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Pacific-Basin Finance Journal 79 (2023) 102006

Contents lists available at ScienceDirect

Pacific-Basin Finance Journal

journal homepage: www.elsevier.com/locate/pacfin

Bank funding costs during the COVID-19 pandemic: Evidence from China

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ARTICLE INFO

JEL classifications:
G12
G21
I18

Keywords:
Bank funding costs
Negotiable certificates of deposit
COVID-19 pandemic
Bank risk

ABSTRACT

This paper investigates whether and how the COVID-19 pandemic affects bank funding costs in China. We find a significantly positive relationship between the offering yield spreads of negotiable certificates of deposit and banks' pandemic exposure. The surge in bank funding costs is alleviated by banks' asset quality, financial flexibility, operational resilience, and government support, indicating that pandemic-induced risks are priced in the interbank market. The alternative explanations of monetary policy interventions, investors' flight-to-liquidity effect, bank liquidity hoarding, and banks' mispricing are further excluded. We contribute to the literature on the pandemic effects on financial markets, and bank funding during crises.

1. Introduction

With the coronavirus disease 2019 (COVID-19) pandemic resulting in widespread economic disruptions and demand shocks (Goldstein et al., 2021), pandemic exposure is widely priced in financial markets (Meyer et al., 2022). Under the unprecedented circumstances, the real economy passes the shock on to banks, and banks are expected to play a crucial role in absorbing the pandemic-related shock and supporting the real sector. Although the pricing effect of pandemic exposure in stock markets and corporate bond markets has been documented (Ding et al., 2021; Gao et al., 2022), the evidence on whether and how pandemic-induced risks on banks are priced in the interbank markets remains scant.

The drastic economic disruptions and heightened uncertainty during the pandemic might increase perceptions of bank insolvency, and stress bank funding (Çolak and Öztekin, 2021; Beck and Keil, 2022).[1] Banks may suffer from impaired asset quality when their borrowers experience shutdowns due to pandemic outbreaks (Taylor, 2022). The mobility restrictions during the pandemic also disrupt bank operations and organizational communication (Kwan et al., 2021), worsening bank operating efficiency. Since the performance of banks that operate regionally is closely linked to the local economic environment (Sun et al., 2013), the disruptions triggered by local pandemic outbreaks may lead to higher prospects of extreme losses and a surge in bank risk premiums (Meyer and Pifer, 1970; Dent et al., 2021). Hence, the pandemic exposure of regional banks may elevate their funding costs.

This paper investigates whether and how the COVID-19 pandemic affects the offering spreads of negotiable certificates of deposit (NCDs), which serve a substantial proportion of short-term financing for commercial banks in China. We adopt the number of newly

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[1] The pandemic effect on banks is magnified by the interaction between banks and the real economy. Demirgüç-Kunt et al. (2021) show that banks' share prices underperformed relative to their local stock markets and relative to domestic non-financial firm during the large crash of global equity in the COVID-19 pandemic.

https://doi.org/10.1016/j.pacfin.2023.102006
Received 30 October 2022; Received in revised form 5 February 2023; Accepted 9 March 2023
Available online 15 March 2023

confirmed COVID-19 cases per capita in a city in which a bank headquarters as a proxy for the pandemic exposure of the bank, for banks operating in regions with higher COVID-19 infection rates are more likely to be exposed to pandemic-induced adverse shocks (Levine et al., 2021b). Using a comprehensive data set of 38,418 NCDs issued by joint-stock banks and city commercial banks in China from 2020 to 2021, we find a significantly positive relationship between a bank's exposure to the COVID-19 and the offering spreads of NCDs when controlling issuer and year-quarter fixed effects, indicating that pandemic-induced bank risks are priced in the interbank market.

Several cross-sectional tests based on pre-pandemic characteristics are conducted to validate the pricing effect of the pandemic-induced bank risk. First, we find that banks holding more loans from sectors severely affected by the pandemic, or operating in regions with worse economic conditions, would experience a more pronounced surge in NCD spreads, implying that the pandemic aggravates bank risk through deteriorating underlying asset quality (Taylor, 2022). Second, the positive relationship between the pandemic exposure and NCD spreads is stronger among banks with weaker financial flexibility measured by total assets and equity-to-assets ratio, an indicator of the capital buffers which support banks' absorbability of adverse shocks. Third, the pandemic pricing effect would be attenuated by a bank's operational resilience that assists the bank in maintaining normal operations and tackling adverse scenarios effectively, including business and geographical diversification, FinTech adoption, board independence, and information transparency. Fourth, since local governments' coordination with the central government is urgently needed to maintain financial stability in this unprecedented crisis, banks that are expected to have higher possibility of governmental bailouts for extreme losses face less stress in interbank funding costs during the pandemic. These results suggest that the interbank market significantly prices pandemic exposure and bank resilience due to the expectation that regional pandemic outbreaks impair bank health and increase bank risk. Furthermore, the higher funding costs induced by the pandemic are not driven by other supply-side factors like monetary policy interventions and the flight-to-liquidity effect, or demand-side factors like banks' liquidity hoarding and mispricing in time of a public health crisis.

Further analyses show that the pricing effect of the COVID-19 pandemic on NCD spreads is heterogeneous to the prospects of COVID-19 control. Proactive pandemic control, which reduces perceptions of the potential damage of pandemic outbreaks, could alleviate the pricing effect of the pandemic exposure on NCD spreads. Also, the imprint of similar health crises helps attenuate investors' concerns about the disruptions resulting from pandemic exposure and the corresponding pricing effect.

We also address endogeneity concerns on the relationship between pandemic exposure and NCD spreads. We utilize the instrumental variable (IV) approach, and adopt three plausible IVs to capture exogenous variation in regional pandemic exposure: the number of newly confirmed COVID cases per capita in neighboring cities where a bank does not operate any branch, the number of newly confirmed COVID cases per capita in neighboring provinces, and lagged-one-year passenger traffic, which are directly related to virus spread and predict the probability of local pandemic outbreak but usually independent with unobservable omitted economic or financial factors of the focal city. The 2SLS estimation results based on these IVs support the causal effect of the pandemic exposure on NCD spreads. We also undertake several robustness checks. The positive effect of the pandemic exposure on NCD spreads is robust to the adoption of alternative variable definitions and the inclusion of stringent fixed effects. The effect is also observed when we use the subsample of city commercial bank issuers, and the bank-day panel of NCD issuances.

The Chinese setting offers three advantages to identify the causal link between the pandemic and bank funding costs. First, the NCD market offers a high-quality data source for the direct measure of risk-sensitive bank funding costs. With the advancement of interest rate marketization, NCDs have become a critical tool for the dynamic liquidity management of Chinese banks with the feature of intensive issuance and marketized pricing. NCD spreads capture risk premiums and their timely response to a particular shock, addressing the difficulties in identifying banks' cost of debt and capturing the risk-sensitive pricing adjustments (Pérignon et al., 2018; Dick-Nielsen et al., 2022). Moreover, it is necessary to separate the cost of deposits and the cost of interbank funding, since they are likely to react differently to crises (Levine et al., 2021b). Therefore, when empirically examining how the pandemic affects bank funding costs by altering investors' perspectives on bank risk, our measure is superior to the total funding cost measure derived from *implicit* interest rates based on quarterly financial reports. Second, the regional commercial banks, which occupy a significant impact in local economic development, provide a unique setting to link the regional pandemic outbreaks to banks' risk exposure (Sun et al., 2013). Third, as for investigating how bank risk elevates bank funding costs, the exogenous shock of COVID-19 pandemic provides a plausible solution to the identification challenge that funding costs can affect bank solvency simultaneously (Aldasoro et al., 2022). We employ the regional pandemic outbreaks, which are rare disasters not rooted in financial systems but rapidly evolve into widespread local economic turmoils, to identify the causal relationship between bank risk and bank funding costs. More importantly, the strict pandemic control and regional mobility restrictions in China infer a strong correlation between regional pandemic outbreaks and banks' risk exposure, and provide substantial spatial and time variation to assess the impact of pandemic exposure on regional banks' funding costs.

We contribute to three strands of literature. First, we add to the burgeoning literature on the impacts of the COVID-19 pandemic on banks from the perspective of bank financing costs. Prior literature preliminarily depicts that the pandemic-induced disruptions impair bank lending and bank performance by deteriorating asset quality and credit conditions (Çolak and Öztekin, 2021; Beck and Keil, 2022; Taylor, 2022), increase the systemic risk of the banking sector through the financing liquidity channel (Huang et al., 2022), and amplify the role of government support policies (Demirgüç-Kunt et al., 2021). However, the knowledge of bank funding in the pandemic era is quite limited. Our findings of the surge in NCD spreads supplement but distinguish from Levine et al. (2021b), who find that banks experience deposit inflows during the pandemic, and indirectly reveal the distinction between funds from depositors and sophisticated investors in interbank markets.

Second, we supplement the literature on bank risk and bank funding costs, especially in rare disasters. Fund suppliers in deposit and interbank markets withdraw during shocks of bank solvency risk (Iyer et al., 2016; Huang and Ratnovski, 2011; Aldasoro et al., 2022),

usually aggravating financial frictions in adverse periods. Prior literature documents that bank leverage (Dent et al., 2021), idiosyncratic liquidity risk (Bechtel et al., 2023), geographic expansion and risk diversification (Levine et al., 2021a), interest rate environment (Gerlach et al., 2018), and regional economic fundamentals (Cottrell et al., 2021), shape investors' perceptions on bank risk and affect bank funding costs. While previous literature has documented the fragility of interbank funding to adverse shocks (Pérignon et al., 2018), we employ the unique setting of the COVID-19 pandemic to complement how bank funding costs response to rare disasters and public crises. Our paper illustrates how general public crises not rooted in financial systems trigger investors' prospects of higher bank risk and increase bank funding costs. Exploiting the exogenous city- and time-varying pandemic exposure, we take an advantage in addressing the reversal causality concern that funding costs also affect bank solvency (Aldasoro et al., 2022), and provide the causal evidence that bank risk increased by worsening local economic conditions raises bank funding costs.

Third, we provide new insights on the importance of bank resilience to get through financial or public crises. How corporate resilience assists firms in stabilizing market value and external financing by enabling them to manage difficult economic circumstances and recover from operating disruptions has garnered substantial attention in the pandemic era (Fahlenbrach et al., 2021; Barry et al., 2022; Xia et al., 2022). Since banks' capacities to absorb adverse shocks and manage liquidity are closely related to financial stability and economy resilience (Vazquez and Federico, 2015), it is urgent to understand the role of bank resilience which is relatively underexplored in previous literature. Prior studies find that financial health (Ikeda et al., 2021; Cao and Chou, 2022), revenue and geographic diversification (Li et al., 2021b; Doerr and Schaz, 2021), and FinTech adoption (Kwan et al., 2021), could provide insurance against adverse shocks and facilitate loan provision in crises. We complement the indispensable role of bank resilience in the scope of bank funding in public crises, providing empirical evidence that asset quality, financial flexibility, operational resilience, and governmental support attenuate the surge in NCD spreads during the pandemic. Our findings are consistent with Billett and Garfinkel (2004) who find that banks' financial flexibility reduces the cost of external financing, and Pérignon et al. (2018) who find that low-quality banks are more likely to experience funding dry-ups during periods of market stress.

The remainder of this paper is organized as follows. Section 2 discusses the institutional background of NCD in China and develops our hypotheses. Section 3 presents the empirical design of the study. Section 4 presents the empirical results. Conclusions are presented in Section 5.

2. Institutional background and hypothesis development

The essential role of NCDs in interbank financing, along with its market-based and risk-sensitive pricing, provides a plausible setting to examine the effect of pandemic exposure on bank funding costs. As wholesale funding allows banks to diversify their capital-raising activities and maintain sufficient funding flexibly to meet regulatory requirements or rating-agency expectations, interbank funding serves as a more and more important source of funding (Cottrell et al., 2021). NCDs are unsecured papers issued by depository financial institutions and purchased by qualified investors in the interbank market, typically with an initial maturity ranging between one month and one year. Since its reopening in 2013, the NCD market in China has seen tremendous growth during the past decade (Fig. 1, Panel A), indicating the increasing importance of NCDs as a source of short-term external funds for banks. In 2020 and 2021, on average, there were 129 NCDs issued per trading day, with the aggregate amount exceeding 92 billion RMB. Among all the banks, city commercial banks and joint-stock commercial banks are predominating issuers, issuing respectively 37.16% and 35.60% of the volume of NCDs issued successfully in these two years. On average, outstanding NCDs take up roughly 35% of city commercial banks' non-deposit-liabilities in recent years, and 20% of joint-stock commercial banks' (Fig. 1, Panel B). In China, regional economic shocks are unlikely to leave regional banks unaffected, because the 12 joint-stock commercial banks have mostly prioritized their business areas in regional centers, and more than100 city commercial banks have been created initially following the rule of "one-city-one-bank" and operated mostly within each city (Sun et al., 2013).

Owing to the intensive issuance of NCDs, market participants use up-to-date information to assess the quality of claims, making bank risk incorporated into NCD spreads timely. Before issuing their first NCD in a calendar year, banks are requested to hand in an issuance plan of NCDs to the People's Bank of China, in which they disclose the bank's basic information, brief reviews on financial and operational situations, ratings, the limits of both total issuance and outstanding amounts, and other matters related to NCDs issuance. As long as the amount is under the limit, banks are free to decide the date, offering amount, initial maturity, and coupon rate for every single NCD. Banks usually follow a simple and quick procedure when issuing an NCD, informing the market of the issuance as well as basic properties like offering amount and initial maturity of the NCD just one or two work-days before it goes onto the market. On the issuance day, qualified buyers in the interbank market decide whether to subscribe and at what amount they subscribe to the NCD issued by a particular bank at the previously given interest rate and finish the subscription process via the interbank market trading system. New NCDs are usually open to subscription from 9:00 a.m. to 4:00 p.m. Once the trading system closes, NCDs that have not been subscribed to will not be available for sale again and may remain under-subscribed or face issuance failure.

At the beginning of 2020, the COVID-19 pandemic struck China, imposing considerable uncertainty on financial markets. The mobility restrictions during the pandemic block logistics transportation and human capital movements, leading to extensive enterprise shutdowns (Fairlie et al., 2022). Meanwhile, the pandemic incurs a negative demand shock, resulting in enterprise revenue decline. Lifting enterprises' default risk which might spread onto the financial system, the pandemic exerts downward pressure on banks' profitability and asset quality, challenging financial stability. To combat the adverse impacts of the pandemic and resolute the

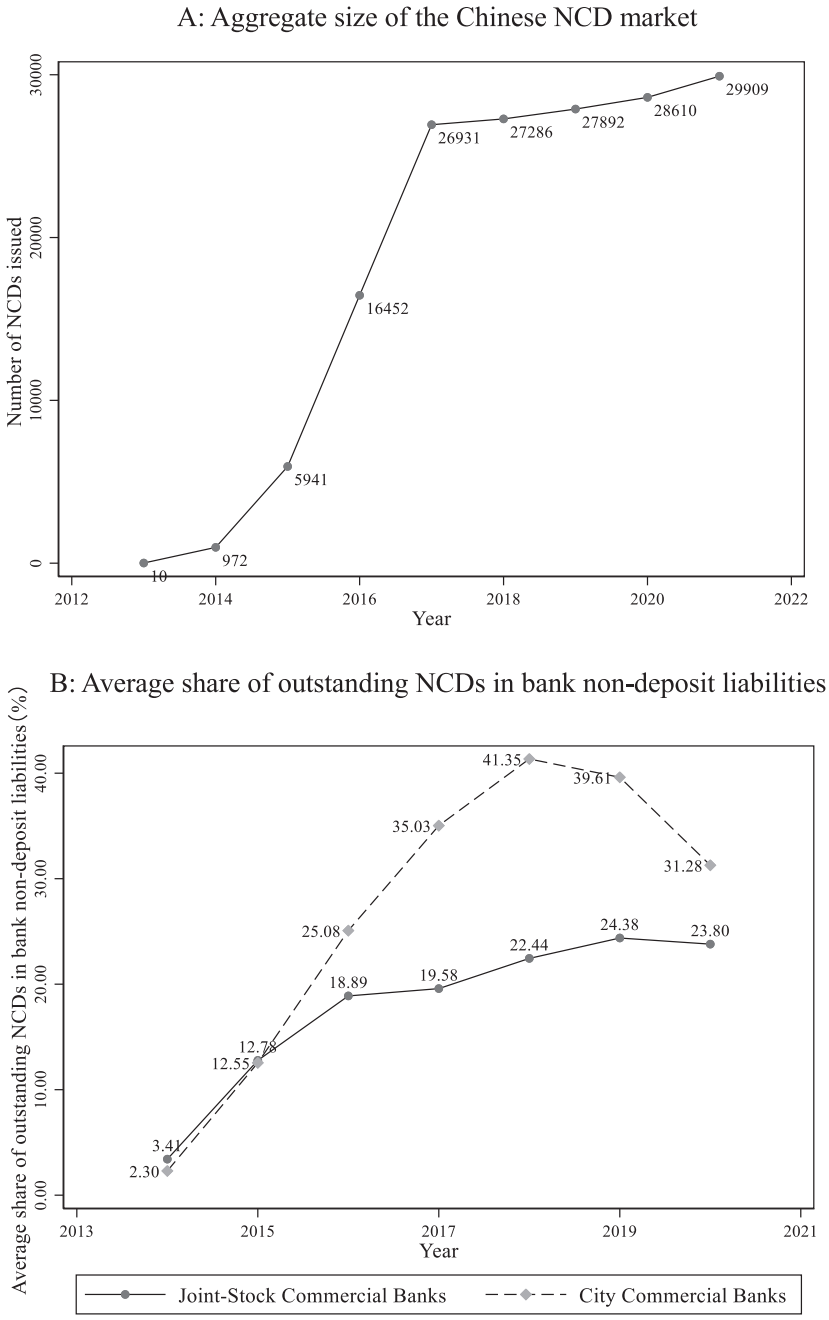

Fig. 1. Size of the NCD market and the average share of outstanding NCDs in bank non-deposit liabilities.
This figure displays the volume and significance of China's NCDs. Panel A displays the number of NCDs issued every year, as constructed from our NCD issuance data, from December 2013 to December 2021. Panel B displays the average share of outstanding NCDs in bank non-deposit liabilities by bank types from years 2014 to 2021.
Panel A: Aggregate size of the Chinese NCD market.
Panel B: Average share of outstanding NCDs in bank non-deposit liabilities.

potential rise of credit risk, the Chinese financial regulatory agencies took various measures of macro-prudential regulation, including maintaining reasonably adequate liquidity in the financial system and improving the financial services for SMEs and micro businesses.[2] This unprecedented public crisis generates non-negligible financial risks and poses challenges to bank resilience as well as central and local governments' capability, which leads our study to critical policy implications on financial stability in the pandemic era.

The pandemic outbreaks may aggravate investors' perceptions of bank insolvency, which increases interbank funding costs (Dent et al., 2021; Aldasoro et al., 2022). Since the deterioration of economic fundamentals would transmit to financial intermediaries through the credit channel, the pandemic may cause banks' asset depreciation, nonperforming loans surge, and bank lending shrinkage (Çolak and Öztekin, 2021). Also, with the Chinese government encouraging banks to provide inclusive financial support to SMEs and micro businesses for pandemic containment and economic reopening, banks may lend to riskier enterprises, leading to higher bank risk. The asset quality and operating performance of regional banks are expected to relate closely to the local economic environment and the operating conditions of credit counterparties. In addition, banking operations are disrupted, because the pandemic hinders face-to-face contact and physical visits to bank branches (Kwan et al., 2021). Thus, a bank headquartered in a city with a pandemic outbreak may be perceived as experiencing an adverse shock and bearing higher risks.

While banks seek liquidity in the interbank market under challenging times, the sophisticated liquidity providers can identify which banks are fragile to fail (Blickle et al., 2022), so the pandemic exposure may be priced in the interbank market. Specifically, bank funding stress during the pandemic can be reflected in the pricing of NCDs, which are unsecured securities whose buyers and holders care about and react to the solvency of banks and generate timely adjustments of risk premiums (Pérignon et al., 2018). Overall, local pandemic outbreaks may be regarded as adverse financial events, increasing banks' funding costs represented by NCD spreads. Hence, we propose the following hypothesis:

H1: Ceteris paribus, the COVID-19 pandemic exposure would increase NCD spreads.

3. Data and empirical design

3.1. Data and summary statistics

Our sample ranges from January 2020 to December 2021, when the COVID-19 pandemic had substantial and widespread impacts in China. We utilize the sample of NCDs issued by joint-stock banks and city commercial banks, two types of typical regional banks with relatively complete financial information disclosure. At the end of 2019, the total assets of the banks in our sample account for 36.10% of the total assets of all commercial banks, and 70.46% of the total assets of commercial banks excluding the six large national state-owned banks. We retrieve from the Wind database data on NCD issuances, banks' headquarters locations, and bank annual financial variables, including total assets, return on assets, non-performing loan ratio, and leverage. We complement the missing bank characteristics as much as possible using data from the China Stock Market & Accounting Research (CSMAR) Database and the Chinese Research Data Services (CNRDS) Database, and handily collect data from the annual reports if the data are missing in all three databases. We exclude NCDs issued by banks that were once in trouble, including Baoshang Bank and Mengshang Bank which was reorganized from Baoshang Bank, Bank of Jinzhou, and Hengfeng Bank. We also exclude NCDs whose issuers have undergone an M&A process. To control for possible unobservable determinants of pricing, we further exclude 20 NCDs denominated in US dollars, 74 NCDs issued specially for anti-pandemic, and 67 interest-bearing NCDs. Finally, we obtain a sample containing 38,418 NCDs issued by 114 individual banks. COVID-19 confirmed cases and regional characteristics are collected from CSMAR. All continuous variables are winsorized at the 5% and 95% levels.

NCD offering spread represents the risk premium required for holding an NCD and bearing a contingent default. Although issuers use Shanghai interbank offered rates (Shibor) as the benchmark rates when pricing NCDs, we measure credit spread as the difference between the NCD's offering yield and the Chinese Development Bank (CDB) yield issued on the same date and with the same initial maturity for two reasons. First, we measure the risk premium required for an NCD, capturing the idea that interbank funding suppliers bear risk compared with holding risk-free assets. Second, we use the yield of CDB bonds from which profits are taxed, rather than the tax-exempted government bonds, to avoid measurement errors derived from taxation, as profits from investing in NCDs are also taxed in China (Geng and Pan, 2022).

In our main analysis, following Ding et al. (2021) and Gao et al. (2022), we use the number of newly COVID-19 confirmed cases per ten thousand people in the issuer's headquarters city over 7 days prior to the offering date to measure an NCD's pandemic exposure. With substantial cross-region and cross-time variation in regional pandemic exposure, we capture the idea that a bank exposed to a higher local COVID-19 infection rate is more likely to bear higher risk stemming from the worsening local economic environment. The intuition is that mobility restriction is more likely to be implemented in a city with a higher infection rate, which adversely affects local economic condition. We also use the Baidu search volume[3] for the COVID-19, which depicts the subjective concern on the pandemic in a region, to proxy for the pandemic exposure in robustness checks. Details of variable definitions are presented in Appendix.

[2] More details can be seen in the China Financial Stability Reports 2020 and 2021, which are available on the People's Bank of China's official website.

[3] Baidu index is constructed based on the big data of netizen keyword search volume provided by a data analysis platform of Baidu (website: https://index.baidu.com), which is the leading search engine in China, especially since 2010, when Google withdrew from China. Baidu index has been a widely-used quantitative measure for public concern, opinions, consensus or sentiment (Fang et al., 2020; Li et al., 2021a).

Table 1 reports summary statistics for the main variables used in our analysis. The average NCD yield spread in our sample is 57.9 basis points (median 51.4), much smaller than the corporate bond yield spread of around 150 basis points in the same period (Gao et al., 2022). The average initial maturity is 7.13 months (median 6), consistent with banks managing short-term liquidity via issuing NCDs.

3.2. Empirical methodology

To examine whether banks exposed to the COVID-19 pandemic experience a surge in funding costs, we start by exploring how the offering yield spread of bank *j*'s NCD *i* issued on date *t* depends on the number of newly COVID-19 cases per capita of city *k* in which bank *j* locates using the baseline regression specification:

$$Spread_{i,j,k,t} = \alpha + \beta COVID_{k,t} + \gamma_1 \sum NCDControls_{i,j,k,t} + \gamma_2 \sum BankControls_{j,k,t} + \varepsilon_{i,j,k,t} \quad (1)$$

where $Spread_{i,\,j,\,k,\,t}$ is the offering yield spread of NCD *i* issued by bank *j* in city *k* on date *t*, and $COVID_{k,\,t}$ is the number of newly confirmed COVID-19 cases per ten thousand people in city *k* over seven days prior to the offering date. Our proxy for banks' exposure to the pandemic captures the idea that banks in regions with a higher density of newly confirmed COVID-19 cases are more likely to suffer from pandemic-induced adverse shocks. Given the large set of potential determinants of credit spreads, we also includeNCD-level and issuer-level control variables in our regression models. Specifically, following Pérignon et al. (2018), the NCD-level control variables include $Size_{i,\,j,\,k,\,t}$, $Term_{i,\,j,\,k,\,t}$, $Rating_{i,\,j,\,k,\,t}$, and the issuer-level control variables include one-year-lagged $BankSize_{j,\,k,\,t}$, $ROA_{j,\,k,\,t}$, $NPL_{j,\,k,\,t}$, and $Lev_{j,\,k,\,t}$, that is, the latest observable information on the bank's financial performance. Our issuer-level control variables are measured at the bank-year level.

From an identification perspective, the timing of having new COVID-19 confirmed cases is plausibly exogenous to the credit risk of NCD issuers and city credit risk due to the random nature of virus spread, distinguishing from typical financial crises where many factors are endogenously determined by bank fundamentals. Nonetheless, we address the potential omitted unobservable variable problem. For instance, higher virus contagion risk might be higher in major cities with intensive human mobility, where local banks are simultaneously more likely to have low credit spreads due to a better economic environment, which may make our estimates downward biased. We deal with this issue by including bank fixed effects, which capture any time-invariant unobserved heterogeneity across banks. We also include year-quarter fixed effects that capture time-varying market-wide factors related to credit spreads to control for time trends. We cluster the standard error by issuer throughout the analysis to allow for within-group correlation.

To investigate the mechanism through which the pandemic exposure increases bank funding costs, we test whether the pandemic pricing effect on NCDs is attenuated by banks' specific characteristics related to their financial conditions and operating reactions in the face of disruptions caused by the adverse shocks. To this end, we estimate the following model:

$$\begin{aligned} Spread_{i,j,k,t} = \alpha + \beta COVID_{k,t} + \theta COVID_{k,t} \cdot Characteristic_{j,k} + \gamma_1 \sum NCDControls_{i,j,k,t} \\ + \gamma_2 \sum BankControls_{j,k,t-1} + \varepsilon_{i,j,k,t} \end{aligned} \quad (2)$$

where $Characteristic_{j,\,k}$ is one dimension of the pre-pandemic features of the bank or the headquarters region related to the bank's immunity or resilience to the pandemic, including asset quality, financial flexibility, operational resilience, and government support. We also discuss the role of good prospects of COVID-19 pandemic controls in alleviating the pandemic pricing effect. The coefficient of interest is θ, which tells whether the characteristic helps mitigate the surge in NCD spreads and sheds light on our bank risk channel.

We also discuss and empirically test several alternative explanations. If it exists, the relationship between pandemic exposure and NCD spreads may be driven by supply shocks such as monetary policy intervention or investors' flight-to-liquidity behavior. In addition, banks may hoard liquidity in response to increasing economic uncertainty in the public crisis era, or try to ensure adequate funding by overreacting to pandemic outbreaks. We address these concerns by including additional control variables, altering regression specifications, and exploiting subsamples. The methodology will be described in detail in Section 4.2.2.

4. Empirical results

4.1. Impact of the COVID-19 pandemic on NCD spreads

Table 2 reports the regression results of estimating the effect of pandemic exposure on bank funding costs. The dependent variable is NCD offering yield spread, and the only independent variable in Column (1) is the newly confirmed COVID-19 cases per capita indicating the impact of the pandemic on the issuer's city right before the NCD is issued. We control for issuer fixed effects to mitigate the possible unobservable effects of issuer-level determinants. Since none of the banks in our sample has relocated its headquarters to another city, the issuer fixed effects can also account for the concern that investors prefer issuers located in major cities. In Column (2), we additionally include year-quarter fixed effects to account for the seasonality of the spreading of COVID-19 and the potential common trends in COVID-19 evolution and NCD spreads across time. In Column (3), we add several relevant variables that may affect credit spreads, including a series of NCD characteristics and bank credit ratings, financial status, capital structure, and profitability.

We find a significantly positive relationship between COVID-19 pandemic exposure and NCD spreads. In our main specification in Column (3), the regression coefficient of *COVID* is 3.088 and is significant at the 1% level; that is, a one-standard-deviation increase in newly COVID-19 confirmed cases per capita among exposed cities leads to approximately a 2.87-basis-point increase in the credit

Table 1
Summary statistics.

Variable	N	Mean	Std. Dev.	Median	Min	Max
Spread	38,418	0.579	0.290	0.514	0.127	1.334
COVID	38,418	0.00300	0.00680	0	0	0.0315
COVID(>0)	12,556	0.00920	0.00930	0.00480	0.000300	0.0315
COVID 10	38,418	0.00460	0.0103	0	0	0.0479
COVID 15	38,418	0.00740	0.0164	0	0	0.0762
COVID 20	38,418	0.0105	0.0228	0	0	0.106
COVID 30	38,418	0.0171	0.0356	0	0	0.164
Term	38,418	7.128	4.166	6	1	12
Rating	38,418	0.933	0.249	1	0	1
Size	38,418	0.764	1.356	0.588	−1.204	3.666
BankSize	38,418	8.606	1.266	8.264	6.876	11.23
ROA	38,418	0.646	0.233	0.679	0.165	1.058
NPL	38,418	1.690	0.539	1.650	0.840	3.100
Lev	38,418	0.0753	0.00960	0.0769	0.0547	0.0932

This table reports summary statistics for the main variables used in our analysis. The sample period is from January 2020 to December 2021.

Table 2
Baseline result: the effect of pandemic exposure on NCD spreads.

	(1)	(2)	(3)
	Spread	Spread	Spread
COVID	7.434***	3.113***	3.088***
	(0.842)	(0.601)	(0.584)
Term			0.002**
			(0.001)
Rating			−0.156***
			(0.031)
Size			0.016***
			(0.001)
BankSize			−0.278**
			(0.133)
ROA			−0.001
			(0.073)
NPL			−0.009
			(0.018)
Lev			−1.487
			(1.488)
Issuer FE	YES	YES	YES
Year-Quarter FE	NO	YES	YES
Observations	38,418	38,418	38,418
Adj. R^2	0.58	0.70	0.71

This table presents regression estimations of the effect of the issuer's COVID-19 pandemic exposure on NCD spreads. The dependent variable is *Spread*, which equals the difference between the NCD offering yield and the CDB yield of the same initial maturity issued on the same date. The independent variable of interest is *COVID*, which is defined as the number of newly confirmed COVID-19 cases per 10,000 people in the issuer's headquarters city over seven days before the offering date. Column (1) presents the univariate results after controlling for issuer fixed effects. Column (2) includes issuer and year-quarter fixed effects. Column (3) further adds control variables including the bond-level characteristics and issuer-level characteristics. Variable definitions are presented in Table A1. All continuous variables are winsorized at the 5th and 95th percentiles. Standard errors are clustered at the issuer level and appear in parentheses below coefficient estimates. ***, **, and * indicates significance at the 1%, 5%, and 10% level, respectively.

spread of NCDs issued by the banks headquartered in the city, which is equivalent to 9.9% (=3.088*0.0093/0.29) of the standard deviation of *Spread*. These results support H1, which proposes that the pandemic results in significantly higher credit spreads, after controlling for NCD characteristics, issuer credit risk, and market-wide effects. These findings suggest that investors price pandemic exposure as a risk factor in interbank markets.

4.2. Mechanism analyses

This subsection explores the potential channels through which the COVID-19 pandemic affects NCD spreads. The NCD spreads may be pulled up by higher risk premiums required for bearing increasing bank risk during the pandemic. Also, the pandemic effect on NCD spreads may be driven by monetary policy intervention, investors' flight-to-liquidity effect, liquidity hoarding, and banks' mispricing.

4.2.1. Increasing bank risk

First, we investigate how investors' perception on bank risk affects the pandemic effect on NCD spreads. We examine how the relationship between the increase in confirmed COVID-19 cases and NCD spreads varies across issuers with different pre-pandemic characteristics associated with the expected increase in bank risk under adverse shocks.

4.2.1.1. Asset quality. Banks' capability to maintain their stability and profitability in a pandemic outbreak is largely relevant to how severely their assets will be deteriorated by the pandemic outbreak. Traditionally, banks make profits by raising money from depositors at a relatively low interest rate and lending to firms in various industries at a higher interest rate. If its main borrowers are more adversely shocked by the pandemic and thus the ability to repay their debts severely deteriorates, the bank's financial health is expected to endure greater impairments through lending relationships (Beck and Keil, 2022). Moreover, as regional banks heavily rely on local economic development and usually withstand local economic shocks (Sun et al., 2013), banks located in a city with stronger economic development are more likely to lend to firms that can survive a pandemic, which helps the bank suffer less. Therefore, banks having more *ex-ante* pandemic-resilient loan portfolios are expected to have better asset quality during a pandemic outbreak, which would lead to a milder increase in their NCD risk premiums when a pandemic hits the city.

We test whether the banks with higher asset quality experience a smaller increase in NCD spreads when the pandemic strikes by using two dummies, *RelaInd* and *GDP_High*, to capture the bank's asset quality. Specifically, we identify transportation, storage and postal services, lodging and catering, and construction as industries more adversely impacted by the pandemic, following Gao et al. (2021). *RelaInd* takes the value of 1 if any of the above three industries was among the five industries a bank holding most loans to at the end of 2019, and 0 otherwise. *GDP_High* is an indicator variable that equals 1 if the GDP of a bank's headquartered city in 2019 is above the median and 0 otherwise.

The results in Table 3 confirm our hypotheses. In Column (1), we obtain a positive and significant interaction coefficient of 2.286,

Table 3
Asset quality and the pandemic effect on NCD spreads.

	(1)	(2)
	Spread	Spread
COVID	1.759*	5.003***
	(0.959)	(1.022)
COVID*RelaInd	2.286*	
	(1.198)	
COVID*GDP_High		−2.321*
		(1.224)
Term	0.002*	0.002**
	(0.001)	(0.001)
Rating	−0.177***	−0.154***
	(0.024)	(0.031)
Size	0.016***	0.016***
	(0.001)	(0.001)
BankSize	−0.270**	−0.272**
	(0.132)	(0.132)
ROA	−0.005	−0.006
	(0.074)	(0.073)
NPL	−0.013	−0.010
	(0.018)	(0.018)
Lev	−1.213	−1.476
	(1.514)	(1.482)
Issuer FE	YES	YES
Year-Quarter FE	YES	YES
Observations	37,475	38,418
Adj. R^2	0.71	0.71

This table presents regression estimations of how bank asset quality influences the effect of pandemic exposure on NCD spreads. The dependent variable is *Spread*, which equals the difference between the NCD offering yield and the CDB yield of the same initial maturity issued on the same date. The independent variable of interest is *COVID*, which is defined as the number of newly confirmed COVID-19 cases per 10,000 people in the issuer's headquarters city over seven days before the offering date. In Column (1), we interact *COVID* with *RelaInd*, an indicator variable that equals one for bank *i* if, at the end of 2019, any one of the industries severely affected by the outbreak of a pandemic (transportation, storage and postal services, lodging and catering, and construction) is among the top five industries to which the bank hold loans. In Column (2), we interact *COVID* with *GDP_High*, an indicator variable that equals one if the GDP per capita of the issuer's headquarters city is above the median of sample cities' GDP per capita in our sample in 2019. Variable definitions are presented in Table A1. All continuous variables are winsorized at the 5th and 95th percentiles. Standard errors are clustered at the issuer level and appear in parentheses below coefficient estimates. ***, **, and * indicates significance at the 1%, 5%, and 10% level, respectively.

which means that the increase in NCD spreads due to pandemic exposure is 130% stronger for the banks engaged more deeply in pandemic-affected industries. The negative and significant interaction coefficient in Column (2) implies that the pandemic effect on NCD spreads is 46% weaker for the banks located in cities with better economic conditions. These results suggest that banks' asset quality is taken into consideration by investors when pricing the pandemic in interbank markets.

4.2.1.2. Financial flexibility. With the pandemic exposing the regional economy to high uncertainty and increasing bank liquidity risk, banks need to use their financial resources to cope with these adverse impacts. Financial flexibility, usually representing the ease of funding a cash flow shortfall, helps avoid financial distress in an economic downturn (Fahlenbrach et al., 2021). Thus, banks with higher financial flexibility are expected to be less prone to a surge in funding costs when exposed to pandemic outbreaks. Specifically, we consider banks to be more financial flexible and would be more resilient to the pandemic if they have more assets and lower leverage *pre-pandemic*. Investors value total assets, which would cushion the revenue shortfall and loan losses resulting from the COVID-19 and avoid liquidity shortage (Beck and Keil, 2022). Thus, large banks are expected to be less negatively affected by pandemic exposure. Similarly, banks with a higher proportion of equity are more flexible in adjusting their capital composition under difficult times. Besides, since NCDs have higher payoff priority than equities, investors will perceive greater safety if the bank has more equity to absorb losses. Therefore, we expect banks with more assets and a higher equity-to-assets ratio are less affected in terms of NCD spreads in a pandemic.

We test whether more financially flexible banks experience a smaller increase in NCD spreads when the pandemic strikes by utilizing two dummies, *TA_High* and *EA_High*, to represent the bank's level of financial flexibility. *TA_High* is an indicator variable that equals one if the issuer's scale of total assets is above the median of banks' in our sample at the end of 2019, while *EA_High* equals one if the issuer's equity-to-assets ratio is above the median at the end of 2019. As predicted, in Table 4, both the coefficients on the interaction term are negative and statistically significant, implying that the effects of pandemic exposure on NCD spreads are at least 54% smaller for banks with high financial flexibility, compared with those with low financial flexibility. Our findings are consistent

Table 4
Financial flexibility and the pandemic effect on NCD spreads.

	(1)	(2)
	Spread	Spread
COVID	6.371***	4.322***
	(0.817)	(0.653)
COVID*TA_High	−3.692***	
	(1.032)	
COVID*EA_High		−2.343**
		(1.031)
Term	0.002**	0.002**
	(0.001)	(0.001)
Rating	−0.153***	−0.155***
	(0.031)	(0.031)
Size	0.016***	0.016***
	(0.001)	(0.001)
BankSize	−0.274**	−0.272**
	(0.132)	(0.133)
ROA	−0.003	0.004
	(0.073)	(0.072)
NPL	−0.009	−0.009
	(0.018)	(0.018)
Lev	−1.424	−1.425
	(1.478)	(1.489)
Issuer FE	YES	YES
Year-Quarter FE	YES	YES
Observations	38,418	38,418
Adj. R^2	0.71	0.71

This table presents regression estimations of how bank financial flexibility influences the effect of pandemic exposure on NCD spreads. The dependent variable is *Spread*, which equals the difference between the NCD offering yield and the CDB yield of the same initial maturity issued on the same date. The independent variable of interest is *COVID*, which is defined as the number of newly confirmed COVID-19 cases per 10,000 people in the issuer's headquarters city over seven days before the offering date. In Column (1), we interact *COVID* with *TA_High*, an indicator variable that equals one if the issuer's total assets is above the median of banks' in our sample at the end of 2019. In Column (2), we interact *COVID* with *EA_High*, an indicator variable that equals one if the issuer's equity-to-assets ratio is above the median at the end of 2019. Variable definitions are presented in Table A1. All continuous variables are winsorized at the 5th and 95th percentiles. Standard errors are clustered at the issuer level and appear in parentheses below coefficient estimates. ***, **, and * indicates significance at the 1%, 5%, and 10% level, respectively.

with Dent et al. (2021) who document that the response of funding costs to an adverse shock is greater at low initial levels of solvency.

4.2.1.3. Operational resilience. Beyond corporate financial flexibility, investors are further concerned about the degree of managerial ability (Jebran and Chen, 2022) and potential agency problems (Yi et al., 2022). Since the pandemic hinders banking operations due to mobility restrictions, investors value a myriad of ways in which banks can maintain normal operations and stay resilient to the pandemic. First, a bank holding more diversified portfolios and depending less on a certain business would be less sensitive to asset-specific shocks (Baele et al., 2007). Second, banks can also improve risk management by geographical diversification, extending their business to other regions to have a wider customer base and diversify regional risk(Goetz et al., 2016). While prior studies reveal that workplace flexibility is helpful for non-financial firms to stabilize operating activities during the pandemic (Fahlenbrach et al., 2021; Barry et al., 2022), banks usually rely on the physical workplace for providing banking services, for certain crucial operations must be conducted by appointed people on site due to accordance requirements. Even in such a technological era, traditional banking still requires in-person communications (Levine et al., 2020). Banks with more inter-region branches are expected to better diversify the uncertainty of regional pandemic outbreaks. Third, since the pandemic has disrupted many offline businesses, FinTech has become increasingly important for banks to promote businesses without spatial restrictions and mitigate the adverse impacts of lockdowns. FinTech has influenced investors' perceptions of banks' ability to maintain stable operations and performance during the pandemic

Table 5
Operational resilience and the pandemic effect on NCD spreads.

	(1)	(2)	(3)	(4)	(5)	(6)
	Spread	Spread	Spread	Spread	Spread	Spread
COVID	5.903***	5.663***	5.069***	6.911***	4.997***	4.781***
	(1.165)	(1.021)	(0.580)	(0.721)	(0.812)	(0.620)
COVID*BusiDiv_High	−3.305**					
	(1.324)					
COVID*GeoDiv		−3.151**				
		(1.212)				
COVID*GeoDiv_Share			−4.751***			
			(1.565)			
COVID*FinTech_High				−4.495***		
				(0.946)		
COVID*BoardInd_High					−2.257**	
					(1.038)	
COVID*Listed_A						−1.954**
						(0.947)
COVID*Listed_H						−2.728**
						(1.067)
Term	0.002**	0.002**	0.002**	0.002**	0.002**	0.002**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Rating	−0.154***	−0.154***	−0.155***	−0.153***	−0.154***	−0.155***
	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)
Size	0.016***	0.016***	0.016***	0.016***	0.016***	0.016***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
BankSize	−0.276**	−0.274**	−0.276**	−0.272**	−0.276**	−0.268**
	(0.133)	(0.133)	(0.133)	(0.132)	(0.132)	(0.133)
ROA	−0.000	0.002	0.004	−0.001	−0.003	0.003
	(0.073)	(0.073)	(0.072)	(0.073)	(0.073)	(0.071)
NPL	−0.009	−0.008	−0.009	−0.009	−0.009	−0.010
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)
Lev	−1.433	−1.439	−1.504	−1.469	−1.473	−1.443
	(1.489)	(1.478)	(1.485)	(1.490)	(1.490)	(1.491)
Issuer FE	YES	YES	YES	YES	YES	YES
Year-Quarter FE	YES	YES	YES	YES	YES	YES
Observations	38,418	38,418	38,052	38,418	38,418	38,418
Adj. R^2	0.71	0.71	0.71	0.71	0.71	0.71

This table presents regression estimations of how bank operational resilience influences the effect of pandemic exposure on NCD spreads. The dependent variable is *Spread*, which equals the difference between the NCD offering yield and the CDB yield of the same initial maturity issued on the same date. The independent variable of interest is *COVID*, which is defined as the number of newly confirmed COVID-19 cases per 10,000 people in the issuer's headquarters city over seven days before the offering date. The regressions also include the interaction between *COVID* and several bank characteristics measured at the end of 2019. *BusiDiv_High* is an indicator variable that equals one if the issuer's level of business diversification, measured as the ratio of bank's net fee and commission income to operating income, is above the median. *GeoDiv* is an indicator variable that equals one if the bank operates at least one branches outside its home province. *GeoDiv_Share* is the bank's proportion of cross-province branches. *FinTech_High* is an indicator variable that equals one if the number of the news concerning the bank's FinTech adoption is above the median. *BoardInd_High* is an indicator variable that equals one if the proportion of independent directors in the board is above the median. *Listed_A* is an indicator variable that equals one if the bank is A-share listed, while *Listed_H* equals one if the bank is H-share listed. Variable definitions are presented in Table A1. All continuous variables are winsorized at the 5th and 95th percentiles. Standard errors are clustered at the issuer level and appear in parentheses below coefficient estimates. ***, **, and * indicates significance at the 1%, 5%, and 10% level, respectively.

(Dadoukis et al., 2021; Kwan et al., 2021). Therefore, banks with a higher level of business diversification, geographical diversification, and FinTech development, are expected to have a stronger capability to maintain normal operations in difficult times, leading to a less sensitive surge in NCD spreads during the pandemic.

Under difficult circumstances, investors perceive managerial diligence as a particularly important factor in predicting to what extent a bank can handle the risk, since managers have more opportunities to intentionally blame economic uncertainty for unsatisfactory performance (Aebi et al., 2012; Wang et al., 2022). This potential outcome undermines investors' trust in bank resilience and increases bank funding costs, especially for banks lacking internal and external supervision. In line with this conjecture, we expect that local pandemic outbreaks lead to a smaller increase in NCD spreads for banks with higher board independence, which indicates stronger internal supervision and better discipline (Liang et al., 2013; Faleye and Krishnan, 2017), and listed banks, which are under stricter information disclosure requirements and external supervision.

Table 5 presents the results on operational resilience's attenuation role in the pandemic exposure pricing effect. To test the conjecture that the increased risk premiums in a pandemic result from disruptions to banking operations, we use five sets of variables identifying banks' operational resilience: business diversification, measured as the ratio of a bank's net fee and commission income to operating income; geographical diversification, proxied by an indicator variable that equals one if a bank owns at least one cross-province branches, and the bank's proportion of cross-province branches; FinTech adoption, measured based on the news volume regarding the bank's FinTech adoption; board independence, measured as the ratio of a bank's proportion of independent directors in the board, and listing status. Column (1) shows that NCD spreads respond less to pandemic exposure for business-diversified banks. The coefficient magnitudes imply that the relation between pandemic exposure and NCD spreads is 56% weaker for such banks,

Table 6
Government support and the pandemic effects on NCD spreads.

	(1)	(2)	(3)	(4)	(5)
	Spread	Spread	Spread	Spread	Spread
COVID	3.606***	3.599***	4.737***	5.143***	2.623***
	(0.633)	(0.587)	(0.723)	(0.701)	(0.670)
COVID*CSOE	−3.215**				
	(1.335)				
COVID*SOEshare_High		−3.766**			
		(1.501)			
COVID*BranchShare_High			−2.639***		
			(0.995)		
COVID*AssetsToGDP_High				−2.621***	
				(0.997)	
COVID*Deficit_High					2.228*
					(1.169)
Term	0.002**	0.002**	0.002**	0.002**	0.002**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Rating	−0.155***	−0.155***	−0.154***	−0.154***	−0.155***
	(0.031)	(0.031)	(0.031)	(0.031)	(0.031)
Size	0.016***	0.016***	0.016***	0.016***	0.016***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
BankSize	−0.278**	−0.277**	−0.273**	−0.272**	−0.280**
	(0.133)	(0.133)	(0.135)	(0.132)	(0.132)
ROA	−0.003	−0.003	−0.002	−0.004	−0.001
	(0.073)	(0.074)	(0.073)	(0.073)	(0.073)
NPL	−0.010	−0.010	−0.009	−0.010	−0.009
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)
Lev	−1.531	−1.446	−1.492	−1.481	−1.531
	(1.480)	(1.478)	(1.482)	(1.481)	(1.492)
Issuer FE	YES	YES	YES	YES	YES
Year-Quarter FE	YES	YES	YES	YES	YES
Observations	38,418	38,418	38,052	38,418	38,418
Adj. R^2	0.71	0.71	0.71	0.71	0.71

This table presents regression estimations of how government support influences the effect of pandemic exposure on NCD spreads. The dependent variable is *Spread*, which equals the difference between the NCD offering yield and the CDB yield of the same initial maturity issued on the same date. The independent variable of interest is *COVID*, which is defined as the number of newly confirmed COVID-19 cases per 10,000 people in the issuer's headquarters city over seven days before the offering date. The regressions also include the interaction between *COVID* and several bank or regional characteristics measured at the end of 2019. *CSOE* is an indicator variable that equals one if the bank's largest shareholder is central government or central state-owned enterprise. *SOEshare_High* is an indicator variable that equals one if the total shares of SOE shareholders in the top five shareholders is > two-thirds of all the shares of the bank. *BranchShare_High* is an indicator variable that equals one if the proportion of the bank's branches in all the bank branches operating in its headquarters province is above the median of sample banks. *AssetsToGDP_High* is an indicator variable that equals one if the ratio of the bank's total assets to the GDP of its headquarters province is above the median of sample banks. *Deficit_High* is an indicator variable that equals one if the ratio of fiscal expenditure to revenue of the bank's headquarters province is above the median of sample provinces. Variable definitions are presented in Table A1. All continuous variables are winsorized at the 5th and 95th percentiles. Standard errors are clustered at the issuer level and appear in parentheses below coefficient estimates. ***, **, and * indicates significance at the 1%, 5%, and 10% level, respectively.

representing a major economic effect. The coefficients of the interaction terms *COVID*GeoDiv* and *COVID*GeoDiv_Share* are also negative and significant in Columns (2) and (3), consistent with the diversification role of cross-region branches. Column (4) shows that the NCD spreads issued by banks with better FinTech adoption is more resilient to pandemic exposure. As is shown in Column (5), the significantly negative coefficient of the interaction term *COVID*BoardInd_High* suggests that the relationship between pandemic exposure and NCD spreads is 45% weaker for banks internally supervised better. Column (6) implies that listed banks with stronger external supervision and higher information transparency experience a smaller increase in NCD spreads during a pandemic outbreak, especially for H-share listed banks which are under stricter information disclosure standards and with better investor protection. These results suggest that, to a significant extent, investors price managerial diligence as operational resilience other than risk responding ability, consistent with Aebi et al. (2012) who find that effective bank governance helps improve bank performance during financial crises.

4.2.1.4. Government support. The pandemic intensifies investors' worry about downside tail risk and improves the value of government bailout. With the unprecedented COVID-19 pandemic arousing enormous economic turmoil, downside tail risk seems more likely to become a real loss. As a result, investors require insurance against downside tail risk compared with normal times. Government ownership plays an indispensable role in counter-cyclical stabilization for banks under difficult times (Bertay et al., 2015) in that it shapes the expectation of government support received by a bank once it goes into distress (Iannotta et al., 2013; Duan et al., 2021). Having shareholders with deep pockets should become more valuable in the pandemic era because it reassures investors' nerves about the rising default risk of banks exposed to a pandemic (Gatev and Strahan, 2006). Additionally, a bank is more likely to receive government support when it is of greater importance to the local economy (O'Hara and Shaw, 1990; Bongini et al., 2015). We measure a bank's importance to the local economy using the proportion of the bank's branches in all the branches in the headquarters province, which is associated with the bank's deposit taking in the province, and the ratio of the bank's assets to the regional GDP, which indicates the significance of the bank's credit supply in the local economy. Besides, a local government with low deficits is expected to be more capable and more willing to recure distressed local banks. Therefore, we expect that banks whose largest shareholder is the central government or central state-owned enterprise, whose SOE shareholders have dominant cash flow rights and control power, whose impact on the local economy is stronger, and whose headquarters province has a solid fiscal capacity, are penalized less by investors when a pandemic outbreak hits.

Table 6 presents how government support influences the NCD spreads of banks exposed to pandemic outbreaks. Consistent with our prediction that investors value government support when the likelihood of extreme losses surges, in Column (1), the pandemic effect on NCD spreads of banks whose large shareholders are central state capital or central government is 89% smaller than other banks. Also, Column (2) shows that the pandemic effect almost vanishes in banks whose government and SOE top five shareholders control > two-thirds of their outstanding shares, where the government has a strong incentive to support banks in crises because of its dominating control over bank decisions. Additionally, in Columns (3) and (4), the impact of pandemic outbreaks on NCD spreads attenuates as the bank being more important to the local economy. In Column (5), banks located in provinces with higher fiscal deficits experience a more pronounced increase in NCD spreads. These results confirm that government bailout expectation is more valuable during the pandemic.

While bank failure is a rare event, which means that the probability of NCD default is quite limited even in the advent of the pandemic, our findings indicate that pandemic exposure is sensitively priced in interbank markets. Although we find sound evidence that investors price the pandemic-induced bank risk when making NCD subscription decisions, we acknowledge that our results are muted in distinguishing whether the risk is mainly default risk, liquidity risk, rollover risk, or other forms of risk. Banks are expected to be exposed to higher liquidity risk if investors anticipate that the pandemic will bring about a severe economic downturn and creditors, mainly depositors, will have to withdraw from the banks due to income shocks. Given the high frequency of NCD issuances, the ability of re-funding in the NCD market should be crucial to NCD pricing, in that once a bank fails to roll over its cash flow, the possibility that it also fails to repay its other previously issued NCDs spikes. These risks are by no means mutually exclusive in pricing the NCDs, a class of unsecured but conditionally insured financial assets only traded in a market whose players are all sophisticated institutional investors.

4.2.2. Alternative explanations

While the above findings support that the pandemic exacerbates bank risk and leads to a surge in bank funding costs, we theoretically discuss and empirically exclude several alternative mechanisms of the pandemic effect on NCD spreads.

One possibility is that contemporaneous monetary policy interventions or banking regulations coincide with pandemic outbreaks and bring about the variation in NCD spreads. Deposit bank funding costs are affected by monetary policy and the interest rate environment (Gerlach et al., 2018); so are interbank financing. However, we argue that monetary policies are unlikely to be the driving determinant for the positive relationship between pandemic exposure and NCD spreads we observe. First, if monetary policies inject liquidity into the financial market instantly, we should see a decrease rather than an increase in the NCD spreads. Government interventions during the pandemic often provide market liquidity and alleviate the rise of credit spreads (Kargar et al., 2021). Since the advent of the COVID-19 pandemic in early 2020, the Chinese government has activated stronger counter-cyclical adjustment measures of monetary policy and released short-term liquidity. The higher liquidity supply is expected to alleviate the rise of interbank financing costs, which makes it more difficult to observe the positive and significant relationship between the pandemic exposure and NCD

spreads. Second, given that monetary policies or regulations implemented by the central government are usually nationwide and influence the market condition as a whole, monetary policy interventions should not lead to differences in NCD spreads between banks exposed to local pandemic outbreaks and those not with the inclusion of the time and bank fixed effects. Third, if the additional liquidity prefers banks not experiencing a pandemic, this structural imbalance also implies the role of bank risk instead of monetary policy intervention. Although the reasons discussed above hint that monetary policies should not drive our results, we still evaluate the merit of this alternative explanation with regression specifications formally.

It still emerges that banks with a pandemic exposure experience higher NCD spreads after controlling for market liquidity and year-month fixed effects to take the potential impacts of monetary policy interventions into consideration. In Columns (1) and (2) of Table 7, we additionally include the logarithm volume of M2 (*lnM2*) and monthly growth rate of M2 (*M2Growth*) as control variables, respectively, and still observe larger NCD spreads for banks located in cities experiencing a pandemic. In Column (3), we alter the year-quarter fixed effects in baseline specification in Column (3) of Table 2 to the year-month fixed effects, and the result remains. While the economic magnitudes of the effects are slightly smaller than our baseline result, we can conclude that our findings are unlikely driven by monetary policy interventions.

Another potential concern is that the relationship between banks' rising interbank funding cost and the pandemic we observe is driven by investors' flight-to-liquidity (Rösch and Kaserer, 2014) or flight-from-maturity (Gorton et al., 2021). If this is the underlying mechanism, the pandemic pricing effect should be more pronounced for NCDs with longer terms under investors' favor of more liquid assets. We augment Eq. (1) with the interaction terms of *COVID* and a series of dummies that indicate the NCD's initial maturity. All four indicator variables equal zero if the NCD has an initial maturity of twelve months.

Table 7
Alternative explanations: monetary policy intervention and investors' flight-to-quality effect.

	(1)	(2)	(3)	(4)
	Spread	Spread	Spread	Spread
COVID	2.747***	2.459***	1.612***	2.330***
	(0.555)	(0.550)	(0.357)	(0.732)
COVID*Month_1				5.251***
				(1.391)
COVID*Month_3				0.064
				(0.943)
COVID*Month_6				0.464
				(1.030)
COVID*Month_9				−0.369
				(0.561)
lnM2	−1.857***			
	(0.273)			
M2Growth		−0.064***		
		(0.008)		
Term	0.002*	0.002**	0.002*	0.003**
	(0.001)	(0.001)	(0.001)	(0.001)
Rating	−0.157***	−0.156***	−0.166***	−0.154***
	(0.033)	(0.033)	(0.040)	(0.031)
Size	0.016***	0.016***	0.015***	0.015***
	(0.001)	(0.001)	(0.001)	(0.001)
BankSize	−0.266**	−0.270**	−0.217	−0.275**
	(0.134)	(0.136)	(0.147)	(0.133)
ROA	0.007	0.006	−0.016	−0.006
	(0.074)	(0.074)	(0.074)	(0.072)
NPL	−0.007	−0.008	−0.011	−0.010
	(0.018)	(0.018)	(0.017)	(0.018)
Lev	−1.448	−1.374	−1.343	−1.416
	(1.494)	(1.476)	(1.392)	(1.482)
Issuer FE	YES	YES	YES	YES
Year-Quarter FE	YES	YES	NO	YES
Year-Month FE	NO	NO	YES	NO
Observations	38,418	38,418	38,418	38,418
Adj. R^2	0.71	0.71	0.76	0.71

This table presents regression estimations of whether monetary policy intervention and investors' flight-to-liquidity cause the increase in NCD spreads. The dependent variable is *Spread*, which equals the difference between the NCD offering yield and the CDB yield of the same initial maturity issued on the same date. The independent variable of interest is *COVID*, which is defined as the number of newly confirmed COVID-19 cases per 10,000 people in the issuer's headquarters city over seven days before the offering date. In Columns (1)–(2), we include additional monthly control variables *lnM2* and *M2Growth*, respectively, to control for monetary policy intervention. In Column (3), we further control year-month fixed effects to rule out unobservable factors related to monetary policy intervention. In Column (4), we investigate whether maturity affects the NCD pricing effect of the COVID-19 pandemic exposure monotonically by interacting *COVID* with a series of dummies indicating the NCD's maturity, respectively. *Month_1* is an indicator that equals one for an NCD with an initial maturity of one month, and the rest are defined analogically. Variable definitions are presented in Table A1. All continuous variables are winsorized at the 5th and 95th percentiles. Standard errors are clustered at the issuer level and appear in parentheses below coefficient estimates. ***, **, and * indicates significance at the 1%, 5%, and 10% level, respectively.

Column (4) of Table 7 reports the results considering the heterogeneous of different initial maturities, showing that prices of NCDs with an initial maturity of one month are most affected by the pandemic, which contradicts what the flight-to-liquidity effect implies. More specifically, the pandemic effect on the spread of one-month NCDs is 225% stronger than on the spread of twelve-month NCDs and statistically significant at the 1% level, more consistent with the hypothesis that investors are concerned about the intensified bank risk in the short term. Furthermore, the pandemic effect is not monotonic across different initial maturities, which also suggests that the flight-to-liquidity effect cannot serve as the underlying mechanism for investors' pattern of NCD pricing during a pandemic.

Certificates of deposit are cheaper than close substitutes like interbank debt or central bank funding (Pérignon et al., 2018), implying that a bank might deliberately shift to the NCD market when its funding is stressed by a pandemic outbreak, which means the pricing effect is likely to be caused by demand-side factors. Prior literature demonstrates the phenomenon of liquidity hoarding in time of a crisis to prepare for an unanticipated liquidity shortage (Afonso et al., 2011). Despite higher deposit inflows during the pandemic (Levine et al., 2021b), it is still necessary for banks to replenish liquidity from the interbank market (Acharya and Mora, 2015). Hence, it is natural that banks turn to interbank lenders, leading to a consequence that liquidity in the interbank market gains a higher price in equilibrium. If this mechanism works, we should see a more pronounced effect on the banks that are weak in raising deposits, because they are likely more heavily dependent on interbank funding. Additionally, if our baseline result is driven by changes in liquidity demand rather than risk, we should observe a positive relationship between the pandemic exposure and the amount of NCDs issued in the same month, or between the amount of NCDs that were subscribed to in the previous month and the spreads.

To test the above conjectures, we first add the interaction of *COVID* and *DepToDebt_High*, an indicator variable that equals one if the issuer's deposit-to-liabilities ratio is above the median at the end of 2019. Column (1) of Table 8 shows that that its coefficient is insignificant, indicating that there is no significant evidence that the sensitivity of NCD spreads to local pandemic exposure depends on whether the bank depends more on interbank funding market or not. Then, we use the monthly total amount of NCDs issued by a bank as the dependent variable, and Column (2) shows no significant evidence on banks issuing more NCDs at the onset of the pandemic outbreaks. We control for the amount of NCDs subscribed to in the headquarters province in the previous month, and find that our main result remains almost unchanged in Column (3), indicating that the surge in NCD spreads is not totally driven by the surplus demand for interbank funding. The coefficient on *IssuedPreMon* implies that this factor has a neither statistically nor economically

Table 8
Alternative explanations: banks' liquidity hoarding and mispricing.

	(1)	(2)	(3)	(4)	(5)
	Spread	Amount	Spread	Spread	Spread
COVID	2.916***	0.034	3.099***	2.791***	3.271***
	(0.701)	(0.040)	(0.591)	(0.713)	(0.622)
COVID*DepToDebt_High	0.745				
	(1.147)				
IssuedPreMon			0.001		
			(0.003)		
Term	0.002**	−0.000***	0.002**	0.004**	0.001
	(0.001)	(0.000)	(0.001)	(0.002)	(0.001)
Rating	−0.155***	0.003	−0.156***	−0.163***	−0.132***
	(0.031)	(0.003)	(0.031)	(0.022)	(0.045)
Size	0.016***	0.001***	0.016***	0.016***	0.015***
	(0.001)	(0.000)	(0.001)	(0.002)	(0.001)
BankSize	−0.278**	−0.013	−0.279**	−0.300	−0.265***
	(0.133)	(0.008)	(0.133)	(0.234)	(0.092)
ROA	−0.001	0.013**	−0.001	−0.055	0.095
	(0.073)	(0.006)	(0.073)	(0.092)	(0.096)
NPL	−0.009	−0.001	−0.009	−0.025	0.005
	(0.018)	(0.001)	(0.018)	(0.021)	(0.023)
Lev	−1.482	−0.097	−1.495	−2.838**	−0.450
	(1.486)	(0.097)	(1.486)	(1.104)	(2.109)
Issuer FE	YES	YES	YES	YES	YES
Year-Quarter FE	YES	YES	YES	YES	YES
Observations	38,418	38,418	38,418	16,905	21,512
Adj. R^2	0.71	0.45	0.71	0.73	0.69

This table presents regression estimations of whether banks' liquidity hoarding and mispricing cause the increase in NCD spreads. In Columns (1) and (3)–(5), the dependent variable is *Spread*, which equals the difference between the NCD offering yield and the CDB yield of the same initial maturity issued on the same date, and the independent variable of interest is *COVID*, which is defined as the number of newly confirmed COVID-19 cases per 10,000 people in the issuer's headquarters city over seven days before the offering date. In Column (1), we interact *COVID* with *DepToDebt_High*, an indicator variable that equals one if the issuer's deposit-to-debt ratio is above the median at the end of 2019. In Column (2), we regress the total amount of NCDs issued in the same month scaled by the bank's total assets on the pandemic exposures. In Column (3), we additionally control for *IssuedPreMon*, which denotes the amount of NCDs issued in the headquarters province the previous month. In Columns (4) and (5), we run the same regression using two subsamples respectively, the former one comprised of NCDs without full subscription while the latter one comprised of NCDs fully subscribed. Variable definitions are presented in Table A1. All continuous variables are winsorized at the 5th and 95th percentiles. Standard errors are clustered at the issuer level and appear in parentheses below coefficient estimates. ***, **, and * indicates significance at the 1%, 5%, and 10% level, respectively.

significant impact on the pricing of highly liquid NCDs. These results help to exclude the explanation of banks' liquidity hoarding.

An alternative, yet not mutually exclusive, explanation is that investors do not envision banks exposed to the pandemic as riskier and require higher premiums, but that banks under idiosyncratic liquidity risk misprice their NCDs to ensure raising enough funds (Bechtel et al., 2023). To address this concern, we exploit the fact that banks disclose the magnitude of money they would like to raise through a single NCD issuance *ex-ante* and the *ex-post* amount of money actually raised. Specifically, we split the sample into two subsamples, one comprised of NCDs without full subscription while the other comprised of NCDs fully subscribed, and rerun the regression using the baseline specification.

The corresponding results of NCD mispricing are reported in Columns (4) and (5) of Table 8, respectively. We find that our main result still holds in Column (4), even though its numerical magnitude declines. Although the effect on NCD pricing is more pronounced among the fully subscribed NCDs as in Column (5), which implies that at least some banks do misprice their NCDs, given that results in Column (4) showcase the equilibrium effect, mispricing cannot fully explain the increase in NCD spreads for banks in pandemic exposure.

Table 9
Prospects of the COVID-19 control and the pandemic effect on NCD spreads.

	(1)	(2)
	Spread	Spread
COVID	5.255***	4.148***
	(0.755)	(0.517)
COVID*WHLifLd	−3.715***	
	(0.865)	
COVID*Vaccine	−5.619***	
	(1.003)	
COVID*SARS		−2.687**
		(1.222)
Term	0.002**	0.002**
	(0.001)	(0.001)
Rating	−0.164***	−0.155***
	(0.034)	(0.031)
Size	0.016***	0.016***
	(0.001)	(0.001)
BankSize	−0.305**	−0.276**
	(0.133)	(0.132)
ROA	0.013	0.000
	(0.078)	(0.072)
NPL	−0.007	−0.010
	(0.019)	(0.018)
Lev	−1.320	−1.486
	(1.484)	(1.485)
Issuer FE	YES	YES
Year-Quarter FE	YES	YES
Observations	38,418	38,418
Adj. R^2	0.71	0.71

This table presents regression estimations of how the prospects of the COVID-19 control influences the effect of pandemic exposure on NCD spreads. The dependent variable is *Spread*, which equals the difference between the NCD offering yield and the CDB yield of the same initial maturity issued on the same date. The independent variable of interest is *COVID*, which is defined as the average number of newly confirmed COVID-19 cases per 10,000 people in the issuer's headquarters city over seven days before the offering date. In Column (1), we split the sample into three periods and investigate how pandemic evolution affects the COVID-19 pandemic exposure's NCD pricing effect. *WHLifLd* denotes an indicator variable that equals one if the date of the NCD issuance is between April 8, 2020, when the lockdown on Wuhan was lifted, and December 31,2020, when it was reported that China's first self-developed COVID-19 vaccine was granted conditional marketing authorization. *Vaccine* denotes an indicator variable that equals one if the NCD's issuance date was after December 31, 2020. In Column (2), we interact *COVID* with *SARS*, an indicator variable that equals one if the province in which the bank's headquarters locate reported >100 confirmed cases of SARS in 2003. Variable definitions are presented in Table A1. All continuous variables are winsorized at the 5th and 95th percentiles. Standard errors are clustered at the issuer level and appear in parentheses below coefficient estimates. ***, **, and * indicates significance at the 1%, 5%, and 10% level, respectively.

4.3. Further discussion

4.3.1. Prospects of COVID-19 pandemic control and the pricing effect of pandemic exposure on NCDs

The timeliness and proactiveness of the response to a COVID-19 outbreak influence the extent to which the pandemic harms the local economy. Therefore, if the worsening effects of pandemic exposure on bank funding are indeed driven by a shock to the local economy which intensifies bank risk, we should observe heterogeneous effects due to the city's ability to respond to the pandemic. In this subsection, we investigate whether the positive relationship between NCD spreads and local pandemic exposure varies across time and regions that might respond to the pandemic differently.

As time goes by, epidemic prevention and control situation evolve, and investors' concern on the potential pandemic damage to the local economy changes. For instance, with the physical lockdown in Wuhan lifted, people nationwide were reassured and encouraged that the epidemic could be controlled, which might lead to investors' re-evaluation of bank risk in case the bank gets involved in a pandemic. Also, after COVID-19 vaccines became available, more people would get immunity to the viruses, mitigating the pandemic's adverse effects on the local economy. To test the conjectures, we construct two dummies, *WHLifLd* and *Vaccine*, and include their respective interaction terms with *COVID* in our baseline specification. *WHLifLd* is an indicator variable that takes the value of one if the date of the NCD issuance is between April 8, 2020, when the lockdown on Wuhan was lifted, and December 31, 2020, when it was reported that China's first self-developed COVID-19 vaccine was granted conditional marketing authorization, while the *Vaccine* dummy equals one if the NCD's issuance date was after December 31, 2020.

As Column (1) in Table 9 shows, in line with our conjectures, both coefficients on the interaction term are negative and statistically significant, suggesting that the unfavorable pricing effect is 71% smaller after the lockdown in Wuhan was lifted and further mitigated after the national vaccination approval. These results indicate that as the society becomes armed to dampen the adverse effects of the COVID-19, banks exposed to pandemic experience a rise in NCD yield spreads to a smaller extent.

Investors' perception of a region's pandemic-induced risks is related to the imprint of similar viruses' experiences (Ru et al., 2021),

Table 10
Instrumental variable estimation.

	(1)	(2)	(3)	(4)	(5)	(6)
	COVID	Spread	COVID	Spread	COVID	Spread
COVID_CityIV	1.327***					
	(0.112)					
COVID_ProvIV			0.806***			
			(0.056)			
PassVol					0.005***	
					(0.001)	
COVID		9.493***		9.385***		13.713***
		(1.066)		(0.970)		(4.295)
Term	−0.000	0.003**	−0.000	0.002**	−0.000	0.002**
	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.001)
Rating	0.001	−0.164***	0.001*	−0.162***	0.001	−0.169***
	(0.001)	(0.033)	(0.001)	(0.034)	(0.001)	(0.038)
Size	0.000**	0.016***	0.000**	0.015***	0.000***	0.015***
	(0.000)	(0.002)	(0.000)	(0.001)	(0.000)	(0.001)
BankSize	0.001	−0.340**	−0.001	−0.273**	0.002	−0.283**
	(0.003)	(0.149)	(0.003)	(0.127)	(0.003)	(0.122)
ROA	0.004*	−0.062	0.004*	−0.019	0.005**	−0.058
	(0.002)	(0.078)	(0.002)	(0.076)	(0.002)	(0.085)
NPL	0.001	−0.025	0.001**	−0.013	0.001	−0.013
	(0.000)	(0.017)	(0.000)	(0.018)	(0.000)	(0.019)
Lev	0.070**	−3.932***	0.039*	−1.596	0.037	−1.812
	(0.032)	(0.997)	(0.022)	(1.493)	(0.027)	(1.496)
Issuer FE	YES	YES	YES	YES	YES	YES
Year-Quarter FE	YES	YES	YES	YES	YES	YES
Observations	28,639	28,640	38,418	38,419	38,269	38,270
Adj. R^2	0.54	0.32	0.50	0.30	0.41	0.25
Cragg-Donald F-stat	7187.91		7757.95		770.45	

This table presents the instrumental variable estimations of the effect of pandemic exposure on NCD spreads. The dependent variable is *Spread*, which equals the difference between the NCD offering yield and the CDB yield of the same initial maturity issued on the same date. The independent variable of interest is *COVID*, which is defined as the number of newly confirmed COVID-19 cases per 10,000 people in the issuer's headquarters city over seven days before the offering date. Column (1) reports the first-stage result corresponding to the second-stage result in column (2), using the average confirmed cases per capita in cities within the home province where a bank does not operate weighted by the inverse of inter-city geographical distance (*COVID_CityIV*) as the instrumental variable of *COVID*. Column (3) reports the first-stage result corresponding to the second-stage result in column (4), using the average confirmed cases per capita in neighboring provinces (*COVID_ProvIV*) as the instrumental variable of *COVID*. Column (5) reports the first-stage result corresponding to the second-stage result in column (6), using the twelve-month-lagged passenger traffic scaled by provincial population (*PassVol*) as the instrumental variable. Variable definitions are presented in Table A1. All continuous variables are winsorized at the 5th and 95th percentiles. Standard errors are clustered at the issuer level and appear in parentheses below coefficient estimates. ***, **, and * indicates significance at the 1%, 5%, and 10% level, respectively.

which may affect the pricing effect of pandemic exposure on NCDs. Compared to swine and chicken flu, whose outbreaks are scattered and could be quickly controlled, interpersonally infectious diseases that transmit rapidly and widely, cause fatalities, and challenge epidemic prevention usually have greater economic and financial impacts and leave a long-lasting impression on investors. There are many similarities between the COVID-19 pandemic and severe acute respiratory syndrome (SARS), which is also a serious infectious disease with a high level of government control. In 2003, SARS hit China, with the first reported case in Guangdong province, and soon spread to 24 provinces in mainland China. Several provinces that went through a severe SARS pandemic may learn from the experience combating the viruses and thus can take more effective measures in the COVID-19 epidemic, including better prepared medical systems, improved contingency plans, and a higher mobilizational ability for anti-epidemic resources. Therefore, investors may expect that SARS imprints could help the local governments take timely and effective containment measures, mitigating the adverse impacts of the COVID-19 pandemic on local banks. Using SARS infections to measure past epidemic experience, we construct the *SARS* dummy, which is defined as one if the bank's headquarters province was severely affected by SARS – that is, >100 confirmed cases of SARS were reported, and add the interaction term of the dummy with *COVID* in our baseline specification.

Column (2) in Table 9 shows that for banks in SARS-affected provinces, the COVID-19 outbreaks' NCD pricing effect is significantly 65% weaker, indicating that investors were less concerned, possibly due to the region's stronger ability to combat the COVID-19 pandemic. Overall, these results confirm that increasing expected losses drive the pandemic-NCD spread link.

4.3.2. Addressing endogeneity with instrument variable regressions

Although the shock of a single pandemic outbreak should be largely exogenous due to the incidentality and unpredictability of virus

Table 11
Robustness tests: alternative measure of banks' exposure to the COVID-19.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Spread	Spread	Spread	Spread	Spread	Spread	Spread
COVID	3.088***						
	(0.584)						
COVID_10		2.119***					
		(0.399)					
COVID_15			1.371***				
			(0.249)				
COVID_20				0.920***			
				(0.172)			
COVID_30					0.460***		
					(0.103)		
COVID_branch						4.058***	
						(0.415)	
COVID_Baidu							2.826***
							(1.063)
Term	0.002**	0.002**	0.002**	0.002**	0.002**	0.002**	0.002**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Rating	−0.156***	−0.156***	−0.158***	−0.158***	−0.158***	−0.162***	−0.157***
	(0.031)	(0.032)	(0.032)	(0.032)	(0.032)	(0.033)	(0.031)
Size	0.016***	0.016***	0.016***	0.016***	0.016***	0.016***	0.016***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
BankSize	−0.278**	−0.279**	−0.281**	−0.284**	−0.286**	−0.288**	−0.307**
	(0.133)	(0.133)	(0.133)	(0.133)	(0.133)	(0.133)	(0.138)
ROA	−0.001	−0.001	−0.000	0.002	0.002	0.003	−0.002
	(0.073)	(0.074)	(0.074)	(0.075)	(0.075)	(0.073)	(0.075)
NPL	−0.009	−0.010	−0.010	−0.009	−0.009	−0.010	−0.006
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)
Lev	−1.487	−1.499	−1.513	−1.516	−1.564	−1.543	−1.635
	(1.488)	(1.489)	(1.496)	(1.504)	(1.506)	(1.493)	(1.484)
Issuer FE	YES	YES	YES	YES	YES	YES	YES
Year-Quarter FE	YES	YES	YES	YES	YES	YES	YES
Observations	38,418	38,418	38,418	38,418	38,418	38,418	38,401
Adj. R^2	0.71	0.71	0.71	0.71	0.71	0.71	0.71

This table presents regression estimations addressing the measurement error issues. The dependent variable is *Spread*, which equals the difference between the NCD offering yield and the CDB yield of the same initial maturity issued on the same date. We record in Column (1) our baseline results in Table 2. The independent variable of interest is the *COVID_10* in Column (2), which is defined as the number of newly confirmed COVID-19 cases per 10,000 people in the issuer's headquarters city over 10 days prior to the offering date; *COVID_15* in Column (3), which is defined as the number of newly confirmed COVID-19 cases per 10,000 people in the issuer's headquarters city over 15 days prior to the offering date; *COVID_20* in Column (4), which is defined as the number of newly confirmed COVID-19 cases per 10,000 people in the issuer's headquarters city over 20 days prior to the offering date; *COVID_30* in Column (5), which is defined as the average number of newly confirmed COVID-19 cases per 10,000 people in the issuer's headquarters city over 30 days prior to the offering date; *COVID_branch* in Column (6) measuring the bank's exposure to the pandemic using branch number weighted confirmed cases over 7 days, and the Baidu search volume for the pandemic scaled by the number of netizens in Column (7). Variable definitions are presented in Table A1. All continuous variables are winsorized at the 5th and 95th percentiles. Standard errors are clustered at the issuer level and appear in parentheses below coefficient estimates. ***, **, and * indicates significance at the 1%, 5%, and 10% level, respectively.

spreads, a potential endogeneity concern is that to what extent a city gets infected may be related to some economic activities that simultaneously affect the regional bank's funding costs. The spread of the virus can be endogenous consequence of intra-city activities and the city's interaction with other cities, which could be directly related to the city's economic development or other city characteristics that might result in the changes in NCD spreads. This would imply that even in the presence of bank fixed effects, we do not adequately control for the unobservable omitted variables. To address the above concern, we utilize three plausible IVs to capture exogenous variation in regional pandemic exposure to identify the causal relationship. Specifically, similar to Gao et al. (2022), we instrument for *COVID* using the average newly confirmed cases per capita in the bank's neighboring cities where it does not operate in the same province weighted by the inverse of inter-city geographical distance, as well as the average newly confirmed cases per capita for the bank's neighboring provinces. We also adopt the lagged twelve-month passenger traffic scaled by the provincial population as an IV.

All the IVs are expected to satisfy the relevance restriction since they capture the bank's headquarters city's exposure to external pandemic outbreaks, or the frequency of the interaction with other regions which is closely related to virus spread across regions. To satisfy the exclusion restriction, the instrument should not be correlated to factors affecting NCD pricing that are orthogonal to the advent of the pandemic outbreaks in a city. In other words, the instrument should not affect NCD pricing via channels other than spillover effects of pandemic outbreaks. It is unlikely that a pandemic outbreak in neighboring cities in which the bank does not own a branch would change the NCD spreads of the bank, in that the bank's operation is not directly exposed to risks in such neighboring cities. Also, due to market segmentations caused by administrative division, banks are unlikely to react to pandemic outbreaks in neighboring provinces. As for passenger traffic which is indeed closely related to a city's economic condition, it is reasonable to assume that there should be no obvious relation between a bank's NCD spreads and local passenger traffic one year ago.

Table 10 presents the IV estimation results. In the first-stage results in Columns (1), (3), and (5), where *COVID* is the dependent variable, the coefficients are all positive and statistically significant, suggesting that neighboring cities or provinces being affected by the pandemic and more cross-region people mobilites increase a city's probability to catch the pandemic. The Cragg-Donald F-statistic is at least 770.45 in all three specifications, much higher than the Stock and Yogo (2005) 10% threshold of 16.4, mitigating the weak instrument concern. In the second-stage results in Columns (2), (4), and (6), the coefficients on the instrumented *COVID* are all positive and statistically significant, suggesting that exposure to local pandemic shocks increases banks' NCD yield spreads.

4.3.3. Robustness tests

The positive relationship between pandemic exposure and local banks' NCD yield spreads we observe is robust to several important robustness tests. First, we use alternative measures for local pandemic exposure to address possible measurement errors. In our tests

Table 12
Miscellaneous robustness tests.

	(1)	(2)	(3)	(4)
	Spread	Spread	Spread	Spread
COVID	4.074***	4.104***	3.148***	3.140***
	(0.502)	(0.699)	(0.563)	(0.529)
Term	0.004***	0.006***	0.003**	0.003***
	(0.001)	(0.002)	(0.001)	(0.001)
Rating	−0.152***	−0.160***	−0.125***	−0.153***
	(0.027)	(0.027)	(0.032)	(0.031)
Size	0.018***	0.023***	0.016***	0.020***
	(0.001)	(0.002)	(0.001)	(0.001)
BankSize	−0.268*	−0.373*	−0.051	−0.299*
	(0.156)	(0.222)	(0.224)	(0.167)
ROA	0.003	0.007	0.036	−0.054
	(0.078)	(0.139)	(0.110)	(0.076)
NPL	−0.012	−0.008	0.001	−0.022
	(0.019)	(0.026)	(0.024)	(0.017)
Lev	−1.135	−5.430***	−1.977	−1.528
	(1.614)	(1.665)	(1.274)	(1.470)
Issuer FE	YES	YES	NO	YES
Year-Quarter FE	YES	YES	NO	YES
Issuer-Year-Quarter FE	NO	NO	YES	NO
Observations	30,850	15,573	38,418	22,660
Adj. R^2	0.68	0.68	0.72	0.70

Bold values signifies p values below 0.05.
This table presents robustness tests on the effect of pandemic exposure on NCD. The dependent variable is *Spread*, which equals the difference between the NCD offering yield and the CDB yield of the same initial maturity issued on the same date. The independent variable of interest is the COVID, which is defined as the number of newly confirmed COVID-19 cases per 10,000 people in the issuer's headquarters city over seven days prior to the offering date. Column (1) reports regression estimations based on the subsample excluding joint-stock commercial banks. Column (2) reports regression estimations based on the subsample excluding banks headquartered in provincial capitals and Shenzhen. Column (3) further includes issuer-year-quarter fixed effects in the baseline specification. Column (4) reports regression estimation using the issuer-day panel. Variable definitions are presented in Table A1. All continuous variables are winsorized at the 5th and 95th percentiles. Standard errors are clustered at the issuer level and appear in parentheses below coefficient estimates. ***, **, and * indicates significance at the 1%, 5%, and 10% level, respectively.

presented above, we choose an event window of 7 days to construct the proxy for pandemic exposure. In Columns (2)–(5) in Table 11, we respectively extend the event window to 10, 15, 20, and 30 days prior to the date of the NCD issuance. Consistent with the estimates in the baseline regressions, which we repeat in Column (1), the pandemic-NCD spread relationship remains positive and significant, though gradually diminishes as we extend the event window. In Column (6), we measure a bank's pandemic exposure with the weighted average of COVID across cities in which the bank operates, where the weights are the fraction of the bank's number of branches in the respective city in 2019. The direction of impact does not change, and the magnitude even gets a bit larger, which is consistent with our notion that banks are exposed to intensified risks resulting from the pandemic outbreaks through their branch networks. In Column (7), we also replace the official-released numbers of confirmed COVID-19 cases with Internet search volume for the pandemic in the seven-day event window, and find that our baseline results remain robust in the absence of official numbers.

Second, we restrict our sample to address the concerns that our results are driven by banks with specific but omitted characteristics or by banks agglomerating in certain cities. In Column (1) in Table 12, we exclude joint-stock banks, which are likely to be different from city commercial banks due to their franchises-related nature, and in Column (2), we exclude banks that are located in provincial capitals or Shenzhen. As is shown, the coefficients on *COVID* are both positive and significant, even slightly larger than our baseline estimate. Given that joint-stock banks are permitted to extend branch networks around the country, and that banks located in provincial capitals usually extend to neighboring cities, these results highlight the role of the potentially disruptive effect a pandemic can have on regionally focused banks like city commercial banks in pricing the pandemic-exposed NCDs.

Third, we include stringent fixed effects to ensure our results are not driven by omitted variables that simultaneously influence pandemic outbreaks and NCD spreads. Column (3) shows that our results are virtually unaltered after further controlling for factors related to particular time-variant issuer characteristics by adding issuer-quarter fixed effects.

Finally, our main results are robust at the bank-day level. Specifically, for banks that issue more than one NCD on the same day, we only keep the NCD observation with the largest offering amountand longest initial maturity, and drop the NCDs issued on a day with <5 banks issuing NCDs. As Column (4) shows, the results are remarkably similar to our baseline regressions.

5. Conclusions

Using the setting of NCD issuance during the pandemic, this study investigates whether and how the COVID-19 pandemic affects bank funding costs. We find that a bank with higher pandemic exposure would experience a significant surge in NCD spreads. Mechanism analyses show that the pandemic effect on NCD spreads can be alleviated by banks' asset quality, financial flexibility, operational resilience, and government support, indicating that the pandemic deteriorates bank assets quality, disrupts operations, and increases tail risk. We rule out the alternative explanations of the concurrent monetary policy interventions and regulations, the flight-to-liquidity effect, banks' liquidity hoarding, and banks' mispricing in NCD offerings. Moreover, the pricing effect of pandemic exposure can be attenuated by investors' prospects of the pandemic being controlled. The findings hold to endogeneity issues and a series of robustness checks. The results indicate that regional pandemic outbreaks result in investors' prospects of higher local bank risks, which are substantially priced in interbank markets.

Our findings provide several implications. First, with the public health crisis exerting widespread impacts on real economic and financial markets similar to those of financial crises, there is an urgent demand for preventing and resolving intensified and accumulated bank risks. Appropriate and effective actions to control the adverse impacts of the pandemic on economic activities may help stabilize regional economic development. Second, bank resilience is expected to be critical in analyzing bank performance and financial decisions in the post-pandemic era.

The long-term changes in the operating and funding environment require banks to enhance the resilience of capital and operation against difficult economic circumstances and increased economic uncertainty. We suggest more research to provide new insights into banking in the pandemic and post-pandemic era. How the pandemic affects bank financing instruments other than NCDs, such as Tier-2 capital bonds, repurchase agreements, and equities, still remains understudied. Moreover, it would be interesting to explore more deeply on how bank business models, bank governance, and government support, affect banks' immunity to the pandemic. On a more general level, our paper hints at a novel and critical topic on how banking activities and financial stability would be disrupted by natural catastrophes and extreme events, whose causes and potential government measures usually distinguish from those of financial crises.

Declaration of Competing Interest

All authors have no competing interests.

Acknowledgements

We thank the editor and an anonymous referee for valuable comments. This work is supported by the Outstanding Innovative Talents Cultivation Funded Programs 2022 of Renmin Univertity of China. All errors are our own.

Appendix A

Table A1 Variable definitions.

Variable	Definition
Key variable	
COVID	The number of newly confirmed COVID-19 cases per ten thousand people in a city over 7 days prior to the offering date
COVID_10	The number of newly confirmed COVID-19 cases per ten thousand people in a city over 10 days prior to the offering date
COVID_15	The number of newly confirmed COVID-19 cases per ten thousand people in a city over 15 days prior to the offering date
COVID_20	The number of newly confirmed COVID-19 cases per ten thousand people in a city over 20 days prior to the offering date
COVID_30	The number of newly confirmed COVID-19 cases per ten thousand people in a city over 30 days prior to the offering date
COVID_branch	Weighted average of COVID across cities where a bank operates, weighted by the bank's proportion of branches in every city at the end of 2019
COVID_Baidu	Baidu search volume for keyword "yiqing" (pandemic) over 7 days prior to the offering date scaled by the number of city-level netizens
Instrument variable	
COVID_CityIV	Weighted average of COVID across cities in the same province where a bank does not operate or neighboring provinces for municipalities, weighted by the inverse of the of inter-city geographical distance
COVID_ProvIV	Average of COVID across neighboring provinces
PassVol_lag	The twelve-month lagged passenger traffic scaled by the provincial population
NCD characteristics	
Spread	The difference between the offering yield of an NCD and the yield of the maturity-matched Chinese Development Bank bond issued on the same date
Term	The initial maturity of an NCD (in months)
Size	The natural logarithm of the NCD's eventually subscribed value
Month_1	An indicator variable that equals one if the initial maturity of an NCD is one month
Month_3	An indicator variable that equals one if the initial maturity of an NCD is three months
Month_6	An indicator variable that equals one if the initial maturity of an NCD is six months
Month_9	An indicator variable that equals one if the initial maturity of an NCD is nine months
Issuer characteristics	
Rating	An indicator variable that equals one if the rating of the issuer is AAA or AA+
BankSize	The natural logarithm of book value of total assets (in 100 million RMB)
ROA	Net income divided by average total assets
NPL	The ratio of non-performing loans to gross loans
Lev	Book value of total equity divided by book value of total assets
RelaInd	An indicator variable that equals one if any one of the industries including (1) transportation, storage and postal services, (2) lodging and catering, and (3) construction is among the top five industries to which the bank hold loans at the end of 2019
TA_High	An indicator variable that equals one if a bank's total assets is above the median of sample banks at the end of 2019
EA_High	An indicator variable that equals one if a bank's equity-to-assets ratio is above the median of sample banks at the end of 2019
BusiDiv_High	An indicator variable that equals one if a bank's ratio of net fee and commission income to operating income is above the median of sample banks at the end of 2019
GeoDiv	An indicator variable that equals one if a bank has at least one interprovince branches
GeoDiv_Share	The proportion of the bank's interprovince branches at the end of 2019
FinTech_High	An indicator variable that equals one if the number of news reports regarding a bank's FinTech development is above the median of sample banks in 2019
BoardInd_High	An indicator variable that equals one if the proportion of independent directors in the board is above the median at the end of 2019
Listed_A	An indicator variable that equals one if a bank is A-share listed at the end of 2019
Listed_H	An indicator variable that equals one if a bank is H-share listed at the end of 2019
CSOE	An indicator variable that equals one if the large shareholder (retail investors excluded) is central government or central state-owned enterprise
SOEshare_High	An indicator variable that equals one if in the top five shareholders, the proportion of the shares held by a SOE entity accumulate to over two-thirds of the bank's outstanding shares at the end of 2019
BranchShare_High	An indicator variable that equals one if the proportion of a bank's branches in all the branches operating in its headquarters province is above the median of sample banks at the end of 2019
AssetsToGDP_High	An indicator variable that equals one if the ratio of the a bank's assets to the GDP of the headquarters province is above the median of samples banks at the end of 2019
DepToDebt_High	An indicator variable that equals one if the ratio of deposit-to-liabilities of a bank is above the median of sample banks at the end of 2019
Region characteristics	
GDP_High	An indicator variable that equals one if the GDP per capita of the headquarters city is above the median of sample headquarters cities in 2019
Deficit_High	An indicator variable that equals one if the ratio of fiscal expenditure to revenue of the headquarters province is above the median of sample headquarters provinces in 2019
IssuedPreMon	The natural logarithm of the total amount of NCDs issued by banks headquartered in the home province in the previous month
SARS	An indicator variable that equals one if the headquarters province was reported to detect >100 confirmed cases of SARS

(*continued on next page*)

(*continued*)

Variable	Definition
Time series	
lnM2	The natural logarithm of monthly broad money supply (M2, in billion RMB)
M2Growth	The monthly year-on-year growth rate of broad money supply
WHLifLd	An indicator variable that equals one if the issuance day of an NCD is after April 8, 2020 and before December 31, 2020
Vaccine	An indicator variable that equals one if the issuance day of an NCD is after December 31, 2020

This table defines the variables used in the empirical analysis. The NCD and bank data, obtained from the Wind database, are complemented with data from CSMAR, CNRDS, CEIC, and the banks' annual reports. All continuous variables are winsorized at the 5th and 95th percentiles.

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