 1986–2021: The making and unmaking of 'the world's most important price'. *Distinktion J. Soc. Theory* 19:170–192.

Stiglitz J, Greenwald B (2003) *Toward a New Paradigm in Monetary Economics* (Cambridge University Press, Cambridge, UK).

The Economist (2018) The price of everything. *The Economist* (September 27), https://www.economist.com/finance-and-economics/2018/09/27/a-scramble-to-replace-libor-is-under-way.

The Economist (2019) Fifty ways to leave your LIBOR. *The Economist* (June 8), https://www.economist.com/finance-and-economics/2019/06/08/libor-is-due-to-die-in-2021-hurry-up-and-drop-it-say-regulators.

Valta P (2012) Competition and the cost of debt. *J. Financial Econom.* 105:661–682.

Vickery J (2008) How and why do small firms manage interest rate risk? *J. Financial Econom.* 87:446–470.