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Collateral-Based Monetary Policy: Evidence From China

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ABSTRACT

We exploit the unique institutional features of Chinese bond markets to estimate the causal effect of collateral-based monetary policy on asset prices and the real economy. A policy change allowed certain bonds to be used as collateral for the Medium-Term Lending Facility in the interbank market, while the same bonds in the exchange market remained ineligible. This change reduced the spreads of the newly eligible bonds by 37–53 basis points, or 10%–15% of the average spread in the secondary interbank market, with a strong pass-through rate of 67 to over 100% to the primary interbank market.

JEL Classification: E52, E58, G12

1 | Introduction

One big lesson from the Global Financial Crisis (GFC) is the important role of collateral and leverage in the modern financial and monetary systems (Gorton and Metrick 2012). Ever since the GFC, unconventional collateral-based monetary policy has been adopted widely across the world, for example, the Federal Reserve's Term Asset-Backed Securities Loan Facility (TALF) and the European Central Bank (ECB)'s Long-Term Refinancing Operations (LTROs).[1] Collateral-based monetary policy tools have been invoked for at least two reasons. First, from a theoretical point of view, the collateral-based monetary policy can be used by the central bank to ease the heightened funding constraint and to reverse the deleveraging cycle in the financial system (e.g., Kiyotaki and Moore 1997; Fostel and Geanakoplos 2008; Geanakoplos 2010; Ashcraft et al. 2011). Second, from a practical point of view, once the zero-lower-bound (ZLB) constraint of short-term rate begins to bind, which renders ineffective the interest rate-based tools, collateral-based tools seem to be a natural alternative.

Despite the theoretical appeal and broad deployment of the unconventional collateral-based monetary policy during and after the GFC, it is empirically difficult to identify its *causal* impact on the financial markets and the real economy. The main challenge is the lack of proper policy counterfactuals (see Nakamura and Steinsson 2018). There are several reasons for the empirical challenge. First, in the leverage cycle theory, both the interest rate (spread) and leverage (or haircut) are endogenously determined in equilibrium. Thus, the empirical relationship between haircuts and spread in the typical bond market data is not causal. Second, the timing of central banks' implementation of collateral-based monetary policy is not random. The policy can be an endogenous response to financial market turmoil, making it difficult to disentangle its effect from confounding factors that triggered the policy response. Third, the assets that are made eligible or ineligible as collateral for financial and nonfinancial institutions to borrow from the central banks' lending facilities are usually carefully selected.[2] As a result, the counterfactual outcomes for the spreads of the collateral assets in the absence of the monetary policy intervention are hard to assess, making it difficult to

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estimate the causal effect of the monetary policy. In this paper, we address the identification problem using a triple-difference (DDD) empirical design, by exploiting a unique feature of China's bond market and a policy intervention by China's central bank. We estimate the causal impact of the collateral-based monetary policy both on the secondary bond markets and on the primary bond issuance markets (thus the real economy).

The unique feature of China's bond markets is that most corporate bonds are *dual-listed* in two trading platforms: the *interbank* market and the *exchange* market. These two platforms are subject to different regulations and *differentially* affected by monetary policy interventions. In particular, the interbank market is connected to the central bank's lending facilities while the exchange market is not. Equally importantly, they are largely *segmented* due to difficulties in arbitrage. As a result, even though the *dual-listed* bonds have exactly the same fundamentals, they can have different prices or spreads in the two markets, due to, for example, different liquidity in the two markets.[3]

On June 1, 2018, the People's Bank of China (PBOC), which is China's central bank, for the first time made corporate bonds and some financial bonds rated AA and AA+ as eligible collateral for financial institutions to borrow from its Medium-Term Lending Facilities (MLF) connected to the *interbank* market. Importantly, the policy does not apply in the exchange market, as the exchange market is not connected to the central bank's lending facilities. Note that all corporate bonds with AAA ratings have always been eligible collateral for the MLF.

The sudden collateral-based policy change in the *interbank* market enables us to implement a DDD approach to examine the effect of the collateral-based monetary policy. By comparing the changes, before and after the policy shock, in the difference of spreads of the newly collateral-eligible bonds (the treatment bonds) and other bonds (the control bonds) between the two markets, we are able to identify the causal effects of the collateral-based monetary policy on the bond spreads. The changes in the difference in the spreads between the "control" and "treatment" bonds in the exchange market (which serves as the role of "policy counterfactual" or the "placebo") reflect the possible differential impact of time-varying factors on the two groups of bonds.[4] Under the plausible identification assumption, which we formally describe in Section 5.4, that the same differential impact of the time-varying factors on the control and treatment bonds applies in the interbank market and the exchange market, then we can use the "placebo effect" estimated from the exchange market to tease out the effect of the time-varying factors in the interbank market. Note that, for our empirical identification strategy, it is crucial that the interbank market and the exchange market are segmented; otherwise, the policy intervention in the interbank market would impact the pricing of the dual-listed bonds in the exchange market, thus contaminating the "placebo."

We find that the collateral-based monetary policy effectively decreases the spreads of bonds in the interbank cash bond market. The policy leads to an average reduction of the spreads of the newly collateralizable bonds by 37–53 basis points (bps)—which is about 10%–15% of the mean spreads—in the interbank market compared to the dual-listed bonds in the exchange market.

We also analyze the pass-through effect of the secondary market policy shock to the primary market (and thus the real economy). We find that making the treated bonds collateral eligible for MLF in the interbank (secondary) market also reduces their spreads at issuance in the interbank market by 35–53 bps, *ceteris paribus*. That is, the pass-through rate is between about 67% and more than 100%. Since the spread reduction of the newly issued collateral-eligible bonds reflects a reduction in the funding cost of the corporate issuers, our estimated high pass-through rate to the primary bond issuance market thus indicates a real effect of the collateral-based monetary policy. The policy not only has an impact on the price of existing bonds but also has an impact on new bond issuance. We also find that collateral-eligible bonds are more likely to be issued in the interbank market after the policy shock.

We further examine the mechanism through which collateral-based monetary policy affects bond spreads. The change of the bond spreads may result from a repricing of the default risk (Geanakoplos 1997;;2010), and/or an improvement in the market liquidity because the central bank is a significant bond trader that can improve the market depth (Kyle 1989).

For the default risk channel, we present a simple model which shows that collateral-based monetary policy may influence the repo haircuts of bonds and, consequently, their prices. A repo, or repurchase agreement, is a wholesale lending contract where bonds are commonly used as collateral. The loan is typically less than the collateral's market value, and the percentage gap between the market value of the collateral and the loan amount is called a "*haircut*." We find that the repo haircut decreases for the new collateral-eligible bonds by 3% in the interbank market after the policy shock, consistent with our model that collateral-based monetary policy decreases the spreads of eligible bonds by increasing their collateral value.

Another potential mechanism is that the MLF collateral expansion increases the market liquidity of the newly eligible bonds. We test this mechanism by decomposing the bond spread into liquidity spread and default spread. We find that the MLF collateral expansion does not have a significant impact on the liquidity spread. Our findings suggest that collateral-based monetary policy changes bond spreads mostly through collateral values instead of market liquidity. Furthermore, we establish the empirical linkage between the repo haircut and the default spread. We use the collateral expansion as an instrumental variable to estimate the causal impact of haircuts on bond spreads. The results suggest that a 1% lower haircut reduces the default spread by nearly 20 bps.

Our paper makes four contributions to the literature. First, to our knowledge, the paper is among the first to use a clean quasi-natural experiment to identify the causal effects of collateral-based monetary policy on asset prices in the secondary market, and further on the real economy. This is important because collateral-based monetary policy has been widely adopted after the GFC. Second, this paper complements the monetary policy research on the risk-taking channel in terms of both asset prices and quantity. We find that the collateral-based monetary policy leads to a repricing of the bond default risk. Furthermore, we find that the monetary policy induces more bonds to be issued in the interbank market. Third, while existing works have analyzed China's traditional monetary policy tools, for example, interest rate adjustments (Chen et al. 2018;;2022), our paper provides detailed documentation and analysis, thus providing a better understanding of China's collateral framework and monetary policies in general. In particular, we focus on the MLF, which has played an increasingly significant role in the PBOC's toolbox since its debut in 2014. Finally, our paper also adds new causal evidence to the existing but scant literature on leverage and asset pricing (Chen et al. 2023; Wang and Xu 2019).

The remainder of the paper is structured as follows. In Section 2, we review the most related literature; in Section 3 we introduce the institutional background of the Chinese bond markets and the relevant policy change; in Section 4 we present a simple model to illustrate how collateral eligibility of a bond affects its secondary market price and the primary market coupon rate in equilibrium; in Section 5, we formalize our identification assumption and proceed to analyze the secondary bond market; in Section 6, we present results related to the primary bond issuance market; in Section 7, we explore the potential mechanisms that explain our findings; and finally, in Section 8, we conclude.

2 | Related Literature

The paper is closely related to the literature on collateral-based unconventional monetary policy, for example, central bank repo and lending facilities. Many theoretical papers point out that assets' collateral value or pledgeability affects their prices, and then draw important implications for financial fragility and financial cycles (Kiyotaki and Moore 1997; Geanakoplos 1997; Fostel and Geanakoplos 2008; Geanakoplos 2010; Garleanu and Pedersen 2011; Gorton and Metrick 2012; Geanakoplos and Zame 2014; Ai et al. 2020).[5] There are several empirical papers evaluating the effect of collateral-based monetary policies on asset prices. Some studies find a positive effect of collateral-based monetary policy. For example, Ashcraft et al. (2011) find that TALF eligibility effectively increased the investors' valuation for Commercial Mortgage-Backed Securities (CMBS) bonds. Benetton and Fantino (2018) study the effects of Targeted Longer-Term Refinancing Operations (TLTROs) by the ECB on the financing costs of Italian firms, and find that the interest rates decreased by 20 bps for the loans from banks that accepted TLTROs. Studies also show heterogeneous effects of the policies. For example, Krishnamurthy et al. (2017) find that LTROs reduced the spreads of Spanish sovereign debts, while they had little effect on those of other EU countries. Benetton and Fantino (2018) show that the effects of TLTROs depended on the market structure of the local banking industry. Despite these findings, it is difficult to establish a proper policy counterfactual and determine the causal effects of collateral-based monetary policies due to the potential endogeneity of these monetary policy interventions to financial market turmoil. Our paper aims to fill this gap in the literature.

Our paper is also related to the empirical literature that examines the risk-taking channel of monetary policy, that is, the impact of monetary policy on the perception and pricing of risk by economic agents (à la Borio and Zhu 2012).[6] Some recent papers find a positive effect of unconventional monetary policy on risk taking. For example, Hattori et al. (2016) find that the communication about the future path of policy rates reduced volatility expectations of long-term rates and the associated risk premia. Rodnyansky and Darmouni (2017) find that QE1 and QE3 has strong effects on banks' credit supply. Chakraborty et al. (2020) find that banks benefiting from MBS purchases of the US Federal Reserve have increased mortgage origination. Some studies find potential distortionary effects of collateral-based monetary policy. For example, Nyborg (2017) argues that more lax collateral eligibility by the ECB creates perverse incentives for financial institutions to produce low-quality assets. In the context of the Netherlands, van Bekkum et al. (2017) find that when the ECB lowered RMBS eligibility to BBB− rating, banks issued more low-rated RMBS with higher default rates. Chen et al. (2018);;2022) find that the nonstate banks in China increase shadow banking in response to contractionary monetary policies. Acharya et al. (2019) find that the ECB's Outright Monetary Transactions (OMT) program led banks to prolong their lending to zombie firms. Our paper complements the literature by showing that the collateral-based monetary policy leads to a repricing of the default risk of newly collateralizable bonds and more issuance of the newly eligible bonds in the primary interbank market.

Finally, this paper is related to a strand of emerging empirical literature testing the asset pricing implications of collateral and leverage (Hansman et al. 2018; Chen et al. 2023; Wang and Xu 2019; Nyborg and Woschitz 2021). Two papers that are closely related to our paper are Chen et al. (2023) and Wang and Xu (2019). They both exploit the sudden tightening of pledgeability requirement in China's *exchange bond market*, and find that decreasing pledgeability as repo collateral reduces bond prices.[7] Compared with these two papers, we complement their studies by considering the central bank's expansion of eligible collateral for the MLF, which directly affects the collateral in the *interbank bond market*.[8] In addition, we provide evidence of the impacts of the collateral-based monetary policy on bond spreads not only in the secondary market but also in the primary issuance market (thus the real economy).

3 | Institutional Background

3.1 | Bond Markets in China

Before we elaborate on the collateral-based monetary policy in China, it is useful to provide an overview of the unique institutional setting of Chinese bond markets.[9] In China, there are two parallel bond markets: the *interbank market*, and the *exchange market*. The interbank bond market, established in 1997, is an over-the-counter (OTC) bond market and is similar to the interbank bond market in the United States. In contrast, the exchange bond market, established in 1990, is a centralized market as part of the Shanghai and Shenzhen Stock Exchanges. Both markets are composed of a *cash* bond market (for primary issuance and secondary trading) and a *repo* market. In the cash bond market, the seller receives cash and cede the ownership of the bonds to the buyer; in contrast, in the repo market a lender provides cash to a borrower with the loan secured by the collateral (typically bonds) from the borrower, but the ownership of the bonds does not change unless the borrower defaults. In most of our analysis, with the exception of Section 7, we focus on the cash bond market, which allows us to abstract away from the endogenous joint determination of "haircuts" and "interest rates" in repo markets.[10]

3.1.1 | Participants

The participants in the two bond markets vary, but they overlap in most of the nonbank institutional investors. The interbank bond market is a wholesale market, where participants are qualified institutional investors including *commercial banks*, mutual funds, insurance companies, and security firms. The exchange-based bond market is a retail market, where nonbank institutions, corporate investors, and retail investors are allowed to invest in bonds. Commercial banks' presence in the exchange market is negligible because they are prohibited from repo transactions. Many nonbank institutions, such as mutual funds and insurance companies, are active in both markets. The fact that commercial banks are for the most part operating only in the interbank bond market is important because, together with the fact that the participants of MLF are "commercial banks and policy banks that are subject to the macroprudential regulations," it implies that the collateral-based monetary policy tools such as the MLF are then closely linked to the interbank market, not the exchange market.[11]

3.1.2 | Bond Products

Bonds traded in the exchange market on average tend to be smaller in size than those traded in the interbank market; nevertheless, many bond products in some categories, mainly enterprise bonds and government bonds, are *dual-listed*, that is, traded in both markets. *Enterprise bonds* are corporate bonds issued by state-owned enterprises or enterprises with a high share of state holdings. Before 2005, investors in the exchange market had no access to enterprise bonds. In 2005, the National Development and Reform Commission (NDRC) in China granted non-public-listed state-owned enterprises access to the exchange market. Since 2005, dual-listed enterprise bonds have been growing rapidly. In 2018, over 28% of the enterprise bonds outstanding were *dual-listed*. In our full data sample, 21.42% of the bond-day transactions observations are from dual-listed bonds. These dual-listed bonds will play an important role in our identification strategy.

3.1.3 | Regulators and Clearing Houses

The two markets have different regulators. The main regulator of the interbank bond market is the PBOC, which is China's central bank. The regulator of the exchange market is the China Securities Regulatory Commission (CSRC).[12]

In the interbank market, participants trade via the China Foreign Exchange Trade System (CFETS). The clearing service is provided by Shanghai Clearing House (SHCH) and China Central Depository & Clearing Co. Ltd (CCDC). The custodial service is provided exclusively by CCDC. In contrast, in the exchange market, all bids from investors are aggregated in electronic order books, with the exchange acting as the central clearing house, and all matched trades are settled via CSDC.

3.1.4 | Repo Transactions

The lion's share of transactions in both the interbank and the exchange markets is repurchase agreement (Repo) transactions. It is estimated that repo transactions take up over 85% of the total volume in the interbank bond market.

The mechanisms of repo transactions in the two markets differ greatly. In the exchange market, the Exchange (CSDC) facilitates and acts as the central counterparty for all repo transactions. The eligible collateral pool and the daily haircut rates of the collateral for repo transactions are both determined by CSDC unilaterally. Specifically, the repo transaction accepts only AAA rated bonds as collateral in 2018.[13]

In the interbank bond market, prior to October 16, 2018, the seller and buyer can bargain over the terms in the contract, including the required collateral, haircut, and repo rate, until the agreement is reached. The haircut and repo rate are customized according to the underlying risk of the collateral and the trading parties. Conversations with practitioners reveal that both AAA and AA+ bonds are popular collateral in the interbank market. After October 16, 2018, CCDC can serve as the triparty agent to determine the eligibility and valuation of the collateral, while the sellers and buyers only need to negotiate the borrowing amount, the repo maturity, and the interest rate.

Although borrowing bonds for the purpose of short-selling is allowed in the interbank bond market, it is very limited.[14] Borrowing cost is high due to the regulation. In addition, once the value of the bonds borrowed by an institution exceeds 30% of its total holdings, or the amount of a bond being borrowed exceeds 15% of its total issuance, it has to be reported to CFETS and CCDC.[15] Such features are crucial to our analysis as the cost of borrowing bonds prevents the investors from short-selling.

The difference in the mechanisms of repo transactions in the two markets results in different collateral values of the same bond across the two parallel markets. The interbank (exchange, respectively) repo transactions can only use the bonds traded in the interbank (exchange, respectively) market as collateral. It prevents the arbitrage of collateral values in the two markets.

3.1.5 | Market Segmentation

Even though traders and products overlap in the interbank market and the exchange market, the two bond markets are largely segmented because specific rules make arbitrage between the two markets very difficult. As a result, the different collateral requirements for repo purchases can result in substantial wedges in the prices of the same bond—if dual-listed—in the two markets.[16]

There are several barriers to arbitrage between the two markets. First, transferring a bond from one market to the other takes substantial time. Suppose an investor wants to exploit a price difference by selling bonds acquired on the exchange market in the interbank market. She must first apply for a transfer of custody from the exchange market to the interbank market. In 2018, such a transfer required about 2–3 business days.

Transferring bonds in the opposite direction—from the interbank market to the exchange market—took even longer, with about 5 business days. The delays expose arbitrageurs to substantial price risk and prevent the same-day arbitrage. Second, only bonds that are dual-listed on both markets are eligible for such transfers. As a result, price differences between bonds traded in the interbank market and other bonds with similar fundamentals traded in the exchange market cannot be arbitraged. Third, the settlement fee is relatively high compared to the potential gains from cross-market arbitrages. If the investor uses 100 million yuan to arbitrage for 50 bps spread, the gain would be around 1300 yuan without considering the settlement delay, while the estimated settlement fee is 170–250 yuan. Compared to other strategies, cross-market arbitrage is not a very profitable option for investors. As a result of these barriers, we can treat the two bond markets as more or less segmented, with potentially sustained price differences across the two markets even for the same bonds. The segmented nature of the two markets plays a crucial role in our identification strategy to estimate the causal impact of collateral-based monetary policy. In Section 5, we will provide direct empirical evidence for the segmentation of the two bond markets.

3.2 | Collateral-Based Monetary Policy in China

In this paper, we analyze the collateral channel of monetary policy using the following unexpected policy shock: On June 1, 2018, China's central bank, the PBOC, expanded the types of collateral it would allow primary dealers (commercial and policy banks) to use when borrowing from the MLF.[17] Launched in September 2014, the MLF is a facility managed by the PBOC that offers lending to commercial banks and policy banks with eligible collateral for 3/6/12 months. An important feature of the MLF is that it only accepts targeted bonds listed in the interbank market as collateral, rather than the same kind of bonds in the exchange market.[18]

Before this expansion of eligible collateral, the MLF accepts Treasury bonds, central bank bills, policy bank financial bonds, municipal bonds, and AAA corporate bonds as collateral. The expansion will enable (1) corporate bonds, (2) bonds issued by small and micro firms (*Xiaowei Bonds*), (3) bonds to support a green economy (*Green Bonds*), and (4) financial bonds serving agriculture and rural areas (*Sannong Bonds*), provided that they are rated at least AA, to be used as collateral for the MLF.[19,20] The total amount of newly pledgeable bonds for the MLF was between 400 and 600 billion yuan (about $80 billion). The PBOC claimed that the move is aimed at lowering funding costs and enhancing support to smaller businesses.

It is not the first time for the PBOC to use collateral-based monetary policy. Table 1 illustrates the collateral-based monetary policy tools that the PBOC launched prior to 2018. In January 2013, the PBOC launched the Short-term Liquidity Operation (SLO) and the Standing Lending Facility (SLF), providing liquidity to primary dealer banks with a maturity of fewer than 7 days and between 1 and 3 months, respectively, backed by high-quality assets. In 2014, the PBOC shifted to a longer-term collateral-based monetary policy: the Pledged Supplementary Lending (PSL) in April 2014, and the MLF in September 2014, respectively. The last row of Table 1 lists the eligible collateral for each lending facility as of December 31, 2018.

The collateral-based lending facilities have gained increasing significance in the PBOC's monetary policy since 2014. Figure 1 depicts the growing size of lending through the SLF, MLF, and PSL by the PBOC during the period of March 2013 and January 2019.[21] It is interesting to note that, although these unconventional monetary policy tools were only introduced between 2013 and 2014, they experienced rapid growth since their launch. At the end of 2018, the balance of the MLF, SLF, and PSL accounted for about 25% of China's monetary base, as is shown in Figure 1, with the MLF being the largest component of the PBOC's collateral-based lending facilities.

Shifting from traditional monetary policy to unconventional monetary policy changes the way China's central bank provides liquidity. Figure 2 illustrates the liquidity transmission mechanism of traditional and collateral-based monetary policy. In the traditional liquidity transmission mechanism, the central bank influences the broad financing conditions in the economy by steering the interbank rate. In the unconventional liquidity transmission system, the central bank decides not only the interest rates but also the eligible collateral for SLF, MLF, or PSL lending facilities. By accepting the relatively illiquid assets as collateral, the central bank can influence the repo haircuts and bond prices in the secondary market. Furthermore, it affects the bond coupon rates in the primary market and therefore the real economy.[22]

Theoretically at least, the collateral-based monetary policy tools offer the central bank more flexibility than the traditional interest rate policies when the policy goals include lowering the borrowing cost of some targeted sectors. Take the MLF as an example. In the expansion of eligible MLF collateral on June 1, 2018, the PBOC made corporate bonds and financial bonds of *Xiaowei* firms, *Green* firms, and *Sannong* firms with at least AA ratings to be eligible collateral, which lowered the spreads of these bonds in the secondary market, as we will show in Section 5. This, theoretically, would in turn further decrease the coupon rate of these bonds in the primary market.[23] If working effectively, the MLF would then ease the funding constraints for commercial banks that support small firms, environmental protection, and agriculture. We will indeed provide evidence of the primary market reactions in Section 6.

China is not alone in adopting unconventional monetary policy tools. The MLF resembles the first three rounds of LTROs by the ECB in the Eurozone, with 6-month to 1-year maturity.[24] The United States launched the TALF in 2008 and the Federal Reserve Bank of New York (FRBNY) loaned up to $200 billion on a nonrecourse basis to holders of certain AAA rated ABS backed by newly and recently originated consumer and small business loans under the TALF.[25] Although the collateral-based monetary policy tools adopted in China and many other countries have been theoretically predicted to be useful, an empirical test of the effectiveness of these unconventional monetary policies is not easy. As these policies are always concurrent with other monetary policies and financial regulations and are endogenous to the underlying macroeconomic conditions, it is difficult to isolate the causal impact of these collateral-based monetary policies from other confounding factors.

TABLE 1 | Collateral-based monetary policy tools of the People's Bank of China as of December 31, 2018

Name	Short-term Liquidity Operation, SLO	Standing Lending Facility, SLF	Medium-term Lending Facility, MLF	Pledged Supplementary Lending, PSL
Launch time	January 2013	January 2013	September 2014	April 2014
Maturity	<7 days	1–3 months	3 months/6 months/1 year	3–5 years
Collateral	Treasury bonds, central bank bills, policy bank financial bonds, commercial bank bonds	High credit rating corporate bonds, and high-quality asset	Treasury bonds, central bank bills, policy bank financial bonds, corporate bonds and *Sannong*, *Green* and *Xiaowei* bonds rated at least AA	High credit rating corporate bonds and high-quality asset

Note: This table documents the launch time, the maturity, and the eligible collateral for collateral-based monetary policy tools of the People's Bank of China as of December 31, 2018.

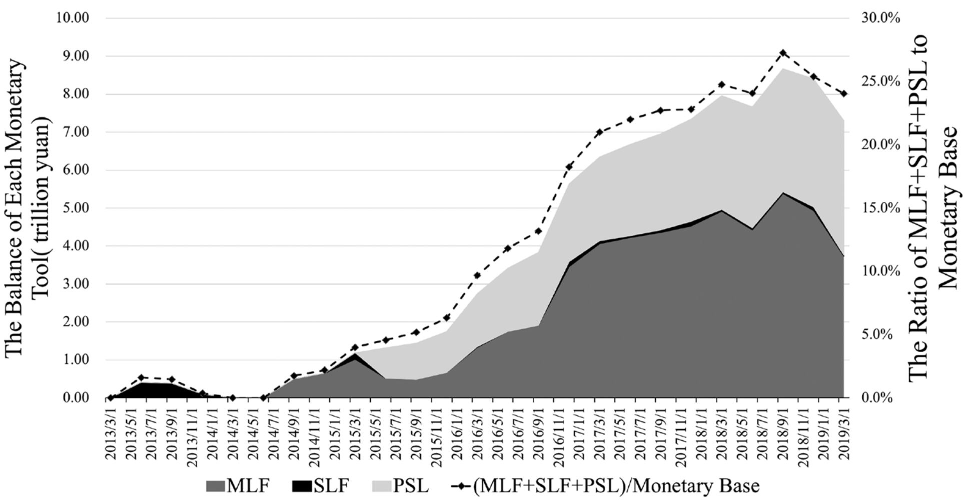


FIGURE 1 | Balance of the PBOC's collateral-based lending facilities.
Note: This figure shows the balance of the PBOC's collateral-based lending facilities in Table 1. Statistics are calculated with data reported by the People's Bank of China, obtained from WIND, as of May 30, 2019.

The unique coexistence and the segmentation of the interbank bond market and the exchange bond market in China offer us a rare opportunity to identify the causal impact of the collateral-based monetary policy using a clear identification strategy. As the policy shock of June 1, 2018 only applies to bonds in the interbank market, and the disparate regulations and barriers between the two bond markets effectively prevent investors from arbitraging, we can isolate the causal impact of the collateral-based monetary policy. By comparing the changes, before and after the policy shock, in the difference of spreads of the newly collateral-eligible bonds (the treatment bonds) and other bonds (the control bonds) in the two markets, we are able to identify the causal effects of the collateral-based monetary policy on the financial market. In addition, we are able to examine the transmission of the monetary policy operations in the secondary market to the primary market, and thus the impact on the real economy. In other words, we will provide causal empirical evidence of the transmission mechanisms of the unconventional collateral-based monetary policy as depicted in Figure 2.

4 | A Simple Model

In this section, we present a simple model, à la Geanakoplos (2010), to illustrate how collateral-based monetary policy affects both the bond price in the secondary market and the coupon rate of new bond issuance in the primary market. In this model, we analyze both the cash bond market and the repo market. In the absence of collateral-based monetary policy, bonds are eligible as collateral for traders to borrow from one another, subject to an endogenous haircut, similar to the functioning of the repo market. When collateral-based monetary policy is in effect, the central bank permits traders to borrow from the MLF using the eligible bonds as collateral with an exogenous haircut.

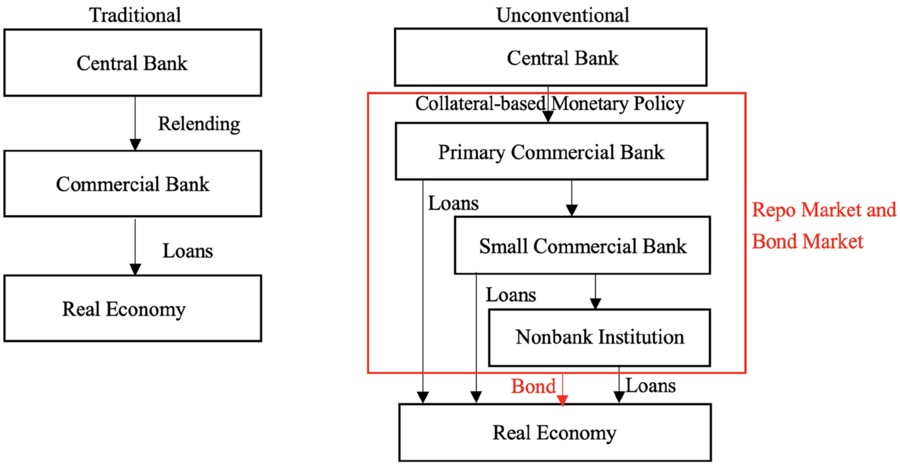


FIGURE 2 | Liquidity transmission mechanisms of traditional and unconventional monetary policies in China.
Note: This figure shows the liquidity transmission mechanisms of the monetary policies in China. See the detailed explanation in the text.

We will demonstrate that this collateral-based monetary policy can influence the prevailing haircut and, consequently, the bond prices, both in the secondary and the primary bond markets.

The economy has two assets: cash and a risky bond. For ease of exposition, we will cast the environment in continuous time. Each unit of the risky bond pays coupons at a rate C from time 0 till maturity. Assume the bond cannot default on its coupon but may default on its principal at the maturity date. Suppose that there are two possible states in the final period: if the economy is in the high state, the bond does not default, and it returns the principal 1; if the economy is in the low state, the bond defaults, and it only returns $R < 1$ in principal. In the secondary market, the existing bond has maturity τ and pays a coupon rate C, and the supply is normalized to 1. In the primary market, the price of the bond at issuance is 1, and the coupon rate is determined by the marginal buyer of the bond in the secondary market.

Assume there is a continuum of risk-neutral traders with heterogeneous beliefs h regarding the probability that the risky bond will not default. Suppose that the belief among the traders is uniformly distributed on [0,1], and that each trader has one unit of cash. For simplicity, assume traders have no time discount and the risk-free rate $i = 0$.

The risky bond is eligible as collateral for borrowing with the no-recourse contract, which means that the only thing the lender can do, if the borrower fails to make the promised payments, is to seize the collateral. The contract is determined by the promised payment A and the underlying collateral. Without loss of generality, we focus on the contract with one unit of bond as the underlying collateral.

Suppose the central bank adopts a collateral-based unconventional monetary policy that allows the bank dealers to use the bond as collateral to borrow from it at a risk-free rate. The central bank sets the promised payment of the debt contract as A_c. The bank dealers can borrow A_c with one unit of the bond as collateral. When $A_c = 0$, the bond is not eligible for the collateral-based unconventional monetary policy; in other words, the central bank does not adopt the collateral-based unconventional monetary policy, and the traders can only use the bond as collateral to borrow from other traders.

4.1 | Equilibrium Without the Unconventional Monetary Policy

Suppose the central bank does not adopt the collateral-based unconventional monetary policy, that is, $A_c = 0$.

As in Geanakoplos (2010), the secondary market equilibrium bond price p^* is determined by the *marginal* buyer. The marginal trader with belief h_0 prices the bond with maturity τ at

$$p = h_0(\tau C + 1) + (1 - h_0)(\tau C + R).$$

The market-clearing condition requires that the demand equals the supply of the bond,

$$\frac{1 - h_0}{p - A} = 1,$$

where $1 - h_0$ is the measure of traders whose belief is higher than the marginal trader. $p - A$ is the trader's net payment to purchase the bond and use that as collateral to borrow from the traders with belief $h < h_0$. Since each trader has one unit of cash, the demand for the bond is $\frac{1-h_0}{p-A}$ as is shown on the left-hand side. The right-hand side is the supply of the bond.

Lemma1 (Endogenous Haircut Without Unconventional Monetary Policy). *When $m = 1$, in equilibrium, the unique debt contract traded is a risk-free debt contract with promised payment $A_0^* = \tau C + R$ backed by one unit of risky bond with maturity τ.*

Lemma 1 follows from the *binomial leverage theorem* in Geanakoplos (2010). Intuitively, traders with beliefs lower than the marginal trader (lenders) will consider any contract with promised payment more than $\tau C + R$ as risky and overpriced. The traders with beliefs higher than the marginal trader (borrowers) would like to borrow as much as possible, as they are optimistic about the asset value. So the equilibrium contract that both sides would be willing to trade is $A_0^* = \tau C + R$ without the unconventional monetary policy.

4.2 | Equilibrium with Unconventional Monetary Policy

If the central bank implements the collateral-based monetary policy, and if the traders can borrow more from the central bank via the MLF, as well as from the other traders with the same collateral, that is, $A_c > A_0^*$, the prevailing debt contract and the bond price can change.[26]

Proposition1 (Bond Prices). *If $A_c < \tau C + R$, the equilibrium price of the bond with maturity τ and coupon rate C satisfies*

$$p_0^* = \tau C + R + \frac{1-R}{2-R}.$$

Given the price at issuance is 1, the coupon rate of the new issuance is

$$C^*_{new,0} = \frac{(1-R)^2}{(2-R)T}.$$

The marginal trader has a belief $h_0^* = \frac{1}{2-R}$. In equilibrium, the traders with belief $h \in [h_0^*, 1]$ hold $\frac{1}{1-h_0^*}$ units of the bond and owes $\frac{1}{1-h_0^*}$ unit debt to the other traders, and the trader with belief $h \in [0, h_0^*)$ holds cash and the debt contract.

If $A_c \geq \tau C + R$, the equilibrium price of the bond with maturity τ and coupon rate C satisfies

$$p_c^* = \tau C + R + \frac{1 + A_c - (\tau C + R)}{2-R}(1-R).$$

Given the price at issuance is 1, the coupon rate of the new issuance is

$$C^*_{new,c} = \frac{(1-A_c)(1-R)}{T}.$$

The marginal trader has belief $h_c^* = \frac{1+A_c-(\tau C+R)}{2-R}$. In equilibrium, the traders with belief $h \in [h_c^*, 1]$ hold $\frac{1}{1-h_c^*}$ units of the bond and owes $\frac{1}{1-h_c^*}$ unit debt to the central bank, and the trader with belief $h \in [0, h_c^*)$ holds cash.

Define the haircut as the percentage difference between the loan value and the market value of the bond, $m \equiv \frac{p-A}{p}$. Proposition 1 implies that the unconventional monetary policy can decrease the prevailing haircut in the market if the central bank's haircut is sufficiently small. Intuitively, if the central bank sets the haircut to be larger than the equilibrium haircut in Lemma 1 for traders to borrow from the other traders ($A_c < \tau C + R$), then the traders will not borrow from the central bank. The prevailing haircut is the endogenous haircut in Lemma 1. If the central bank sets the haircut to be smaller than the equilibrium haircut in Lemma 1 ($A_c \geq \tau C + R$), traders will borrow from the central bank, and the prevailing haircut is the exogenous haircut specified by the unconventional monetary policy. So we have the following testable hypothesis.

Hypothesis 1. *When the collateral-based unconventional monetary policy is implemented and the haircut is sufficiently low, the prevailing haircut decreases.*

Second, the bond price increases when the collateral-based unconventional monetary policy is implemented. Since the bond spread is defined as the difference between the bond yield and the risk-free rate, which is inversely related to the market price, we can formulate the following testable hypothesis.

Hypothesis 2. *When the unconventional monetary policy is implemented and the haircut is sufficiently low, the spread of the existing bond decreases.*

Third, the coupon rate of new issuance decreases when the collateral-based unconventional monetary policy is implemented. The primary market dealers, anticipating that the bond has a higher collateral value in the secondary market for any given coupon rate, would bid down the coupon rate in the primary market. We have the following testable hypothesis.

Hypothesis 3. *When the unconventional monetary policy is implemented and the haircut is sufficiently low, the coupon rate of the new issuance decreases.*

We also simulate the change in spreads of existing bonds and new issuance when the unconventional monetary policy is implemented, as illustrated in Figure 3. Our observations are as follows. First, consistent with our analytical result, the spread of existing bonds and new issuance decreases more if the pledgeability of the bond is higher. Second, the reduction in the spread for new bonds can either be less than or greater than that of existing bonds, depending on the maturity of the new issuance in comparison to the existing bonds. This suggests that the pass-through from the secondary market to the primary market can vary, potentially being lower or higher than 100%, which is consistent with our empirical findings in Section 6.

5 | Secondary Market: Data, Methods, and Results

In this section, we describe the data, methods, and results of the impact of the unconventional monetary policy on bond prices in the secondary market. We also provide empirical evidence for the segmentation of the interbank and the exchange markets, which is essential for our empirical strategy.

5.1 | Data

5.1.1 | Sample Selection

As the June 1, 2018 policy shock was mainly targeted at corporate bonds and a subset of the financial bonds, we restrict our analysis sample to only corporate bonds and financial bonds. We obtain the bond characteristics, including credit ratings and issuers, and

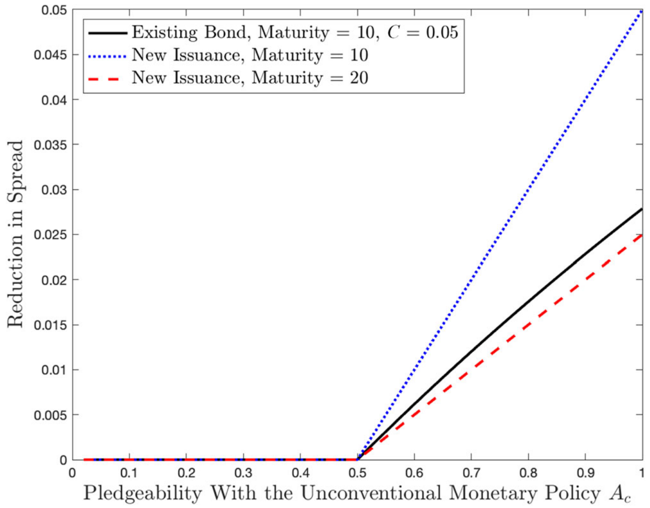


FIGURE 3 | Reductions in bond spreads in response to unconventional monetary policy.

Note: This figure illustrates the simulated reduction in bond spreads when unconventional monetary policy is implemented, that is, when A_c increases from 0 to a positive value. We set the down state payoff $R = 0$. The risk-free rate is 0. The spread of the existing is the difference between bond yield and the risk-free rate, where the bond yield y^* is calculated based on $p^* = \frac{C}{y^*}(1 - e^{-y^*\tau}) + e^{-y^*\tau}$ for bond of price p^* with coupon rate C and maturity τ. The spread of the new issuance is the difference between the coupon rate and the risk-free rate. The black solid line "existing bond, maturity = 10, $C = 0.05$" plots the reduction in spread for an existing bond with coupon rate 0.05 and maturity $\tau = 10$. The blue dotted line "new issuance, maturity = 10" plots the reduction in spread for the new issuance with maturity $T = 10$. The red dashed line "new issuance, maturity = 20" plots the reduction in the spread for the new issuance with maturity $T = 20$.

daily bond transaction information, including yield-to-maturity, trade volume, close price, and so forth from WIND.[27]

Our sample period is from January 1 to September 30, 2018, with a 5-month window (99 trading days) before the June 1, 2018 policy shock and a 4-month window (83 trading days) after the policy shock, respectively. If a bond does not have any trading on a particular day, we will code the bond's observation as missing for that day. We follow Schwert (2017) to exclude observations of bonds with less than 1 year to maturity, because at such a short maturity, small price changes can lead to large deviations in the implied yield. We further restrict the bonds to those issued before September 1, 2017, because newly issued bonds tend to exhibit high markups.

We also restrict our analysis sample to bonds with AA or higher ratings. Bonds rated under AA account for only a small proportion (less than 5%) of our sample, and such bonds are considered risky in China; we thus exclude bonds with ratings lower than AA in order to eliminate the potential noise from these risky bonds.[28]

For part of the analysis, we will further restrict our sample to bonds that are *dual-listed* in both the interbank and the exchange market. A dual-listed bond has the advantage of being able to be matched to *itself* in the other market, and by definition, the matched pair has the same fundamentals.

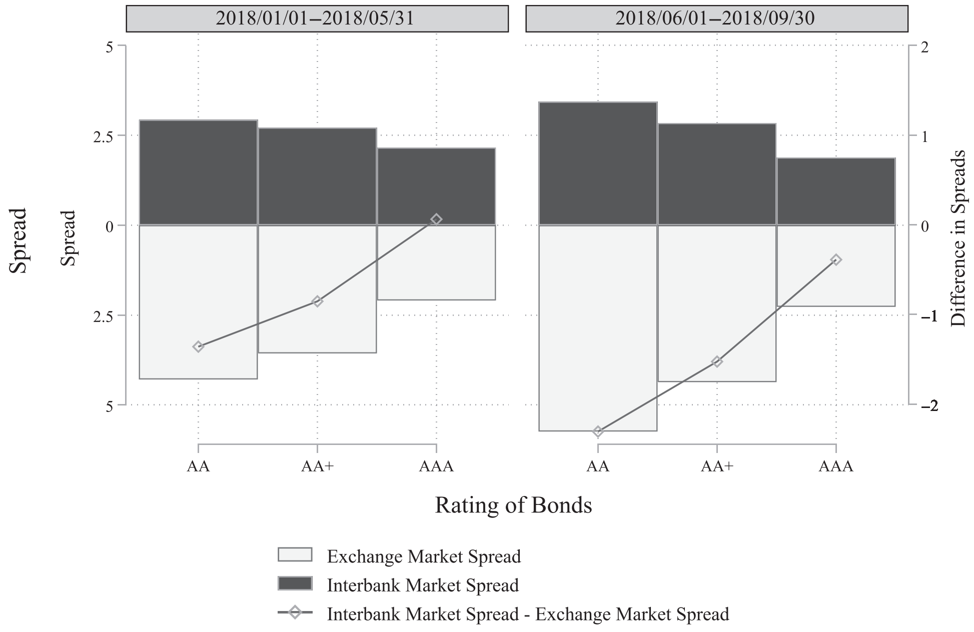
5.1.2 | Construction of Spread

The main dependent variable of our analysis is the spread of the bonds, which is calculated as the difference between the yield (to maturity) of bonds and the yield of ChinaBond Government Bond (CGB) with the same term to maturity on the same day.[29] The yield to maturity for the bonds in the exchange market is obtained from WIND, and the yield to maturity for bonds in the interbank market is calculated by CFETS. Both calculations are based on the secondary market transaction prices.[30,31]

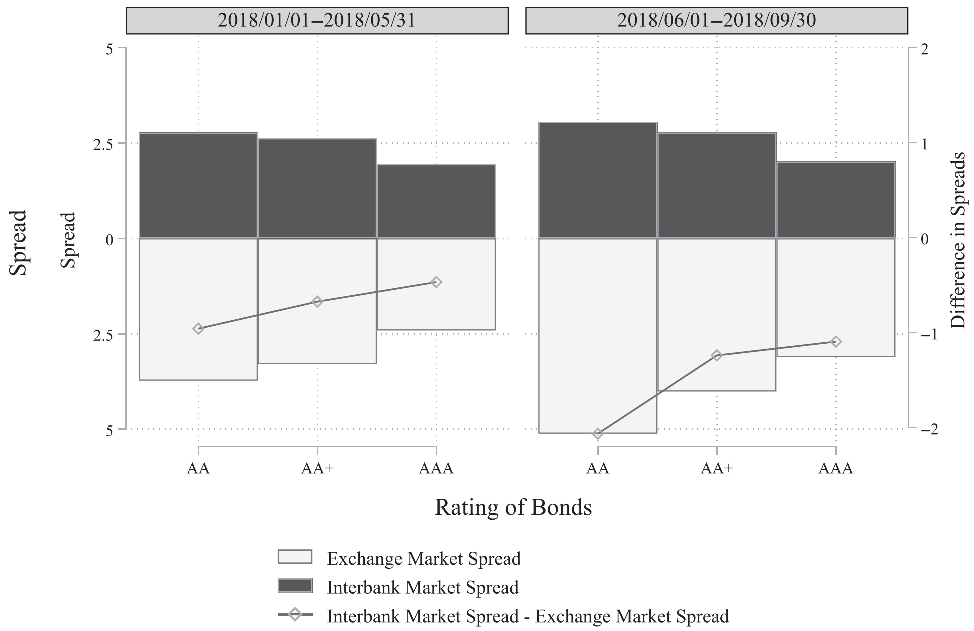
We take the targeted bonds, that is, the bonds in the interbank market that are newly eligible as collateral for MLF as described in Section 3.2, as *treatment bonds in the treatment market*, and the same type of bonds in the exchange market as *treatment bonds in the control market*. Similarly, we consider other bonds that are not impacted by the policy shock on June 1, 2018 as *control bonds in the treatment market* and *control bonds in the control market*, respectively. The control bonds include AAA rated bonds, and financial bonds that are not in the targeted sectors.

Figure 4 provides suggestive evidence that the policy shock reduces the spreads of the treatment bonds in the interbank market. Figure 4a compares the average daily spreads for *all* corporate and financial bonds in the two markets by ratings before (the left panel) and after (the right panel) the policy shock. Both panels show that, for a given bond rating, the average daily spreads are lower in the interbank market than in the exchange market. The difference in the spreads is most significant for AA rated bonds, followed by AA+ rated bonds, and it is the smallest for AAA rated bonds. However, following the policy shock, the difference in spreads between the two markets of AA and AA+ rated bonds—which include all the treatment bonds—increased drastically, while the spread difference of AAA rated bonds only increased marginally. In Figure 4b, we restrict the sample to dual-listed bonds only. As we mentioned in Section 3.1, dual-listed bonds are all enterprise bonds, therefore the AA+ and AA rated dual-listed bonds are almost all treatment bonds, and the AAA bonds are all control bonds which were already collateral eligible for MLF prior to the June 1, 2018 policy shock. Figure 4b reaffirms the same qualitative effect as that from Figure 4a: after the policy shock, the treatment bonds (AA+ and AA rated bonds) experienced somewhat larger decreases in spreads than the control bonds (AAA rated bonds).

Figure 5 further shows the daily movements of the spread differences between the interbank and the exchange market, by bond ratings, before and after the policy shock. The shaded area is a five-trading-day period after the expansion of the eligible collateral for MLF. Figure 5 suggests that in the 5-day window, the spreads of AA and AA+ rated bonds (treatment bonds) in interbank market (the treatment market) fall relative to that in the exchange market (the control market), while at the same time, the spread differences between the two markets for AAA bonds (control bonds) somewhat increased. Figures 4 and 5 both suggest that the expansion of MLF-eligible collateral to include corporate bonds and some financial bonds rated AA+ or AA may have causally increased the prices, and thus decreased the spread, of these targeted bonds in the secondary market.



(a) Full Sample



(b) Dual-listed Bonds Only

FIGURE 4 | Average daily spread of bonds in the exchange market and the interbank market before and after the expansion of MLF collateral on June 1, 2018: Secondary market.

Note: The sample period of the left graph is January 1–May 31, 2018. Panel (a) uses the full sample, and Panel (b) uses dual-listed bonds only. The sample period of the right graph is June 1 to September 30, 2018. The horizontal axis denotes the three ratings of bonds. The darker bar is the average spread in the interbank market, and the lighter bar is the average spread in the exchange market (left scale). The solid line depicts the difference between the two spreads (right scale).

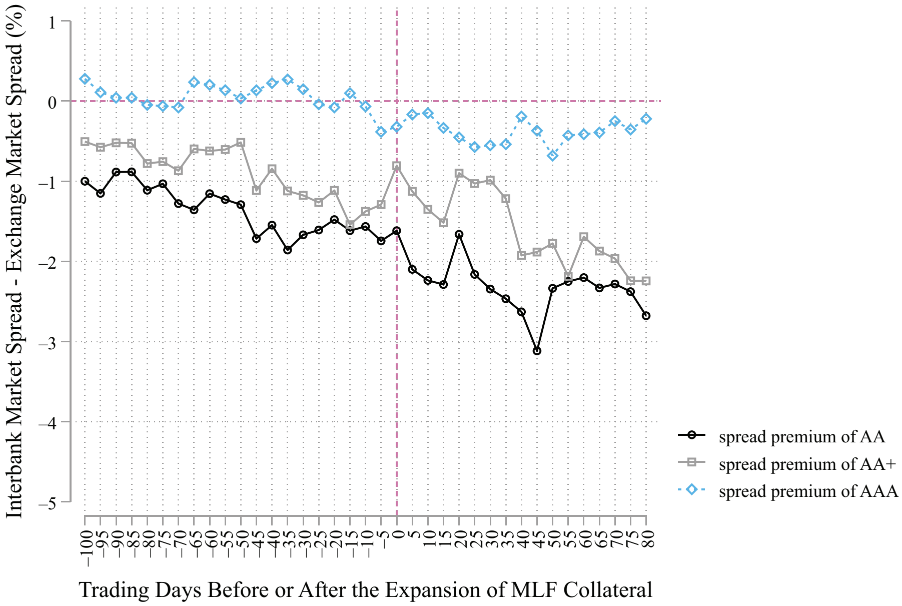


FIGURE 5 | Spread differences between the interbank and the exchange market, by bond ratings: Secondary market.
Note: Date 0 is June 1, 2018, the date of the policy shock. The graph covers the period of January 1 to September 30, 2018. Each point represents the average spread premium in 5-day window, where average spread premium = average spread of bonds in the interbank market—the average spread of bonds in the exchange market. The black, blue, and green lines depict the change in the spread premium of AA, AA+, and AAA bonds over time.

5.2 | Descriptive Statistics

In Table 2, we provide the summary statistics for *all* corporate and financial bonds in the secondary market with AA or higher ratings. Recall that our sample restrictions exclude a very small percentage of bonds with below AA ratings. In Panels A–C, an observation is at bond-day level. In the columns headed by "Full sample," we include all bond-day observations (a total of 78,592). We also provide summary statistics for bond-day observations in the interbank market (a total of 35,406, about 45% of the total observations) and the exchange market (a total of 43,186, about 55% of the total observations) separately. Panel A shows that the average daily spread is 3.123% in the full sample, and the average daily spreads are 2.547% and 3.594% in the interbank market and the exchange market, respectively. In the full sample, about 42% of the bond-day observations are after the June 1, 2018 policy shock (Post = 1); separately by market, the postshock observations account for 40.4% and 43.3%, respectively, in the interbank and exchange market. In the full sample, 59.5% of the observations are those of the treatment bonds (Treat = 1); the corresponding percentages are 54.8% and 63.4% in the interbank and the exchange market, respectively. The maturity to term averages 2.955 years in the overall sample; and it is 3.069 and 2.861 years, respectively, in the interbank and the exchange market. As expected, the average daily volume of trade is much larger in the interbank market (115.8 million yuan) than in the exchange market (8.443 million yuan).

In Panels B and C of Table 2, we report the summary statistics of bond ratings and bond types, respectively. Panel B shows that AAA rated bonds account for 40% of the observations in the overall secondary market, and about 44.1% and 36.3% in the interbank and the exchange market, respectively. The percentages of AA+ and AA rated bond-day observations are both somewhat smaller in the interbank market than in the exchange market. Panel C shows that about 33.4% of observations are those of exchange-traded corporate bonds, which by definition do not appear in the interbank market transactions. Similarly, a type of corporate bond, known as medium-term notes, is only traded in the interbank market. Observations of enterprise bonds (which are corporate bonds for large state-owned enterprises) account for about 36.2% of the total observations, and they appear in both the interbank market and the exchange market. As we will show in Table 3, indeed all dual-listed bonds are enterprise bonds. Financial bonds appear in both markets, but they account for only a relatively small fraction of all the observations .

In Panel D of Table 2, we summarize the data at the unique bond level. It shows that in total there are 6057 unique bonds in the full sample, of which 5650 of them are corporate bonds of various kinds—including 1880 enterprise bonds, 1447 exchange-traded corporate bonds, and 2323 medium-term notes; and only 407 are financial bonds. Note that medium-term notes are only traded in the interbank market, and exchange-traded corporate bonds are only traded in the exchange market. There are a total of 526 enterprise bonds that are dual-listed in both markets.

In Table 3, we provide the summary statistics, focusing on the *dual-listed bonds only*. First of all, as shown in Panel C of Table 2, only enterprise bonds are dual-listed. Moreover, of the 28,460 bond-day observations of enterprise bonds listed in Panel C of Table 2, 16,831 of them are those of dual-listed enterprise bonds. Thus, about 60% bond-day transactions of all enterprise bonds are those of dual-listed bonds. At the unique bond level, Panel D of Table 3 shows that 526 out of the 1880, namely, about 28%, of the enterprise bonds are dual-listed and have transactions in both markets during our sample period.

Panel A of Table 3 shows that the basic patterns of the spread differences between the interbank market and the exchange

TABLE 2 | Summary statistics for secondary market: All bonds

Panel A	Full sample					Interbank market					Exchange market				
Variable	**Obs**	**Mean**	**Std.Dev.**	**Min**	**Max**	**Obs**	**Mean**	**Std.Dev.**	**Min**	**Max**	**Obs**	**Mean**	**Std.Dev.**	**Min**	**Max**
Spread (%)	78,592	3.123	2.190	0.263	14.43	35,406	2.547	1.294	0.263	14.43	43,186	3.594	2.619	0.263	14.43
Default Spread (%)	78,440	3.041	2.174	−2.081	14.43	35,314	2.444	1.265	−1.830	14.43	43,126	3.530	2.599	−2.081	14.43
Liquidity Spread (%)	78,440	0.0829	0.253	0	2.344	35,314	0.103	0.235	0	2.093	43,126	0.0666	0.265	0	2.344
Post	78,592	0.420	0.493	0	1	35,406	0.404	0.491	0	1	43,186	0.433	0.495	0	1
IB	78,592	0.451	0.498	0	1	35,406	1	0	1	1	43,186	0	0	0	0
Treat	78,592	0.596	0.491	0	1	35,406	0.549	0.498	0	1	43,186	0.634	0.482	0	1
Quantity (Billion RMB)	78,592	2.079	2.668	0.0600	50	35,406	2.225	3.423	0.100	50	43,186	1.960	1.821	0.0600	20
Term (Year)	78,592	2.955	1.620	1	17.87	35,406	3.069	1.739	1	17.87	43,186	2.861	1.509	1	15.58
Volume (Million RMB)	78,592	56.80	141.6	0.000100	6000	35,406	115.8	191.9	0.0590	6000	43,186	8.443	32.91	0.000100	3000
Clean Price (RMB)	78,592	90.44	16.76	19.30	122	35,406	93.67	13.29	20	119.6	43,186	87.79	18.73	19.30	122
Amihud (% per million RMB)	78,440	0.375	1.945	0	18.51	35,314	0.000136	0.000264	2.06e−07	0.00185	43,126	0.683	2.583	0	18.51

Panel B	Full sample		Interbank market		Exchange market	
Bond rating	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**
AA	23,640	30.08	9831	27.77	13,809	31.98
AA+	23,684	30.14	9974	28.17	13,710	31.75
AAA	31,268	39.79	15,601	44.06	15,667	36.28
Total	78,592	100	35,406	100	43,186	100

(Continues)

TABLE 2 | (Continued)

Panel C	Full sample		Interbank market		Exchange market	
Bond type	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**
Corporate bonds	76,282	97.06	33,826	95.53	42,456	98.31
- *Enterprise bond*	28,460	36.21	12,245	34.58	16,215	37.55
- *Exchange-traded corporate bond*	26,241	33.39	-	-	26,241	60.76
- *Medium-term note*	21,581	27.45	21,581	60.95	-	-
Financial bond	2310	2.940	1580	4460	730	1.690
Total	78,592	100	35,406	100	43,186	100

Panel D	Full sample		Interbank market		Exchange market	
Unique bond numbers	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**
Corporate bonds	5650	93.28	4093	92.87	2,083	95.73
- *Enterprise bond*	1880	31.04	1770	40.16	636	29.23
- *Exchange-traded corporate bond*	1447	23.89	-	-	1447	66.50
- *Medium-term note*	2323	38.35	2323	52.71	-	-
Financial bond	407	6.720	314	7.130	93	4.270
Total	6057	100	4407	100	2176	100

Panel E	Full sample					Interbank market					Exchange Market				
Variable	**Obs**	**Mean**	**Std.Dev.**	**Min**	**Max**	**Obs**	**Mean**	**Std.Dev.**	**Min**	**Max**	**Obs**	**Mean**	**Std.Dev.**	**Min**	**Max**
$RRcut \times IB$	78,592	0.239	0.427	0	1	35,406	0.531	0.499	0	1	43,186	0	0	0	0
$RRcut \times IB \times AAA$	78,592	0.100	0.301	0	1	35,406	0.223	0.416	0	1	43,186	0	0	0	0
$RRcut \times IB \times AA+$	78,592	0.0645	0.246	0	1	35,406	0.143	0.350	0	1	43,186	0	0	0	0

Note: This table provides sample summary statistics for variables used in our secondary market baseline regressions. Panel A describes the variables used in the regressions in Section 5. *Spread*, *Default Spread*, and *Liquidity Spread* are in percentage terms. *Post* is a dummy which equals 1 if the date is after June 1, 2018; and 0, otherwise. *IB* is a dummy which equals 1 if the bond is listed in the interbank market, and 0 otherwise. *Treat* is a dummy which equals 1 if the bond is a corporate bond rated AA and AA+ and financial bond in the targeted sectors rated at least AA, and 0 otherwise. *Quantity* is the total value of the bond issuance, measured in the billion-yuan term. *Term* is the bond's remaining terms to maturity, measured in years. *Volume* is the daily trading volume of the bond, measured in million yuan. *Clean Price* is the clean close price of bonds, measured in RMB. *Amihud* is estimated from regressions with Equation (15), quarter by quarter, measured in percentages.

TABLE 3 | Summary statistics for secondary markets: Dual-listed bonds only

Panel A	**Full sample**					**Interbank market**					**Exchange market**				
Variable	**Obs**	**Mean**	**Std.Dev.**	**Min**	**Max**	**Obs**	**Mean**	**Std.Dev.**	**Min**	**Max**	**Obs**	**Mean**	**Std.Dev.**	**Min**	**Max**
$Spread$ (%)	16,831	3.478	2.067	0.263	14.43	3393	2.612	1.152	0.263	14.43	13,438	3.696	2.187	0.263	14.43
$Default\ Spread$ (%)	16,802	3.414	2.054	−2.081	14.43	3381	2.482	1.107	−0.847	13.29	13,421	3.648	2.168	−2.081	14.43
$Liquidity\ Spread$ (%)	16,802	0.0659	0.225	0	2.344	3381	0.130	0.296	0	2.093	13,421	0.0498	0.201	0	2.344
$Post$	16,831	0.423	0.494	0	1	3393	0.403	0.491	0	1	13,438	0.428	0.495	0	1
IB	16,831	0.202	0.401	0	1	3393	1	0	1	1	13,438	0	0	0	0
$Treat$	16,831	0.765	0.424	0	1	3393	0.787	0.410	0	1	13,438	0.759	0.428	0	1
$Quantity$ (Billion RMB)	16,831	1.569	1.570	0.300	20	3393	1.658	1.986	0.300	20	13,438	1.547	1.445	0.300	20
$Term$ (Year)	16,831	2.852	1.544	1	12.26	3393	2.905	1.496	1.003	12.26	13,438	2.838	1.556	1	12.22
$Volume$ (Million RMB)	16,831	15.94	44.53	0.00100	1000	3393	74.32	73.89	0.0590	1000	13,438	1.203	5.222	0.00100	128.5
$Clean\ Price$ (RMB)	16,831	72.41	22.63	19.30	116	3393	76.55	22.59	20.09	110.6	13,438	71.37	22.52	19.30	116
$Amihud$ (% per million RMB)	16,802	0.432	1.919	0	18.51	3381	0.000167	0.000318	2.06e−07	0.00185	13,421	0.541	2.133	0	18.51

Panel B	**Full sample**		**Interbank market**		**Exchange market**	
Bond rating	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**
AA	7176	42.64	1391	41.00	5785	43.05
AA+	5697	33.85	1278	37.67	4419	32.88
AAA	3958	23.52	724	21.34	3234	24.07
Total	16,831	100	3393	100	13,438	100

(Continues)

TABLE 3 | (Continued)

Panel C	Full sample		Interbank market		Exchange market	
Bond type	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**
Enterprise bond	16,831	100	3393	100	13,438	100
Total	16,831	100	3393	100	13,438	100

Panel D	Full sample		Interbank market		Exchange market	
Unique bond numbers	**Freq.**	**Percent**	**Freq.**	**Percent**	**Freq.**	**Percent**
Enterprise bond	526	100	526	100	526	100

Panel E	Full sample					Interbank market					Exchange market				
Variable	**Obs**	**Mean**	**Std.Dev.**	**Min**	**Max**	**Obs**	**Mean**	**Std.Dev.**	**Min**	**Max**	**Obs**	**Mean**	**Std.Dev.**	**Min**	**Max**
$RRRcut \times IB$	16,831	0.109	0.312	0	1	3393	0.543	0.498	0	1	13,438	0	0	0	0
$RRRcut \times IB \times AAA$	16,831	0.0232	0.150	0	1	3393	0.115	0.319	0	1	13,438	0	0	0	0
$RRRcut \times IB \times AA+$	16,831	0.0422	0.201	0	1	3393	0.210	0.407	0	1	13,438	0	0	0	0

Note: This table provides sample summary statistics for variables used in our secondary market baseline regressions. Panel A describes the variables used in the regressions in Section 5. *Spread*, *Default Spread*, and *Liquidity Spread* are in percentage terms. *Post* is a dummy which equals 1 if the date is after June 1, 2018; and 0, otherwise. *IB* is a dummy which equals 1 if the bond is listed in the interbank market, and 0 otherwise. *Treat* is a dummy which equals 1 if the bond is a corporate bond rated AA and AA+ and financial bond in the targeted sectors rated at least AA, and 0 otherwise. *Quantity* is the total value of the bond issuance, measured in the billion-yuan term. *Term* is the bond's remaining terms to maturity, measured in years. *Volume* is the daily trading volume of the bond, measured in the million-yuan term. *Clean Price* is the clean close price of bonds, measured in RMB. *Amihud* is estimated from regressions with Equation (15), quarter by quarter, measured in percentages.

TABLE 4 | Differences between the spreads of dual-listed bonds in the interbank and exchange markets

Panel A						
Absolute difference in spreads (bps)	Obs	Mean	Std.Dev.	Min	Max	t-Statistic (H_0: Mean = 0)
	1179	109.2	135.4	0.0185	1166	27.69

Panel B								
Absolute difference in spreads (bps)	0–0.1	0.1–1	1–5	5–10	10–50	50–100	100+	Total
Obs.	8	34	76	47	309	272	433	1179
Percentage	0.68%	2.88%	6.45%	3.99%	26.21%	23.07%	36.73%	100.00%

Note: This table presents the absolute value of the difference between the spreads in the interbank market and the exchange market for the same bond, based on "simultaneous transactions," following the construction in Chen et al. (2023). Denote the date of the transaction in the interbank market as t. If there are transactions of the same bond in the exchange market that fall within the $[t-2, t+2]$ trading window, then these transactions are called "simultaneous" exchange transactions. The difference between the spreads is simply the spread of the simultaneous exchange transaction closest to date t minus the interbank spread on date t of the same bond. The t-statistic in Panel A is the result of a t-test under the null hypothesis that the mean absolute spread difference between the two markets is zero.

market for all bonds also hold when looking only at the dual-listed bonds. For example, the average spread tends to be lower in the interbank market than in the exchange market (2.612% vs. 3.696%). About 42% of the bond-day observations are after the policy shock (*Post* = 1), and about 76.5% of the bond-day observations are those of the treatment bonds (*Treat* = 1). At the bond-day observation level, dual-listed enterprise bonds tend to have shorter term-to-maturity than non-dual-listed bonds: the average term-to-maturity for dual-listed bonds is 2.852 years, in contrast to 2.955 years for all bonds as reported in Panel A of Table 2. Comparing Panel B of Tables 2 and 3 reveals that there is a much smaller fraction of AAA rated bond-day observations among dual-listed bonds than among all bonds.

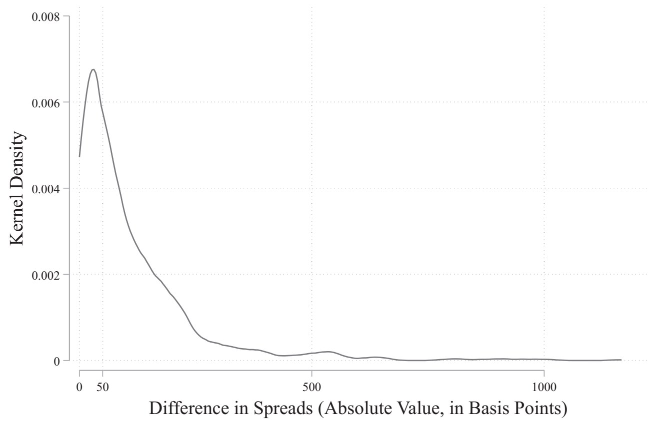


FIGURE 6 | Kernel distribution of absolute difference between spreads of dual-listed bonds in interbank market and exchange market: Secondary market.

Note: This figure shows the kernel density for the absolute spread difference between the interbank market and exchange market for the same bond, based on "simultaneous transactions," following the construction in Chen et al. (2023).

5.3 | Evidence for Market Segmentation

An important institutional feature of the parallel bond markets in China that is crucial for our empirical approach is that the interbank market and the exchange market are effectively segmented, despite the fact that there are many dual-listed bonds and that many market participants trade in both markets. In Section 3, we provided detailed information about the barriers to cross-market arbitrage. In this subsection, we provide further evidence about the spread discrepancies between the two markets for dual-listed bonds when there were "simultaneous transactions" in the two markets. Our definition of "simultaneous transactions" is close to that in Chen et al. (2023). For any transaction of a dual-listed bond in the interbank market at a particular date, say date t, the "simultaneous transactions" in the exchange market are transactions of the *same* bond on trading days between $t-2$ and $t+2$. We then calculate the spread difference between the trades in the interbank market and their closest corresponding "simultaneous transactions" in the exchange. We are able to construct 1089 such matched pairs in our sample.

Panel A of Table 4 shows that the mean absolute difference of the matched trades is 109.2 bps, with a minimum difference of 0.0185 bps and a maximum difference of 1166 bps. In Panel B, only slightly more than 10% of all the matched trades have absolute spread differences of less than 5 bps; and more than 36% of the matched trades differ in spread exceeding 100 bps.

Figure 6 presents the kernel density plot of the absolute spread difference of dual-listed bond trades in the interbank market and the "simultaneous transactions" of the same bond in the exchange market. It shows that the distribution has a significant probability mass on absolute spread differences exceeding more than 30 bps.

We formally test whether the same bond trades at different prices across the interbank and exchange markets by conducting a t-test under the null hypothesis that the mean absolute difference is zero. The test rejects the null hypothesis with a t-statistic of 27.69 (see Panel A of Table 4). This provides strong evidence that, on average, prices differ across the two markets for the same bond at the same time.

The large absolute spread differences between matched trades in the two markets provide direct empirical evidence that the two markets are effectively segmented. This is crucial because the segmentation allows us to interpret the exchange market as the "control market" that is immune to "contamination" when the interbank market experiences the policy shock of June 1, 2018. The availability of such a control market allows us to construct the "counterfactual outcome" of the *treatment bonds in the control market*.

5.4 | Identifying Assumptions

Before we present our main regression specification and empirical results, it is useful to formally describe our identification assumptions using the potential outcomes framework (see, e.g., Rubin 1974; Imbens and Rubin 2015), and explain why the unique institutional features of China's bond market provide an ideal opportunity to estimate the causal impact of collateral-based monetary policy on asset prices and implied bond yields.

We will first introduce some notations. Let $Z = 1$ and $Z = 0$, respectively, denote "treatment" and "control" where "treatment" refers to "changing the bond from being ineligible to being eligible collateral to borrow from the MLF," and "control" refers to "no change in eligibility." Let Y_1 and Y_0, respectively, denote the bond price (equivalently, the implied yield) of bonds with treatment ($Z = 1$) and without treatment ($Z = 0$). Let $M = 1$ and $M = 0$ denote the treatment market (Interbank bond market) and the control market (Exchange bond market), respectively. Finally, let $T = 0$ and $T = 1$, respectively, denote the period before and after the policy shock time of June 1, 2018.

We are interested in estimating the causal effect of making a bond eligible as collateral for borrowing from the MLF on its yield, which we denote by Δ:

$$\Delta = E\left[Y_1 - Y_0 \,\middle|\, Z = 1,\ M = 1,\ T = 1\right], \tag{1}$$

where $E\left[Y_0 \,\middle|\, Z = 1,\ M = 1,\ T = 1\right]$ is the expectation of the *nonobserved* potential outcome of the treated bonds ($Z = 1$) in the treated market ($M = 1$) during the postshock period ($T = 1$), *had the June 1, 2018 policy shock not happened*; and $E\left[Y_1 \,\middle|\, Z = 1,\ M = 1,\ T = 1\right]$ is the observed outcome of the treated bonds in the treated market in the postshock period.

Our DDD estimator, which we will implement in Equation (6) below, after abstracting from the conditional observable variables including, among others, the observable characteristics of the bonds, can be written as:

$$\hat{\beta} = \underbrace{\left[\left(\bar{Y}_{Z=1,M=1,T=1} - \bar{Y}_{Z=1,M=1,T=0}\right) - \left(\bar{Y}_{Z=0,M=1,T=1} - \bar{Y}_{Z=0,M=1,T=0}\right)\right]}_{\Delta\bar{Y}\, for\, Treated\, Bonds - \Delta\bar{Y}\, for\, Control\, Bonds,\, in\, the\, Interbank\, Market} - \underbrace{\left[\left(\bar{Y}_{Z=1,M=0,T=1} - \bar{Y}_{Z=1,M=0,T=0}\right) - \left(\bar{Y}_{Z=0,M=0,T=1} - \bar{Y}_{Z=0,M=0,T=0}\right)\right]}_{\Delta\bar{Y}\, for\, Treated\, Bonds - \Delta\bar{Y}\, for\, Control\, Bonds,\, in\, the\, Exchange\, Market}$$

where $\bar{Y}_{Z,M,T}$ denotes that sample averages of outcome Y under specific values of Z, M, T. As the sample size increases to infinity, this converges to

$$\left(E\left[Y_1 \middle| Z = 1,\ M = 1,\ T = 1\right] - E\left[Y_1 \middle| Z = 1,\ M = 1,\ T = 0\right]\right)$$
$$-\left(E\left[Y_0 \middle| Z = 0,\ M = 1,\ T = 1\right] - E\left[Y_0 \middle| Z = 0,\ M = 1,\ T = 0\right]\right)$$
$$-\left(E\left[Y_1 \middle| Z = 1,\ M = 0,\ T = 1\right] - E\left[Y_1 \middle| Z = 1,\ M = 0,\ T = 0\right]\right)$$
$$+\left(E\left[Y_0 \middle| Z = 0,\ M = 0,\ T = 1\right] - E\left[Y_0 \middle| Z = 0,\ M = 0,\ T = 0\right]\right)$$

$$\overset{(*)}{=} \left\{ E\left[Y_1 \middle| Z = 1,\ M = 1,\ T = 1\right] - \boxed{E\left[Y_0 \middle| Z = 1,\ M = 1,\ T = 1\right]} \right\}$$
$$+\left\{ \boxed{\left(E\left[Y_0 \middle| Z = 1,\ M = 1,\ T = 1\right]\right.} - E\left[Y_1 \middle| Z = 1,\ M = 1,\ T = 0\right]\right) \tag{3}$$
$$\left.-\left(E\left[Y_1 \middle| Z = 1,\ M = 0,\ T = 1\right] - E\left[Y_1 \middle| Z = 1,\ M = 0,\ T = 0\right]\right)\right\} \tag{4}$$
$$-\left\{ \left(E\left[Y_0 \middle| Z = 0,\ M = 1,\ T = 1\right] - E\left[Y_0 \middle| Z = 0,\ M = 1,\ T = 0\right]\right)\right.$$
$$\left.-\left(E\left[Y_0 \middle| Z = 0,\ M = 0,\ T = 1\right] - E\left[Y_0 \middle| Z = 0,\ M = 0,\ T = 0\right]\right)\right\}, \tag{5}$$

where we added and subtracted the term $E\left[Y_0 \middle| Z = 1,\ M = 1,\ T = 1\right]$ at step (*). Note that the bracketed term on line (3) is exactly the treatment effect of interest Δ as in (1), thus our identification assumption for the DDD estimator $\hat{\beta}$ to be a consistent estimator for Δ is that the two bracketed terms (4) and (5) cancel out. Note that the bracketed term on line (4) is the differential of the prepost changes in the yields of the treated bonds between the interbank and the exchange markets, *had the policy shock not happened*; and the bracketed term on line (5) is the differential of the prepost changes in the yields of the control bonds between the interbank and the exchange markets. Thus the condition for our DDD estimator to be consistent is that the differential of the prepost changes of the yields of the treated bonds between the treated and control markets, had the policy not happened, must be the same as that of the control bonds.

It is worth noting that our identification assumption differs from that for a simple difference estimator, that is, only relying on the yields of treated bonds in the control market in the postshock period, that is, $E\left[Y_1 \middle| Z = 1,\ M = 0,\ T = 1\right]$, as a proxy for $E\left[Y_0 \middle| Z = 1,\ M = 1,\ T = 1\right]$. Such a proxy is likely not ideal because the interbank and the exchange bond markets differ in liquidity, participants, and how they operate (see Section 3.1 for a description of the institutional differences between the two markets). It is also differs from that for difference-in-difference estimators that use either the prepost changes in the yields of the control bonds in the interbank market, namely, $\left(E\left[Y_0 \middle| Z = 0,\ M = 1,\ T = 1\right] - E\left[Y_0 \middle| Z = 0,\ M = 1,\ T = 0\right]\right.$, or the prepost changes in the yields of the treatment bonds in the exchange market, namely, $E\left[Y_1 \middle| Z = 1,\ M = 0,\ T = 1\right] - E\left[Y_1 \middle| Z = 1,\ M = 0,\ T = 0\right]$, as the proxies for $E\left[Y_0 \middle| Z = 1,\ M = 1,\ T = 1\right] - E\left[Y_1 \middle| Z = 1,\ M = 1,\ T = 0\right]$. The former might be contaminated by the spillover effects of the treatment of the treated bonds on the control bonds in the interbank market, because both types of bonds are traded in the same market and there will be equilibrium interactions; the latter would likely be a poor proxy because the interbank and the exchange markets have important institutional differences, as we emphasized in Section 3.1. Our identification assumption for the DDD estimator described above is weaker than both the simple difference estimator and the difference-in-difference estimators, to the extent that it permits possible spillover of the treatment to the control bonds in the interbank market, as well as the institutional differences between the interbank and the exchange bond markets.

5.5 | Baseline Regression Specifications and Results

5.5.1 | Baseline Result

In order to examine whether the expansion of the MLF eligible collateral to include the treatment bonds has any impact on their spreads in the secondary market, our main estimating equation is a DDD specification:

$$\begin{aligned}\text{Spread}_{ijt} = {} & \beta_1 \text{Post}_t \times \text{IB}_j \times \text{Treat}_i + \beta_2 \text{IB}_j \times \text{Treat}_i + \beta_3 \text{Post}_t \times \text{Treat}_i \\ & + \delta_i + \theta_{jt} + (\text{BR} \times \text{BT})_{it} + \boldsymbol{Z}'_{ijt}\boldsymbol{\eta} + \varepsilon_{ijt},\end{aligned} \tag{6}$$

where the subscripts i, j, and t, respectively denote bond (i), bond market (j), and the date (t). The dependent variable Spread_{ijt} is the yield of bond i in market j at date t relative to the CGB bonds of the same date t as we have discussed in Section 5.1. The right-hand side variables are as follows:

- Post_t is a dummy that equals 1 if the date t is after June 1, 2018, and 0 otherwise.
- Treat_i is a dummy which equals 1 if the bond is one of the newly included bonds in the MLF eligible collateral expansion, that is, if i is one of the treatment bonds: (i) corporate bonds rated AA and AA+; (ii) financial bonds rated AA, AA+, and AAA in the targeted *"Xiaowei," "Green,"* and *"Sannong"* sectors.
- IB_j is a dummy which equals to 1 if the bond-day observation is from the interbank market (the treatment market), and 0 otherwise.
- δ_i represents bond fixed effects, which absorb bond fixed effects (capturing the effects of bond characteristics such as bond type, bond ratings, bond issuance size, bond issuer, etc.), as well as $Treat_i$ which would have appeared in a typical DDD setting.
- θ_{jt} captures market by date fixed effects, which absorb the day-by-day average difference in bond spread between the two markets due to different market liquidity and institutional differences between them. If there were other monetary policies and/or shocks during our study period, the market by date fixed effects would also absorb them as long as their effects do not vary across the control and treatment bonds. Note that θ_{jt} also absorbs IB_j and $Post_t \times IB_j$, which would have appeared in a typical DDD setting.
- $(\text{BR} \times \text{BT})_{it}$ are the bond rating (BR) by bond type (BT) by the date fixed effects, which absorb the day-by-day average differences in the bond spread for each type and each rating level of bonds. The $(\text{BR} \times \text{BT})_{it}$ fixed effects are not market-specific, hence, these fixed effects capture the fluctuations in the average spreads for each bond type and each bond rating level from common shocks affecting both markets. Also, note that $(\text{BR} \times \text{BT})_{it}$ fixed effects do not fully absorb the $\text{Post}_t \times \text{Treat}_i$ when we use the observations from the full sample in our analysis. The reason is that only financial bonds (a particular bond type) with AA or AA+ ratings in "*Xiaowei*," "*Green*," and "*Sannong*" are treated. Thus, we also include $\text{Post}_t \times \text{Treat}_i$ in the regression when using the full sample.[32]
- The control variables $\boldsymbol{Z}_{ijt}$ account for macroeconomic factors other than the MLF collateral expansion on June 1, 2018. We control for the impact from the 100 bps bank reserve requirements ratio (RRR) cut on April 25, 2018, for commercial and foreign banks to pay back loans obtained via the MLF.[33] To allow for the possibility that the RRR cut impacts the spread of corporate bonds differently in the interbank market and the exchange market, we add control variables $\text{RRRcut}_t \times \text{AAA}_i \times \text{IB}_j$, $\text{RRRcut}_t \times \text{AAplus}_i \times \text{IB}_j$, where RRRcut_t is a dummy equals 1 if the trading day is after April 25, 2018, and 0 otherwise, IB_j is a dummy which equals to 1 if the bond is listed in the interbank market, *AAA* is a dummy if the bond is AAA rated corporate bond, and *AAplus* is a dummy if the bond is AA+ rated corporate bond.
- ε_{ijt} are the bond-market-day-specific errors which are two-way clustered at the bond level and date level. In other words, we allow the error terms to be correlated at the bond and date levels, but independent across market j.

In estimating regression equation (6), β_1 is our main parameter of interest. It captures the average changes in the spread between the treatment bonds and the control bonds after the treatment bonds were included as eligible collateral for MLF in the interbank market, *ceteris paribus*, where we proxy for the potentially differential effects of time-varying macro shocks on the treatment and control bonds by the spread movements in the exchange market (the control market). We expect β_1 to be negative, as predicted by the leverage cycle theory presented in Section 4: as the treatment bonds in the interbank market acquire collateral values after the MLF expansion, their spreads relative to the control bonds should decrease, *ceteris paribus*.

Table 5 reports the results from the baseline regression as specified by Equation (6). Column (1) uses the full sample of bond-day transactions as summarized in Table 2, and Column (2) uses only the bond-day transactions of the dual-listed bonds as summarized in Table 3. Recall that, when we use the dual-listed bond-day transactions, the $\text{Post}_t \times \text{Treat}_i$ interaction is subsumed by the Bond Type × Bond Rating × Date fixed effects.

Column (1) shows that the β_1 coefficient estimate of the triple interaction term Post × Treat × IB is −0.525 and statistically significant at 1% level. That is, the spread difference between the treated bonds and the control bonds is reduced by 52.5 bps in the (treated) interbank market relative to the (control) exchange market after the treated bonds were made eligible as collateral for MLF. Note also that the coefficient estimate of the Post × Treat is positive and significant, suggesting the importance of allowing for the possibility of the treated bonds and control bonds to be differentially impacted by other macro shocks, which

TABLE 5 | Impact of the MLF collateral expansion on bond spreads in the secondary market

Variables	Full sample (1)	Dual-listed bonds only (2)
Post × Treat × IB	−0.525***	−0.365*
	(0.142)	(0.201)
IB × Treat	−0.310	−0.646
	(0.596)	(0.653)
Post × Treat	0.423***	
	(0.149)	
Macro factors	Yes	Yes
Bond type × Bond rating × Date FE	Yes	Yes
Market × Date FE	Yes	Yes
Bond FE	Yes	Yes
Observations	77,731	16,661
Adjusted R^2	0.860	0.809

Note: This table shows the impact of the expansion of the MLF eligible collateral to include the treatment bonds on their spreads in the secondary market using a triple-difference (DDD) specification. The regression equation is specified by Equation (6). Standard errors are two-way clustered at the bond and date levels. ***,**, and * represent statistical significance at 1%, 5%, and 10%, respectively.

TABLE 6 | Spillover effect of the MLF collateral expansion on the secondary interbank market

Variables	Full sample (1)	Dual-listed bonds only (2)
Post × Treat × IB	−0.541***	−0.458**
	(0.140)	(0.190)
Post × IB	−0.0642	−0.202
	(0.0798)	(0.138)
Post × Treat	0.419***	
	(0.147)	
IB × Treat	−0.268	−0.515
	(0.600)	(0.667)
Macro factors	Yes	Yes
Bond type × Bond rating × Date FE	Yes	Yes
Bond FE	Yes	Yes
Observations	77,731	16,661
Adjusted R^2	0.859	0.811

Note: This table examines whether the MLF collateral expansion has a spillover effect on the spreads of bonds traded in the interbank market as a whole. Regression is specified by Equation (7). Standard errors are two-way clustered at the bond and date levels. ***,**, and * represent statistical significance at 1%, 5%, and 10%, respectively.

we do by using the exchange market as the control market. In Column (2), we use only the matched dual-listed bond-day transactions in the regression. Importantly, we find that the coefficient estimate of the triple interaction is qualitatively and quantitatively consistent with that of Column (1): the expansion of MLF collateral decreases the relative spread of treatment bonds by about 36.5 bps; however, due to the smaller sample size, the statistical significance of this estimate is now at the 10% level.

5.5.2 | Spillover Effect to Other Bonds in the Interbank Market

We also investigate whether the impact of the policy shock is restricted to the treated bonds, or it can impact the spreads of *all* bonds in the (treated) interbank market. For example, Ashcraft et al. (2011) point out that, if the haircut rates of a subset of securities are sufficiently reduced, the supply of collateral in the market will increase substantially, which eases the investors' funding constraint, and in turn decreases the spread of other securities even though their haircut rates are not directly impacted. In other words, collateral-based monetary policy tools can possibly result in positive spillover effects from the treated bonds to the control bonds in the treatment market, leading to overall lower average spreads in the interbank bond market.

To test whether the MLF collateral expansion has a spillover effect on the spreads of bonds traded in the interbank market as a whole, we use the following regression specification:[34]

$$\begin{aligned}\text{Spread}_{ijt} &= \gamma_1 \text{Post}_t \times \text{IB}_j + \gamma_2 \text{Post}_t \times \text{IB}_j \times \text{Treat}_i + \gamma_3 \text{IB}_j \times \text{Treat}_i \\ &\quad + \gamma_4 \text{Post}_t \times \text{Treat}_i + \delta_i + (\text{BR} \times \text{BT})_{it} + \boldsymbol{Z}'_{ijt}\boldsymbol{\eta} + \varepsilon_{ijt},\end{aligned}$$

where γ_1 captures the average policy effect on the spreads of bonds in the interbank market. γ_1 is expected to be negative if the MLF collateral expansion has effectively reduced the spreads of other nontreated bonds in the interbank market.

Table 6 reports the results. We find a negative yet statistically insignificant impact of the MLF collateral expansion on the spread of nontreated bonds in the interbank market. This indicates that the spillover effect is not significant overall. This result is not entirely surprising, as most nontreated bonds in the sample are AAA rated corporate bonds, which typically have low spreads, leaving little room for improvement. It is important to note that the spillover effect may vary across different types of bonds. In Section 5.6, we explore the spillover effects on corporate bonds and financial bonds separately. Our analysis reveals a significant spillover impact on the spreads of financial bonds.

5.6 | Additional Analysis

5.6.1 | Parallel Trends

A requirement for DDD as specified by Equation (6) to be a valid identification strategy is that the difference in the spreads between treated and control bonds in the interbank market (the treatment market) and those in the exchange market (the control market) exhibit parallel trend prior to the policy shock.[35] In this subsection, we conduct the parallel trend analysis. The model is specified in Equation (8):

$$\text{Spread}_{ijt} = \sum_{k=-20,k\neq 0}^{k=17} \alpha_k \text{D}_t^k \times \text{IB}_j \times \text{Treat}_i + \beta_1 \text{IB}_j \times \text{Treat}_i + \beta_2 \text{Post}_t \times \text{Treat}_i + \delta_i + (\text{BR} \times \text{BT})_{it} + \boldsymbol{Z}'_{ijt}\boldsymbol{\eta} + \theta_{jt} + \varepsilon_{ijt},$$

where we divide our sample period (a total of 184 trading days) into 36 subperiods, with each period consisting of a 5-day window. The dummy variables D_t^k are equal to 1 if the date t falls in the subperiod k, and 0 otherwise. Following Freyaldenhoven et al. (2019), we normalize the point estimate of the DDD coefficient immediately before the policy shock date to zero. The same sets of control variables as those specified for regression specification (6) are included. The parallel trend assumption requires the coefficients of the interaction terms $\text{D}_t^k \times \text{IB}_j \times \text{Treat}_i$ to be not significantly different from 0 before the policy shock.

Figure 7 plots the point estimate of $\alpha_k, k \in \{-20, \dots -1, 1, \dots, 17\}$ and the corresponding 95% confidence intervals. Panel A of Figure 7 suggests that the spread differences between the (later) treated bonds and the control bonds in the interbank market parallel those in the exchange market before the collateral expansion policy took effect on June 1, 2018. However, after the expansion of the set of eligible collateral for MLF, the spread difference between the treated bonds and the control bonds significantly decreased in the interbank market relative to that in the exchange market. The magnitude reaches close to 100 bps about 20 trading days after the policy shock. The negative impact on the spreads for treated bonds persists for around 60 trading days. Panel B of Figure 7 shows that the pattern of α_k estimated when we use only the transactions of the dual-listed bonds is similar, with slightly larger magnitudes.

5.6.2 | Heterogeneous Analysis

One of the policy objectives of the PBOC's unconventional collateral-based monetary policy to include the treated bonds as MLF-eligible collateral is to adjust the leverage structure of the economy and free up funding for small firms (*Xiaowei*), green firms (*Green*), and agricultural firms (*Sannong*). To examine whether the expansion of MLF collateral indeed helps achieve these policy objectives, we conduct a heterogeneous analysis where we further allow $Post \times Treat \times IB$ to interact with *Green*, *Xiaowei*, or *Sannong* dummies in the baseline regression specification (6). Since the dual-listed bonds do not include any financial bonds (see Table 3), such a heterogeneous analysis can be performed only using the full sample. In Appendix Table A.1, we report the results. We do not find significant heterogeneous impacts on the bond spreads of *Xiaowei*, *Green*, and *Sannong* bonds in the secondary market.

5.6.3 | Tighter Event Window

Our identification strategy relies on assumptions that the interbank and secondary markets are segmented. One concern is that this assumption may be less likely to hold with a postpolicy window of 4 months, as in our baseline regression. We test the impact of the MLF collateral expansion on bond spreads with a tighter event window with a sample of 30 trading days before and after the policy shock. Appendix Table A.2 shows the regression results for the specification in Equation (6) with a tighter event window, and it shows that the impacts are still significant for both the full sample of bonds and the dual-listed bonds only.

5.6.4 | Spillover Effect by Bond Types

To examine whether the spillover effects we documented in Subsection 5.5 are heterogeneous across different types of bonds, we also run the following regression:

$$\begin{aligned}\text{Spread}_{ijt} = &\sum_{k=-20,k\neq 0}^{k=17} \alpha_k \text{D}_t^k \times \text{IB}_j \times \text{Treat}_i + \sum_{k=-20,k\neq 0}^{k=17} \gamma_k^{Corp} \text{D}_t^k \times \text{IB}_j \times \text{Corp}_i \\ &+ \sum_{k=-20,k\neq 0}^{k=17} \gamma_k^{Fin} \text{D}_t^k \times \text{IB}_j \times \text{Fin}_i + \beta_1 \text{IB}_j \times \text{Treat}_i + \beta_2 \text{Post}_t \times \text{Treat}_i \\ &+ \delta_i + (\text{BR} \times \text{BT})_{it} + \boldsymbol{Z}'_{ijt}\boldsymbol{\eta} + \varepsilon_{ijt},\end{aligned} \tag{9}$$

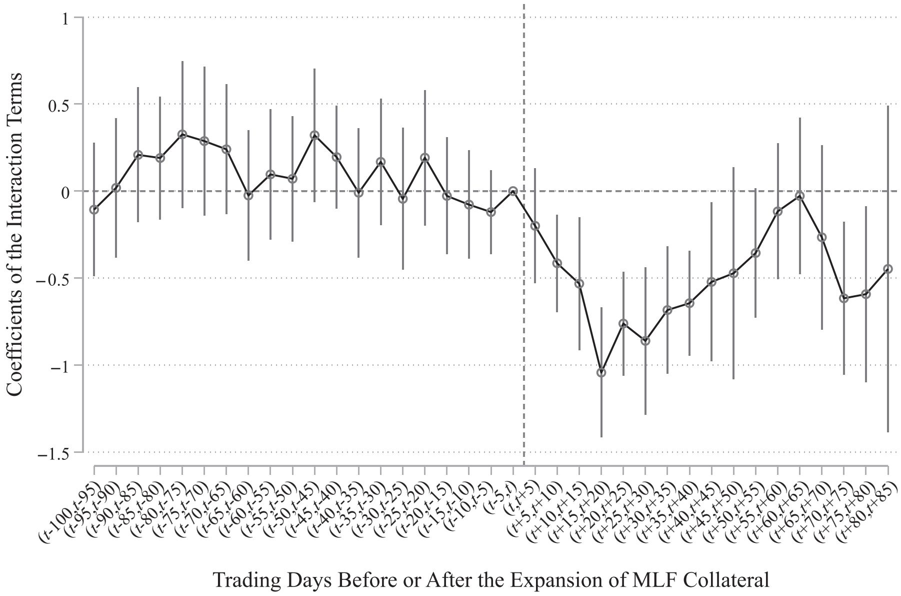
where Corp_i and Fin_i are dummy variables that take value 1 if bond i is a corporate bond and a financial bond, respectively; and γ_k^{Corp} and γ_k^{Fin}, respectively, measure the spillover effects on nontreated corporate bonds and financial bonds in the interbank market.

Figure 8 shows the estimated coefficients for γ_k^{Corp} and γ_k^{Fin}. We can see that the spillover effect is not significant for corporate bonds, but significantly decreases the spread for nontreated financial bonds. One potential explanation is that the AAA corporate bonds were eligible before the policy, and therefore, their collateral values are less affected by the spillover. However, AAA financial bonds were not eligible collateral for MLF before the policy shock. Despite the fact that only "*Xiaowei*," "*Sannong*," and "*Green*" financial bonds are made newly eligible as MLF collateral under the policy, it can potentially decrease traders' perception of the risks of similar high credit-rating financial bonds and thus increase their collateral values.

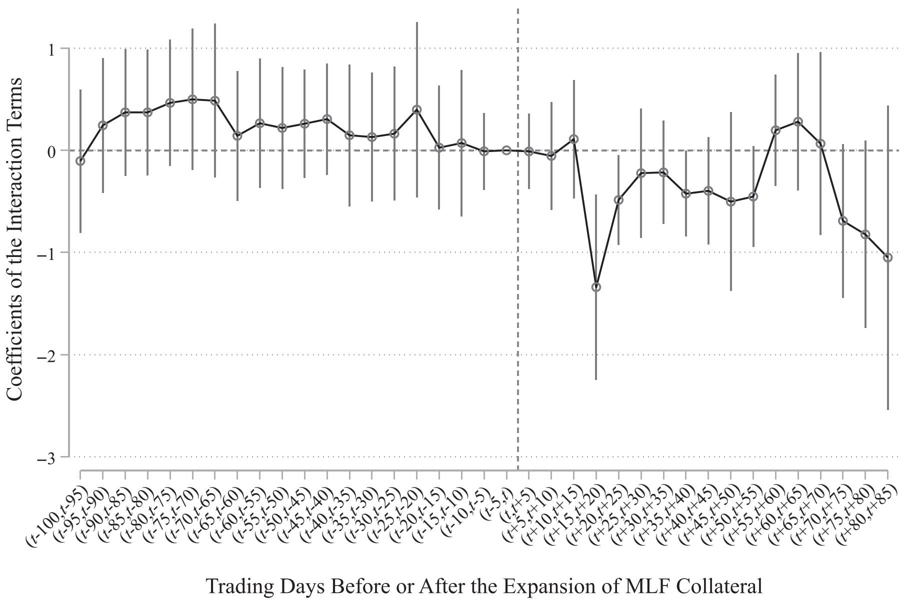
6 | Primary Market: Data, Methods, and Results

Since the secondary market does not directly involve the financing of the bond issuers, to assess the impact of the collateral-based monetary policy on the real economy, it remains to be shown whether the policy has decreased the borrowing cost of bond issuers in the primary market.

The transition of the monetary policy effect from the secondary market to the primary market relies on the fact that the tender process for new bond issuance ensures that the coupon rate is correlated with the market rate of a comparable bond in the secondary market. In China, the new corporate bond issuance is marked with several important dates. The bond issuer first has to submit an application to the NDRC. The issuer usually has to wait for 2–3 months for the NDRC to process the application. After the approval, the issuer can decide when and in which market to issue the bonds. After the issuer has decided on the time and the place, a bond prospectus is published, and a tender process is scheduled. The tender day is usually two trading days



(a) Full Sample

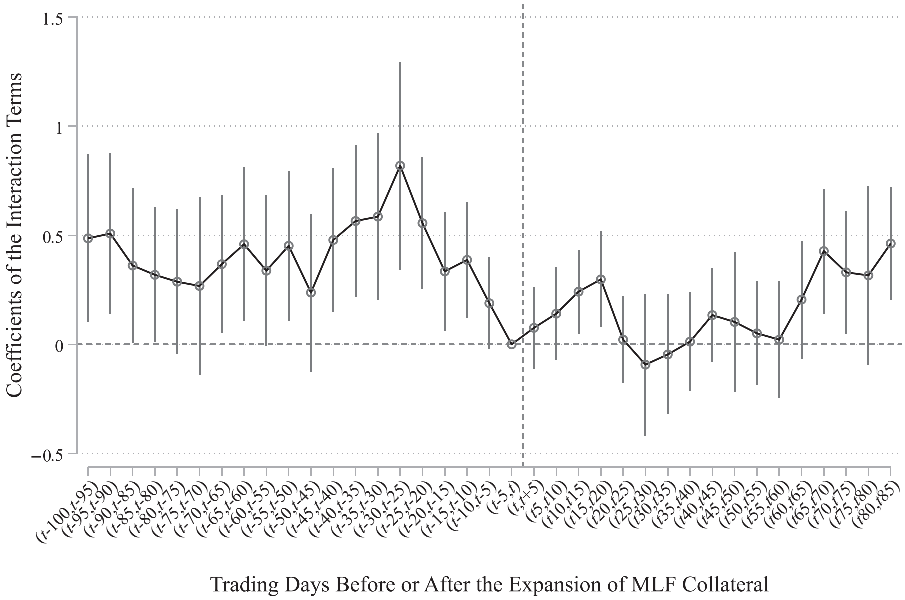


(b) Dual-listed Bonds Only

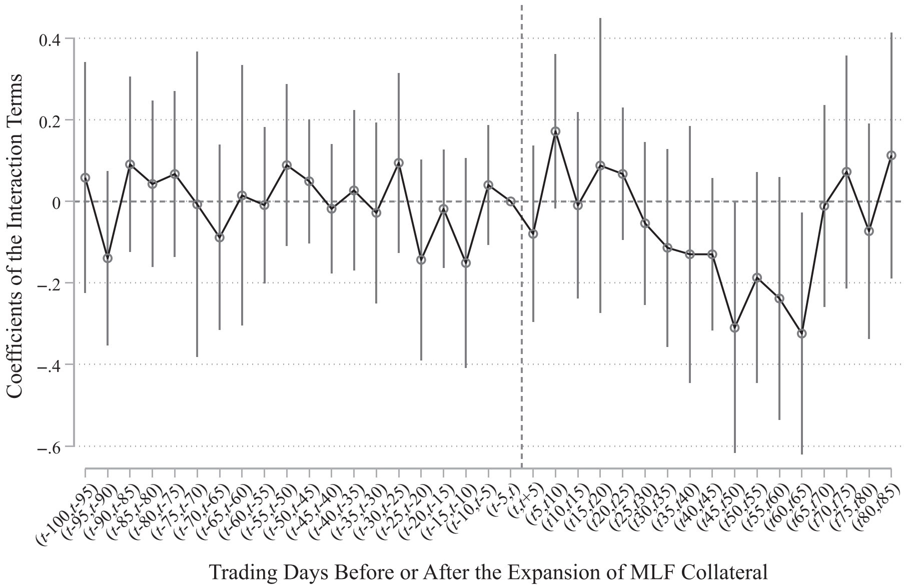
FIGURE 7 | Parallel trend and time patterns of the MLF collateral expansion effects in the secondary market.
Note: Each dot in window $[t-5+5k, t+5k]$ stands for the point estimate of coefficient α_k in regression equation (8). The vertical line around the point is the associated 95% confidence interval. The point in window $[t-5, t]$ is normalized to 0.

after the bond prospectus is issued. On a tender day, all qualified tenders participate in a *uniform-price* auction where they submit sealed bids of yield-quantity pairs that specify the amount they are willing to purchase at a specified minimum yield to the underwriter. The market-clearing yield, which determines the coupon rate of the bond, is the yield at which the aggregate demand submitted by all tenders equates to the bond issuance amount. The bond is settled on the following day, and the bond will be traded in the secondary market on the first business day after the settlement.[36] The tender process ensures that a new bond's coupon rate will be closely related to that of an existing comparable bond in the secondary market. If the spreads of comparable bonds in the secondary market have decreased, it is likely that the coupon rate of new issuance would also decrease.

In this section, we use bond issuance data to examine whether the expansion of MLF-eligible collateral resulted in lower financing costs for new bond issuers.



(a) Spillover on Corporate Bonds



(b) Spillover on Financial Bonds

FIGURE 8 | Spillover effect by bond types.
Note: Each dot in window $[t-5+5k, t+5k]$ stands for the point estimate of coefficients γ_k^{Corp} for corporate bonds (or γ_k^{Fin} for financial bonds) in regression equation (9) with full sample. The vertical line around the point is the associated 95% confidence interval. The point in window $[t-5, t]$ is normalized to 0.

6.1 | Data

6.1.1 | Sample Selection

We focus on the issuance of corporate bonds and financial bonds. Following the logic behind the sample selection rules used in Section 5 for the secondary market, we restrict the sample to newly issued bonds rated at least AA. In baseline analysis, we restrict the sample period to January 1–August 31, 2018; later we also use data from January 1 to August 31, 2015 to conduct a placebo test. We choose to focus on the primary bond issued *before* August 31, 2018 because the applications for such new bond issuance almost certainly would have been submitted to the NDRC for approval before the policy shock date of June 1, 2018, because as we previously mentioned, it would typically take the NDRC 2–3 months to process a new bond issuance application. We restrict our analysis to include new bonds issued after the policy date, but whose applications for approval before

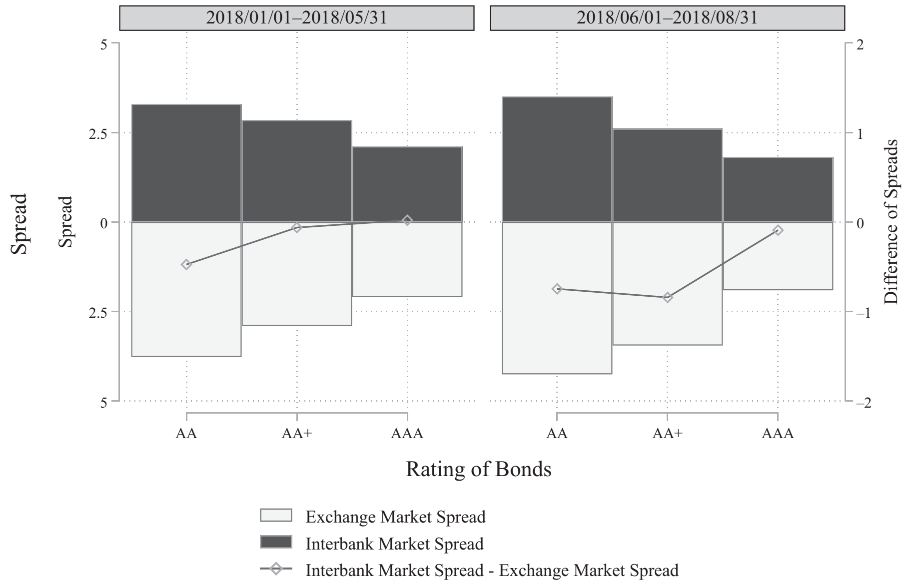


FIGURE 9 | Spread differences for primary market between the interbank and the exchange markets, by bond rating: Primary market.
Note: The sample period of the left graph is January 1–May 31, 2018. The sample period of the right graph is June 1–August 31, 2018. The horizontal axis denotes the three ratings of bonds. The lighter bar is the average spread in the exchange market, and the darker bar is the average spread in the interbank market (left scale). The solid line depicts the difference between the two spreads (right scale).

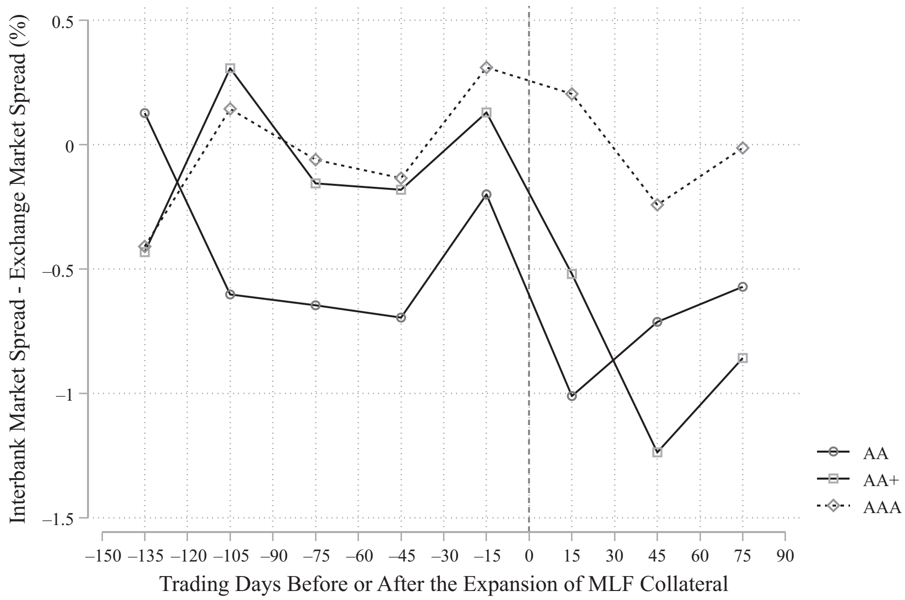


FIGURE 10 | Primary market data: Spreads before and after June 1, 2018.
Note: The sample period of the graph is January 1–August 31, 2018. Each point represents the average difference of spread at issuance between the interbank market and the exchange market in 5-day windows, where the average spread difference is simply the average spread at issuance of interbank market bonds minus the average spread at issuance of exchange market bonds.

the policy date to avoid potential biases from firms changing their venue of bond issuance (see Section 6.3 for some evidence of firms shopping for the venue of bond issuance after August 1, 2018). It is possible that some firms would take advantage of the monetary policy and shift their bond issuance from the exchange market to the interbank market, which may result in a selection bias if bonds issued by these "mover" firms are of lower default risk or higher liquidity than bonds of the same rating issued by "nonmover" firms. Bond issuance information is obtained from WIND.

6.1.2 | Construction of Spread

The dependent variable is spread, calculated as the difference between the coupon rate and the yield of CGB with the same term to maturity on the same day. In China, all bonds are issued at face value, and therefore the yield to maturity *at issuance* equals the coupon rate of the bonds.

We first provide a first glance at the effect of the expansion of MLF collateral on the issuance spread of treated bonds. Figure 9 shows the monthly average bond spreads in the interbank market and the exchange market, by rating categories, as well as the difference in the average spreads in the two markets. The left graph uses data from the 5 months before the policy change, and the right graph uses data from the 3 months after the policy change. It shows that the spread is lower in the interbank market than in the exchange market for all rating categories. However, comparing the left and right panels reveals that the spread difference between the interbank market and the exchange market is significantly lower for AA and AA+ rated bonds after the policy change, but there is no change in the spread difference between the two markets for AAA rated bonds. Figure 10 shows the evolution of the differences in the average spreads of bonds in the two markets before and after the expansion of MLF collateral by rating categories in 5-day windows. The figure suggests that, before the policy change, the spread difference between the interbank market and the exchange market does not exhibit a clear trend for all three rating categories; however, after the policy change, the AA and AA+ rated bonds experienced a sharp decline in spreads in the interbank market relative to those in the exchange market; in contrast, the change for AAA rated bonds (control bonds) is smaller and does not exhibit a significant decline.

6.1.3 | Control Variables

Because a new bond cannot be issued both before and after the policy shock, the identification strategy for the effect of the policy shock on the primary market spreads of the treated bonds must be different from that for the secondary market. To ensure that the bonds issued before the policy shock and those issued after the policy shock are comparable, we need to include an exhaustive list of control variables that may be relevant for new bond yield rates. Now we describe our control variables, which include bond level controls, bond issuer controls, bond market level controls, and macroeconomic factors.

Bond Level Controls. For bond level controls, we include the following variables from WIND: quantity of issuance; term; guaranteed or not; issued by SOE or not; puttable bond or not; callable bond or not.

Bond Issuer Controls. For bond issuer controls, we include the following variables from WIND: debt-to-asset ratio; liquidity ratio; cash coverage ratio; logarithm of asset; and logarithm of equity.

Bond Market-Level Controls. For bond market-level controls, we include the following variables from WIND: daily total new issuance of bonds of the same rating category (AAA, AA+, or AA) and same type (financial bond, corporate bond, enterprise bond, and medium-term note) in the same market (a variable that is referred to as "Similar Bond Issuance" in Table 7); daily issuance of Treasury bonds (Chinese Government Bonds, CGB); and daily issuance of local government bonds (China Municipal Bonds, CMB).

Macroeconomic Factors. It is also important for us to account for macroeconomic factors other than the MLF collateral expansion on June 1, 2018. We control for the quarterly growth rate of GDP in the province of the issuer, which we obtain from the China Statistical Yearbook. In addition, we control for the monthly M2 growth rate, which we obtain from the PBOC. Finally, similar to the analysis for the secondary bond market, we control for the impact of the 100 bps bank RRR cut on April 25, 2018, for commercial and foreign banks to pay back loans obtained via the MLF. We add a series of control variables to account for the RRR cut impact, including $\text{RRRcut}_i \times \text{AAA}_i$, $\text{RRRcut}_i \times \text{AAplus}_i$, $\text{RRRcut}_i \times \text{AAA}_i \times \text{IB}_i$, $\text{RRRcut}_i \times \text{AAplus}_i \times \text{IB}_i$, where RRRcut_i is a dummy equals 1 if the date of issuance is after April 25, 2018, and 0 otherwise, IB_i is a dummy which equals to 1 if the bond is listed in the interbank market, *AAA* is a dummy if the bond is AAA rated corporate bond, and *AAplus* is a dummy if the bond is AA+ rated corporate bond.

6.2 | Baseline Regression Specifications

Our baseline equation for the primary market is based on the following DDD specification:

$$\begin{aligned}\text{Spread}_{it} = {} & \beta_1 \text{Post}_t + \beta_2 \text{Treat}_i + \beta_3 \text{IB}_i + \beta_4 \text{Post}_t \times \text{Treat}_i + \beta_5 \text{Post}_t \times \text{IB}_i \\ & + \beta_6 \text{Treat}_i \times \text{IB}_i + \beta_7 \text{Post}_i \times \text{Treat}_i \times \text{IB}_i + \mathbf{X}'_{it}\boldsymbol{\eta} + \theta_t + \varepsilon_{it},\end{aligned} \tag{10}$$

where Spread_{it}, the dependent variable, is the yield of bond i issued at date t relative to the yield of CGB bonds at date t; Post_t is a dummy which equals to 1 if issue date t was after June 1, 2018, and 0 otherwise; Treat_i is a dummy which equals to 1 if bond i belongs to the categories of bonds that became newly eligible for MLF collateral on June 1, 2018, that is, corporate bonds rated AA and AA+, and financial bonds of *Xiaowei*, *Green*, and *Sannong* firms rated AA or higher; IB_i is a dummy which equals to 1 if bond i is issued in the interbank market; $\mathbf{X}_{it}$ is a list of control variables discussed in the previous section; and finally, θ_t are quarter fixed effects. We focus specifically on coefficient β_7 for the triple interaction term $\text{Post}_i \times \text{Treat}_i \times \text{IB}_i$.

Table 7 presents the summary statistics of the variables used for primary market analysis. Panel A shows that, during the sample period of January 1–December 31, 2018, there were 1791 new bonds being issued in total, among which 1091 (60.9% of the total) were issued in the interbank market and 700 (39.1%) in the exchange market; 37.8% of the new bond issuance took place after June 1, 2018; and about 43.4% of the new bonds were treated bonds. The mean issuance size of the new bonds is 1.39 billion yuan, and the bonds issued in the interbank market tend to have a larger size than those issued in the exchange market: 1.50 billion yuan for the interbank market versus 1.2 billion yuan for the exchange market. The mean terms to maturity are about 4.28 years, and those issued in the interbank market have a slightly longer term. Panel B shows that 53% of the new bonds are rated AAA, 28% AA+, and 19% AA. Panel C shows that 89% of the new bonds are corporate bonds, and about 11% are financial bonds.

TABLE 7 | Summary statistics for the primary market data: January 1, 2018–August 31, 2018

Panel A		Full sample					Interbank market					Exchange market				
Variables		Obs	Mean	Std.Dev.	Min	Max	Obs	Mean	Std.Dev.	Min	Max	Obs	Mean	Std.Dev.	Min	Max
Dep.var.	*Spread*	1791	2.537	1.029	0.503	5.889	1091	2.501	0.989	0.568	5.249	700	2.592	1.086	0.503	5.889
Dummies	*Post*	1,791	0.378	0.485	0	1	1091	0.347	0.476	0	1	700	0.426	0.495	0	1
	IB	1791	0.609	0.488	0	1	1091	1	0	1	1	700	0	0	0	0
	Treat	1791	0.434	0.496	0	1	1091	0.487	0.500	0	1	700	0.353	0.478	0	1
Bond info	*Quantity* (Billion RMB)	1791	1.389	1.930	0.0300	40	1091	1.503	2.321	0.0800	40	700	1.212	1.042	0.0300	7.200
	Term	1791	4.275	1.846	0.917	15	1091	4.395	2.017	2	15	700	4.089	1.525	0.917	15
	Guarantee	1791	0.111	0.314	0	1	1091	0.104	0.306	0	1	700	0.121	0.327	0	1
	SOE	1791	0.782	0.413	0	1	1091	0.858	0.349	0	1	700	0.664	0.473	0	1
	Put	1791	0.341	0.474	0	1	1091	0.158	0.365	0	1	700	0.627	0.484	0	1
	Call	1791	0.0882	0.284	0	1	1091	0.120	0.325	0	1	700	0.0386	0.193	0	1
Issuer info	*Debt Asset Ratio*	1791	62.33	18.23	0	95.59	1091	62.16	18.70	0	95.17	700	62.60	17.49	0	95.59
	Liquidity Ratio	1791	3.795	68.24	0	2887	1091	5.194	87.41	0	2887	700	1.614	1.771	0	26.46
	Cash Coverage Ratio	1791	0.501	2.048	−2.571	3.024	1091	0.428	2.071	−2.571	3.024	700	0.615	2.008	−2.571	3.024
	Log Assets	1766	24.99	1.394	19.93	30.68	1079	25.04	1.424	20.76	30.68	687	24.91	1.342	19.93	27.78
	Log Equity	1766	23.86	1.259	19.35	29.00	1079	23.90	1.281	19.84	29.00	687	23.80	1.222	19.35	26.64
Market info	*Similar Bond Issuance* (Billion RMB)	1791	4.885	5.037	0.0300	40	1091	5.358	5.637	0.0800	40	700	4.149	3.812	0.0300	14.60
	CMB Issuance (Billion RMB)	1791	24.79	34.74	0	176.9	1091	18.41	22.73	0	88.44	700	34.74	46.06	0	176.9
	CGB Issuance (Billion RMB)	1791	16.80	61.68	0	500.2	1091	15.50	50.76	0	250.1	700	18.83	75.61	0	500.2
Macro info	ΔGDP	1774	11.63	2.895	−13.58	20.30	1082	11.65	2.725	−13.58	20.30	692	11.59	3.144	−13.58	20.30
	$\Delta M2$	1791	8.869	0.276	8.174	9.233	1091	8.880	0.282	8.174	9.233	700	8.851	0.266	8.174	9.233
	$IB \times AA+$	1791	0.180	0.385	0	1	1091	0.296	0.457	0	1	700	0	0	0	0
	$IB \times AAA$	1791	0.263	0.440	0	1	1091	0.432	0.496	0	1	700	0	0	0	0
	$RRRcut \times IB$	1791	0.322	0.467	0	1	1091	0.528	0.499	0	1	700	0	0	0	0
	$RRRcut \times AA+$	1791	0.128	0.334	0	1	1091	0.142	0.349	0	1	700	0.106	0.308	0	1
	$RRRcut \times AAA$	1791	0.294	0.456	0	1	1091	0.238	0.426	0	1	700	0.380	0.486	0	1
	$RRRcut \times IB \times AA+$	1791	0.0865	0.281	0	1	1091	0.142	0.349	0	1	700	0	0	0	0
	$RRRcut \times IB \times AAA$	1791	0.145	0.352	0	1	1091	0.238	0.426	0	1	700	0	0	0	0

(Continues)

TABLE 7 | (Continued)

Panel B		**Full sample**		**Interbank market**		**Exchange market**	
Bond rating		**Obs.**	**Percent**	**Obs.**	**Percent**	**Obs.**	**Percent**
Rating	AA	339	18.93	209	19.16	130	18.57
	AA+	497	27.75	345	31.62	152	21.71
	AAA	955	53.32	537	49.22	418	59.71
	Total	1791	100	1091	100	700	100
Panel C		**Full sample**		**Interbank market**		**Exchange market**	
Bond type		**Obs.**	**Percent**	**Obs.**	**Percent**	**Obs.**	**Percent**
Type	Corporate bonds	1596	89.11	985	90.28	611	87.28
	- *Enterprise bonds*	141	7.870	140	12.83	1	0.14
	- *Exchange-traded corporate bonds*	610	34.06	-	-	610	87.14
	- *Medium-term notes*	845	47.18	845	77.45	-	-
	Financial bonds	195	10.89	106	9.720	89	12.71
	Total	1791	100	1091	100	700	100
Panel D		**Full sample**		**Interbank market**		**Exchange market**	
Issuance size (Billion RMB)		**Quantity**	**Quantity/Total**	**Quantity**	**Quantity/Total**	**Quantity**	**Quantity/Total**
Issuance	Corporate bonds	1815.8	72.97	1165.5	71.07	650.3	76.64
	- *Enterprise bonds*	125.1	5.027	123.5	7.530	1.600	0.189
	- *Exchange-traded corporate bonds*	648.7	26.07	-	-	648.7	76.45
	- *Medium-term notes*	1042	41.87	1042	63.54	-	-
	Financial bonds	672.7	27.03	474.5	28.93	198.2	23.36
	Total	2488.5	100.00	1640	100.00	848.5	100.00

Note: This table presents a summary of statistics of primary bond market data. See text in Section 6 for details of the variables.

TABLE 8 | Impact of the MLF collateral expansion on bond spreads in the primary market

	Weighted by bond issuance size					Unweighted
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Post	0.0205	0.00238	0.0520	0.102	0.116	−0.0383
	(0.0920)	(0.0807)	(0.0791)	(0.0828)	(0.0869)	(0.0857)
Treat	1.238***	0.907***	0.817***	0.827***	0.583***	0.599***
	(0.0880)	(0.130)	(0.117)	(0.117)	(0.131)	(0.111)
IB	−0.268***	−0.0942	0.0340	0.0239	−0.614***	−0.849***
	(0.0798)	(0.0593)	(0.0562)	(0.0556)	(0.151)	(0.129)
IB × *Treat*	−0.132	−0.190**	−0.300***	−0.302***	−0.00982	0.499***
	(0.118)	(0.0955)	(0.0958)	(0.0963)	(0.161)	(0.146)
Post × *Treat*	0.829***	0.905***	0.881***	0.884***	0.823***	0.631***
	(0.151)	(0.161)	(0.162)	(0.163)	(0.157)	(0.121)
Post × *IB*	−0.0821	−0.108	−0.137*	−0.159*	−0.209**	−0.160
	(0.115)	(0.0871)	(0.0824)	(0.0825)	(0.0946)	(0.103)
Post × *Treat* × *IB*	−0.557**	−0.537***	−0.483**	−0.485**	−0.529**	−0.353**
	(0.216)	(0.201)	(0.195)	(0.197)	(0.207)	(0.169)
Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Bond info.	No	Yes	Yes	Yes	Yes	Yes
Bond issuer info.	No	No	Yes	Yes	Yes	Yes
Market info.	No	No	No	Yes	Yes	Yes
Macro factors	No	No	No	No	Yes	Yes
Obs.	1791	1791	1766	1766	1757	1757
Adjusted R^2	0.415	0.588	0.611	0.612	0.632	0.606

Note: This table shows the impact of the expansion of the MLF eligible collateral on the bond spreads in the primary market using a triple-difference (DDD) specification. The regression equation is specified by Equation (10). In Columns (1)–(5), the regression is weighted by bond issuance sizes. Column (6) reports the results from an unweighted regression. Standard errors are clustered at the bond level. ***,**, and * represent statistical significance at 1%, 5%, and 10%, respectively.

6.3 | Baseline Result, Robustness Checks, and Heterogeneous Analysis

6.3.1 | Baseline Result

Table 8 presents the baseline estimation results for Equation (10). The coefficient of particular interest is that of the interaction term $\text{Post}_t \times \text{Treat}_i \times \text{IB}_i$, which is estimated to be negative and statistically significant in all specifications. In Columns (1)–(5), the regression is weighted by bond issuance sizes. In our view, the bond issuance size-weighted regressions provide a more useful estimate of how the collateral expansion affects the overall funding cost of borrowers in the economy. In the preferred specification, where we include all the relevant control variables, we find that the spread of the treated bonds is 52.9 bps lower in the treatment market (the interbank market) relative to the control market (the exchange market). The estimates suggest that, for a firm issuing a 1.4 billion yuan corporate bond (which is the mean bond issuance size of our sample) with semiannual coupon payment, the expansion of MLF collateral will save its borrowing cost by about 7.4 million yuan every year. This is a substantial reduction in the funding cost of the firms that issue treated bonds in the interbank market. In Column (6), we also report the results from an unweighted regression, where we estimate that the MLF collateral expansion reduces the spread of treated bonds by 35.3 bps.

Recall that in Section 5, we find that in the secondary market, the June 1, 2018 policy shock reduced the spreads of the newly collateralizable bonds in the interbank market by 36.5–52.5 bps; thus our finding that at primary issuance, the treated bonds enjoyed a 35.3–52.9 bps lower spread in the treatment market (interbank market) relative to the control market (exchange market) suggests that pass-through rate is between about 67% (35.3 bps relative to 52.5 bps) to as high as more than 100% (52.9 bps relative to 36.5 bps). This is consistent with our simulation in Section 4. As illustrated in Figure 3, the pass-through rate from the secondary market to the primary market can indeed be lower or higher than 100%, depending on the maturity of the new issuance relative to that of the existing bonds traded in the secondary market.

6.3.2 | Parallel Trends and Dynamic Effects

In order to examine the parallel trend assumption necessary for the DDD strategy specified in (10) to work, we also estimated the

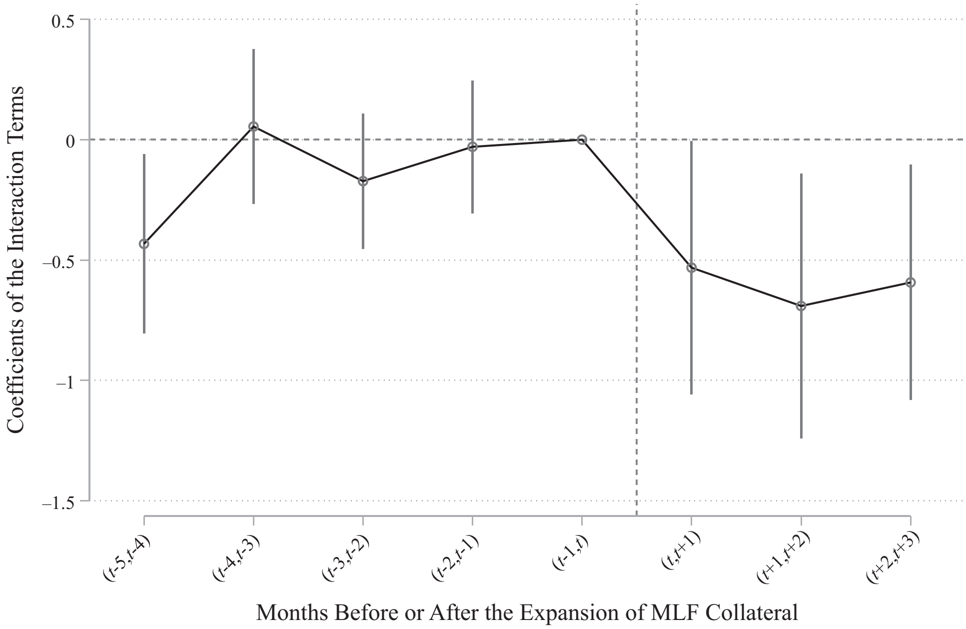


FIGURE 11 | Parallel trend and dynamic effects: Primary market.
Note: Each dot in window $[t-1+k, t+k]$ stands for the point estimate of coefficient α_k from Equation (11). The vertical line around the point is the associated 95% confidence interval. The point in window $[t-1, t]$ is normalized to 0.

following specification:

$$\text{Spread}_{it} = \beta_1 \text{Post}_t + \beta_2 \text{Treat}_i + \beta_3 \text{IB}_i + \beta_4 \text{Post}_t \times \text{Treat}_i + \beta_5 \text{Post}_t \times \text{IB}_i + \beta_6 \text{Treat}_i \times \text{IB}_i + \sum_{k=1,k\neq 5}^{k=9} \alpha_k \text{Month}_{it}^k \times \text{Treat}_i \times \text{IB}_i + \mathbf{X}_{it}'\eta + \theta_t + \varepsilon_{it}, \tag{11}$$

where Month_{it}^k is dummy which equals 1 if bond i is issued in the kth month in 2018. We normalize the dummy for the fifth ($k = 5$) month to 0 as the benchmark.

Figure 11 presents the estimated values of α_k based on Equation (11) for $k \in \{1, \dots, 9\}$. It shows that, prior to the policy shock, the α_k estimates are small and tend to be statistically insignificant, that is, before the policy shock, the difference between the spread in the interbank market and that in the exchange market is similar for the treatment bonds and the control bonds. After the policy shock, the spreads of treatment bonds in the interbank market are significantly reduced relative to the control bonds. The effect is immediate and persists for all three months after the policy shock in our estimation sample.

6.3.3 | Seasonal Effect? A Placebo Test

We used only the new bond issuance data within 3 months of the policy shock to deal with the potential selection bias from “movers” choosing to issue their bonds in the interbank market. This short postpolicy sample period, however, introduces a concern: maybe the changes in the difference of the spreads of the treated bonds in the interbank market and in the exchange market are driven by a seasonal effect that *differentially* impacts the interbank market and the exchange market, instead of the policy effect. To address such a concern, we conduct the following placebo test: we use the new bond issuance data for bonds issued during the period of *January 1 to August 31, 2015*, and rerun regression equation (10), setting June 1, 2015, as the factitious policy date.[37] The variable $Post_t$ is redefined so that it equals 1 if the bond is issued after June 1, 2015, and 0 otherwise.

Table 9 reports the result from this placebo test. We find that different from the findings reported in Table 8, the coefficient estimates of the triple interaction term $\text{Post}_t \times \text{Treat}_i \times \text{IB}_i$ in this placebo test tend to be statistically insignificant, and if anything, of a positive sign. This implies that seasonal factors are unlikely to be the driver for the findings reported in Table 8.

6.3.4 | Heterogeneous Analysis

It is also interesting to see whether there are heterogeneous effects of the expansion of the collateral-eligible bonds for MLF depending on the sector of the bond issuer. In Appendix Table A.3, we report the regression results from the heterogeneous analysis, where we add additional interaction terms of $\text{Post}_t \times \text{Treat}_i \times \text{IB}_i$ with *Xiaowei*, *Green*, and *Sannong*. The *Xiaowei*, *Green*, and *Sannong* bonds see a larger decrease in spread. The magnitude of the impact is large for these bonds, ranging from 2 to 4 times the impact of an average targeted bond.

6.3.5 | Shopping for “Venue”?

Results reported in Table 8 provide strong evidence that the collateral expansion monetary policy reduced the yield of the targeted bonds in the interbank market relative to that in the exchange market. This of course has direct implications for funding costs for the firms issuing the targeted bonds in the interbank market. An additional implication is that, to the extent

TABLE 9 | Placebo test of the MLF collateral expansion on bond spread in the primary market: Using June 1, 2015 as the fictitious event date

	Weighted by bond issuance size					Unweighted
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Post	0.108	0.630	0.673	0.714*	0.701**	0.662*
	(0.316)	(0.404)	(0.409)	(0.399)	(0.337)	(0.349)
Treat	0.574*	0.755*	0.678*	0.675*	0.689*	0.995***
	(0.333)	(0.394)	(0.408)	(0.400)	(0.388)	(0.316)
IB	−0.361*	0.140	0.195	0.115	−0.300	−0.273
	(0.201)	(0.346)	(0.353)	(0.345)	(0.392)	(0.356)
$IB \times Treat$	0.586*	0.379	0.319	0.339	0.981**	0.913**
	(0.345)	(0.370)	(0.379)	(0.374)	(0.389)	(0.361)
$Post \times Treat$	−0.514	−0.975**	−1.002**	−0.893**	−0.650	−0.952**
	(0.451)	(0.465)	(0.471)	(0.447)	(0.466)	(0.412)
$Post \times IB$	−0.0968	−0.658	−0.726*	−0.680*	−0.545	−0.527
	(0.331)	(0.414)	(0.425)	(0.401)	(0.340)	(0.356)
$Post \times Treat \times IB$	0.138	0.687	0.742	0.678	0.515	0.791*
	(0.473)	(0.484)	(0.495)	(0.472)	(0.483)	(0.428)
Quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Bond info.	No	Yes	Yes	Yes	Yes	Yes
Bond issuer info.	No	No	Yes	Yes	Yes	Yes
Market info.	No	No	No	Yes	Yes	Yes
Macro factors	No	No	No	No	Yes	Yes
Obs.	581	581	580	580	580	580
Adjusted R^2	0.367	0.556	0.554	0.567	0.617	0.552

Note: This table shows the placebo test of the expansion of the MLF eligible collateral on the bond spreads in the primary market using primary bond market data between January 1 and August 31, 2015. The regression equation is specified by Equation (10). In Columns (1)–(5), the regression is weighted by bond issuance sizes. Column (6) reports the results from an unweighted regression. Standard errors are clustered at the bond level. ***,**, and * represent statistical significance at 1%, 5%, and 10%, respectively.

that bond issuers have a choice of which market—the interbank market or the exchange market—to issue their bonds, we may expect that eligible firms would take advantage of the policy and issue bonds in the interbank market. We call this phenomenon "*shopping for the venue.*" Recall that any new bond issuance application needs to be submitted to the NDRC for approval, which takes about 2–3 months typically. That is, even though the policy shock occurred on June 1, 2018, the effect of the policy on the venue of the new bond issuance should not manifest itself until at least August 2018. Only for results here, we redefine the L.Post_t variable to take the value 1 if t is after August 1, 2018. In addition, we include all new bonds issued before December 31, 2018 in our analysis sample.[38]

To test this hypothesis, we estimate the following logistic regression model:

$$\ln\left[\frac{\Pr(\text{IB}_{it}=1)}{1-\Pr(\text{IB}_{it}=1)}\right] = \alpha_1\text{Post}_t + \alpha_2\text{Treat}_i + \alpha_3\text{Post}_t \times \text{Treat}_i + \mathbf{X}'_{it}\boldsymbol{\eta}, \tag{12}$$

where $\text{IB}_{it} = 1$ if new bond i is issued in the interbank market at date t; $\text{Post}_t = 1$ if the bond issuance date t is after August 1, 2018; $\text{Treat}_i = 1$ if bond i is one of the targeted bonds; $\mathbf{X}_{it}$ stands for the same sets of control variables we described in Subsection 6.1, and the coefficient of interest is α_3 for the interaction term $\text{Post}_t \times \text{Treat}_i$. We expect that α_3 will be positive and statistically significant if targeted firms engage in venue shopping in that they are more likely to apply to the NDRC to issue their bonds in the interbank market after the policy shock.

Table 10 presents the result from the logistic regressions specified by Equation (12). In the preferred specification reported in Column (4) where we control for month fixed effects, as well as all the controls we described in Subsection 6.1, we find that, indeed, *ceteris paribus*, firms are more likely to apply to issue the treated bonds in the interbank market after the June 1, 2018 policy shock of the MLF collateral expansion. The coefficient estimates of L.Post × Treat are positive and statistically significant. The coefficient estimates imply that, after June 1, 2018, the odds ratio that firms issuing treated bonds apply to have their bonds issued in the interbank market went up by more than 50% relative to firms issuing control bonds. That is, firms are indeed more likely to choose the venue with a lower funding cost to issue their bonds.

TABLE 10 | Shopping for venue in primary markets: Logit regression results

Variables	(1)	(2)	(3)	(4)
Treat	2.323***	2.507***	2.576***	2.686***
	(0.273)	(0.263)	(0.261)	(0.275)
L.Post × *Treat*	0.427**	0.422**	0.478**	0.518**
	(0.193)	(0.199)	(0.206)	(0.233)
Month FE	Yes	Yes	Yes	Yes
Bond info.	Yes	Yes	Yes	Yes
Bond issuer info.	No	Yes	Yes	Yes
Market info.	No	No	Yes	Yes
Macro factors	No	No	No	Yes
Obs.	3075	3042	3042	3026

Note: This table examines whether the MLF collateral expansion increases the probability for eligible-bond issuers to choose the interbank market. Results are reported from a logistic regression as specified by Equation (12). *L.Post* dummy takes the value of 1 if the bond was issued after August 1, 2018: the application for the approval to issue such bonds would have been submitted after the policy shock date of June 1, 2018, because the NDRC typically takes 2–3 months to approve the bond issuance. Standard errors are clustered at the bond level. ***,**, and * represent statistical significance at 1%, 5%, and 10%, respectively.

7 | Exploring the Mechanisms

In this section, we explore several mechanisms that may explain the results we have documented so far for the collateral-based monetary policy.

7.1 | Repo Haircuts

One potential mechanism of the collateral-based monetary policy is through the repo haircut. Repo, or repurchase agreement, is a transaction in which one party sells securities, usually bonds, to another party with a commitment to repurchase them at a specified price and date. It can also be seen as short-term wholesale funding using the securities as collateral. The loan size is usually lower than the market value of the collateral. The percentage difference between the loan value and the market value of the securities is referred to as "haircut." For example, if the market value of the securities is \$100, a 2% haircut would mean that the lender lends \$98 with the collateral. When the treated bonds become eligible as collateral for MLF, their haircuts as MLF collateral decrease from 100% to some value less than 100%, which may also decrease their haircut when serving as collateral for other repo trades in the interbank market. Our simple model in Section 4 shows that lower haircuts can lead to higher asset prices. So far, our analysis has focused on the cash bond markets where the counterparties only negotiate on bond prices (which implies bond yields) and in the background the relevant margin (or haircut) is *exogenously* modified by the central bank when the treatment bonds were made as eligible collateral for the MLF. However, in repo markets the haircuts will be determined *endogenously* by the counterparties or by the centralized exchange, and the haircuts for the treated bonds in the repo transactions may change in response to the policy shock on June 1, 2018.

TABLE 11 | Average haircuts of bonds in the exchange repo market and the interbank repo market before and after the MLF collateral expansion

	Control		Treat	
	Pre	**Post**	**Pre**	**Post**
Exchange repo market	19.32	19.41	50.78	54.70
Interbank repo market	3.28	3.71	9.07	11.74

Note: This table shows the average haircuts of bonds in the exchange repo market and the interbank repo market before and after the MLF collateral expansion. The sample period is from January 1 to September 30, 2018, with a 5-month window (99 trading days) before June 1, 2018 defined as "Pre" expansion and a 4-month window (83 trading days) on and after June 1, 2018 defined as "Post" expansion, respectively.

We collected repo haircuts to explore whether the collateral-based policy works through the repo market. There are two repo markets in China, the interbank repo market and the exchange repo market. The interbank (exchange, respectively) repo market uses the bonds traded in the interbank (exchange, respectively) market as collateral. In the interbank market, repo trades are bilateral and haircuts are determined by the traders. As bonds may be used as collateral infrequently, we calculate the haircut of each bond on date t using a 5-day moving-average haircut from date $t-2$ to date $t+2$.[39] We obtained the standardized haircut in the exchange market from WIND. Different from the interbank market, the exchange acts as the central clearing party, and the standardized repo haircut is set by CSDC daily. We merge the secondary cash bond market transactions data with their haircuts calculated from the repo market transactions on the same day. Our sample period is from January 1 to September 30, 2018. and the definition of variables besides Haircut follows from Section 5. Table 11 shows the haircuts in the exchange market and interbank market repo transactions before and after the policy shocks.

First, we estimated the impact of the policy on the haircut of the treated bonds using the following regression:

$$\begin{aligned}\text{Haircut}_{ijt} \quad = \quad & \beta_1 \text{Post}_t \times \text{IB}_j \times \text{Treat}_i + \beta_2 \text{IB}_j \times \text{Treat}_i + \beta_3 \text{Post}_t \times \text{Treat}_i \\ & + \delta_{ij} + \theta_{jt} + (\text{BR} \times \text{BT})_{it} + \boldsymbol{Z}'_{ijt}\eta + \varepsilon_{ijt},\end{aligned} \tag{13}$$

where the dependent variable is the haircut of bond i in market j on date t and the control variables are the same as the baseline regression in Equation (6).

Table 12 shows the regression results. We find that the MLF collateral expansion decreases the haircuts of treated bonds in the interbank market by 3.31%.

We also have a parallel trend analysis using the following regression,

$$\begin{aligned}\text{Haircut}_{ijt} = & \sum_{k=-10,k\neq 0}^{k=18} \alpha_k \text{D}_t^k \times \text{IB}_j \times \text{Treat}_i + \beta_1 \text{IB}_j \times \text{Treat}_i + \beta_2 \text{Post}_t \times \text{Treat}_i \\ & + \delta_{ij} + (\text{BR} \times \text{BT})_{it} + \theta_{jt} + \boldsymbol{Z}'_{ijt}\eta + \varepsilon_{ijt},\end{aligned} \tag{14}$$

where we divide our sample period (a total of 184 trading days) into 18 subperiods, with each period consisting of a 10-day

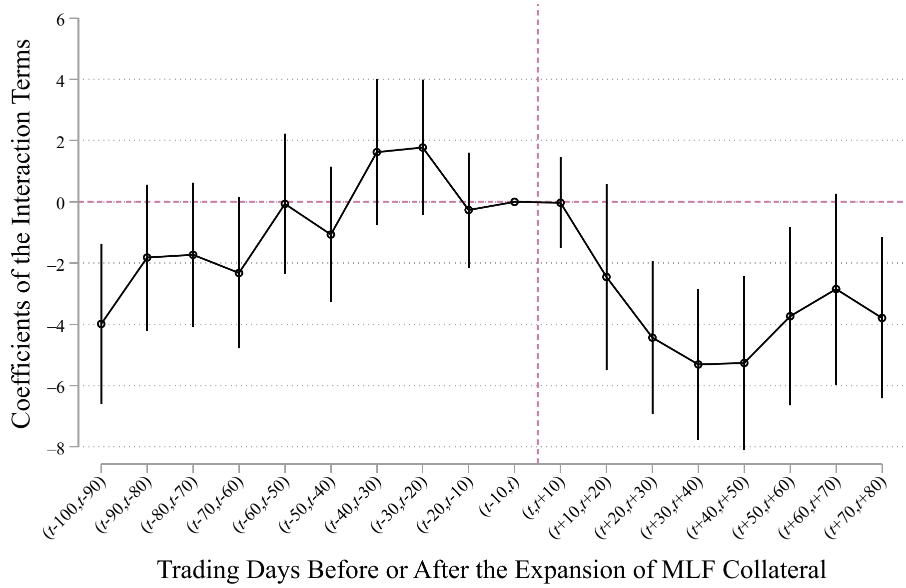


FIGURE 12 | Parallel trend analysis of the impact of the MLF collateral expansion on repo haircuts.
Note: Each dot in window $[t+10(k-1), t+10k]$ stands for the point estimate of coefficient α_k from Equation (14). The vertical line around the point is the associated 95% confidence interval. The point in window $[t-10, t]$ is normalized to 0.

TABLE 12 | Impact of the MLF collateral expansion on bond haircuts in the repo markets

	Haircut
$Post \times Treat \times IB$	−3.314***
	(0.939)
$Post \times Treat$	1.818*
	(1.036)
$IB \times Treat$	−16.21***
	(2.103)
Macro factor	Yes
Bond type × Bond rating × Date FE	Yes
Market × Date FE	Yes
Bond FE	Yes
Observations	74,936
Adjusted R^2	0.976

Note: This table examines whether the MLF collateral expansion decreases the haircuts of the newly eligible bonds in the repo markets. The result is reported from the regression specified by Equation (13). Standard errors are two-way clustered at the bond and date levels. ***,**, and * represent statistical significance at 1%, 5%, and 10%, respectively.

window.[40] The dummies D_t^k equals 1 if the date t falls in the subperiod k, and 0 otherwise. We normalize the point estimate of the DDD coefficient immediately before the policy shock date to zero. The same sets of control variables as those specified for regression in Equation (6) are included. Figure 12 plots the point estimate of α_k and the corresponding 95% confidence intervals. It indicates that the haircuts for the newly eligible collateral were in parallel with the control group before the policy shock, but their haircuts decreased after the policy change. This effect is consistent with the findings in Chen et al. (2023), where they studied the effect of a policy shock in 2015 of opposite direction when the exchange repo market made certain corporate bonds ineligible as collateral in repo transactions, effectively increasing the haircut for these bonds to 100%; they found that the haircut for these bonds in the repo transactions in the interbank market increased.

7.2 | Liquidity versus Default Spreads

Besides the effect on repo market, another potential mechanism of the collateral-based monetary policy is through the improvement of market liquidity. Because the central bank is a significant market participant, the expansion of MLF collateral may increase the market depth and thus *market liquidity* of the targeted bonds. It might be that the decrease in the spread of targeted bonds is due to improvements in market liquidity without necessarily changing their collateral values. To test this alternative explanation, we provide a decomposition of the policy impact on *liquidity spread* and *default spread*.

We follow Schwert (2017) to decompose the spread into liquidity spread and default spread as follows. First, we construct the *illiquidity* measure in the existing finance literature proposed by Amihud (2002). The illiquidity measure, which we denote by Amihud, for bond i in market j at time t is based on the absolute daily return relative to the trading volume, averaged over a seven-trading-day window around the focal date. Specifically,[41]

$$\text{Amihud}_{ijt} = \frac{1}{7}\sum_{s=t-3}^{t+3}\frac{|r_{ijs}|}{\text{Vol}_{ijs}}, \quad (15)$$

TABLE 13 | Liquidity spread versus default spread in the secondary market

	Full sample			Dual-listed bonds only		
	Total spread	**Liquidity spread**	**Default spread**	**Total spread**	**Liquidity spread**	**Default spread**
Variables	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
$Post \times Treat \times IB$	−0.525***	0.104***	−0.627***	−0.365*	0.0361	−0.399**
	(0.142)	(0.0280)	(0.141)	(0.201)	(0.0515)	(0.196)
$IB \times Treat$	−0.310	0.00988	−0.316	−0.646	0.105	−0.751
	(0.596)	(0.0586)	(0.559)	(0.653)	(0.0686)	(0.617)
$Post \times Treat$	0.423***	−0.0638	0.483***			
	(0.149)	(0.0581)	(0.162)			
Macro factors	Yes	Yes	Yes	Yes	Yes	Yes
Bond type × Bond rating × Date FE	Yes	Yes	Yes	Yes	Yes	Yes
Market × Date FE	Yes	Yes	Yes	Yes	Yes	Yes
Bond FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	77,731	77,579	77,579	16,661	16,631	16,631
Adjusted R^2	0.860	0.273	0.854	0.809	0.329	0.809

Note: This table shows the impact of MLF collateral expansion on the liquidity spreads and default spreads of the newly collateralizable bonds. Regression equation is specified by Equation (6) for Columns (1) and (4); for Columns (2) and (5), the dependent variables are replaced by the liquidity spread constructed in Equation (17); and for Columns (3) and(6), they are replaced by the default spread constructed in Equation (18). Standard errors are two-way clustered at the bond and date levels. ***,**, and * represent statistical significance at 1%, 5%, and 10%, respectively.

TABLE 14 | Impact of haircuts on bond spreads

	Total spread	**Liquidity spread**	**Default spread**
	(1)	**(2)**	**(3)**
$\widehat{Haircut}$	0.163***	−0.0348***	0.196***
	(0.0433)	(0.00883)	(0.0428)
$Post \times Treat$	0.178*	0.0151	0.160
	(0.0943)	(0.0608)	(0.127)
$IB \times Treat$	2.405**	−0.573***	2.956***
	(0.956)	(0.160)	(0.931)
Macro factor	Yes	Yes	Yes
Bond type × Bond rating × Date FE	Yes	Yes	Yes
Market × Date FE	Yes	Yes	Yes
Bond FE	Yes	Yes	Yes
Observations	74,936	74,816	74,816
Adjusted R^2	0.860	0.271	0.854

Note: This table shows the estimated impact of the change in the haircuts on bond spreads using the policy shock as the instrumental variable. $\widehat{Haircut}$ is the fitted value of repo haircuts given the regression results in Table 12. The result of Column (1) is reported from the regression specified by Equation (19). For Column (2), the dependent variable is replaced by the liquidity spread constructed in Equation (17); and for Column (3), it is replaced by the default spread constructed in Equation (18). Standard errors are two-way clustered at the bond and date levels. ***,**, and * represent statistical significance at 1%, 5%, and 10%, respectively.

where $|r_{ijs}| = \frac{|P_{ijs} - P_{ijs-1}|}{|P_{ijs-1}|}$ is the absolute daily return constructed using P_{ijs}, the clean close price for bond i in bond market j on date s; and Vol_{ijs} is the trading volume of bond i in market j on the day s, where s are the seven trading days around the focal date t. The higher is Amihud_{ijt}, the lower is the liquidity of bond i in market j at date t because more liquid bonds are likely associated with larger trading volumes and less day-to-day price volatility.

Second, with the illiquidity measure constructed by (15), we follow Schwert (2017) to decompose the yield spread of a bond into a liquidity spread and a default spread. In order to construct the liquidity spread, we run, separately by quarter $q \in \{1, 2, 3\}$ and by market j, the following set of regressions:

$$\text{Spread}_{ijt} = \alpha_{qj}\text{Amihud}_{ijt} + \boldsymbol{\Gamma}'_{ijt}\boldsymbol{\beta}_{qj} + \text{BR}_{ij} + \theta_t + \varepsilon_{it}, \text{if } t \in \mathcal{D}_q, \tag{16}$$

where Amihud_{ijt} is the illiquidity measure constructed in (16), $\boldsymbol{\Gamma}_{ijt}$ refers to a set of bond characteristics such as issuance size, term to maturity, bond coupon rate, BR_{ij} is the bond rating fixed effect, θ_t is the trading day fixed effect, and $\mathcal{D}_q$ denotes the trading days in quarter $q \in \{1, 2, 3\}$.[42] By running the regressions of Equation (16) separately for each quarter and each market, we generate $\widehat{\alpha_{qj}}$. In addition, for each market j, we denote the first percentile of the distribution of computed Amihud_{ijt} as Amihud_{1pj}, and use it to benchmark the illiquidity measure of a very liquid bond in the market j.

We follow Schwert (2017) to decompose the spread of bond i in market j at date t into *liquidity spread* and *default spread*; specifically, the liquidity spread of bond i in market j at date t is calculated as

$$\text{Liquidity Spread}_{ijt} = \widehat{\alpha_{qj}}(\text{Amihud}_{ijt} - \text{Amihud}_{1pj}); \tag{17}$$

and its default spread is simply the residual of its spread after subtracting the liquidity spread estimated in (17):

$$\text{Default Spread}_{ijt} = \text{Spread}_{ijt} - \text{Liquidity Spread}_{ijt}. \tag{18}$$

The summary of statistics of the liquidity spread and default spread for the full sample and the dual-listed bonds sample can be found in Tables 2 and 6, respectively.

We then regress the liquidity spread and default spread constructed above as the dependent variable and run the baseline regression as specified in (6). The results are reported in Table 13. The left panel uses the full sample and the right panel only the dual-listed bond transactions. Columns (1) and (4) simply replicate the results in Table 5. Columns (2) and (5) report the results for liquidity spread, and Columns (3) and (6) for the default spread. Column (2) shows that the coefficient estimate of the triple interaction term *Post* × *Treat* × *IB* is positive and statistically significant, suggesting that the treated bonds may have actually experienced an increase in the liquidity spread in the interbank market after the policy shock. This is theoretically possible, for example, if a large quantity of treatment bonds is used as collateral for MLF, which reduces the availability of such bonds for transactions in the interbank market. However, when we restrict to the dual-listed bonds only, we find in Column (5) that the causal impact of the MLF collateral expansion has almost no effect on the liquidity spread of the treated bonds in the interbank market. In contrast, we find that the coefficient estimates of the triple interaction term *Post* × *Treat* × *IB* are almost identical to those of Columns (1) and (4) for the total spread. Thus, we conclude that almost all the decrease in the total spread is due to the decrease of the default spread, and the liquidity spread is not significantly affected by the expansion of the MLF collateral.[43]

The model implies that the decrease in the default spreads can be a result of the decrease in prevailing haircuts induced by the MLF collateral expansion. To establish the linkage between the haircut and the default spread of the eligible bonds, we further examined the relationship between repo haircuts and the bond spreads with the following equation:

$$\begin{aligned}\text{Spread}_{ijt} = \beta_1\widehat{\text{Haircut}}_{ijt} + \beta_2\text{IB}_j \times \text{Treat}_i + \beta_3\text{Post}_t \times \text{Treat}_i + \delta_i \\ +\theta_{jt} + (\text{BR} \times \text{BT})_{it} + \boldsymbol{Z}'_{ijt}\boldsymbol{\eta} + \varepsilon_{ijt},\end{aligned} \tag{19}$$

where $\widehat{\text{Haircut}}_{ijt}$ is the fitted value from Equation (13), and the policy shock is used as an instrumental variable which exogenously changed the haircut in the interbank market. The other control variables are the same as the baseline regression in Equation (6). The dependent variable can be the total spread, liquidity spread, and default spread. Table 14 reports the regression results of Equation (19). Consistent with the model, Column (3) of Table 14 suggests a 1% lower haircut can decrease the default spread by 19.6 bps. In contrast, we find a negative relationship between haircuts and the liquidity spread (see Column (2)).

Our results suggest that the MLF collateral expansion does not improve market liquidity for new eligible bonds, but significantly decreases their default spreads. The decrease in default spreads may reflect their higher collateral values in the repo market. Our findings are consistent with the prediction of the leverage cycle theory (e.g., Geanakoplos 2010) as described in our simple model in Section 4 that higher leverage allows more optimistic investors to buy more of the assets, thus a more optimistic investor with a lower perceived default risk will become the marginal investor. This increases the bond price, which in turn lowers its spread.

There are of course alternative theories consistent with our findings, for example, risk-taking channel (Borio and Zhu 2012; Bruno and Shin 2015) where traders reprice the default risk of the eligible bonds. Due to the limitation in data, we are not able to distinguish between the changes in risk appetite (i.e., the risk-taking channel) and the change in the marginal trader's belief (i.e., the leverage cycle theory). We leave it for future research to differentiate these channels.

8 | Conclusion

In this paper, we provide a *causal* evaluation of collateral-based unconventional monetary policy on asset prices in the secondary market and in the real economy. This is an empirically challenging problem because of the well-known policy endogeneity problem. In the estimation of the causal effects of collateral-based monetary policy, we exploit the unique institutional features of the Chinese bond market, namely, dual-listed bonds are traded in two largely segmented markets: the interbank market regulated by the central bank, and the exchange market regulated by the securities regulator. During a policy shift in our study period (June 1, 2018), China's central bank included a class of previously ineligible bonds in the interbank market to become eligible collateral for financial institutions to borrow money from its MLF. These bonds that were newly eligible as MLF collateral are referred to as "*treated bonds*." However, these treatment bonds are treated only in the interbank market (*"treatment market"*) but not in the exchange market (*"control market"*). Since many of these treatment bonds are dual-listed in both markets, we can use the changes in the spread difference between the "control" and "treatment" bonds in the exchange market, which reflects the possible differential impact of time-varying factors on the two groups of bonds. as the counterfactual outcome of the treatment bonds, if they did not receive the treatment. Thus, this policy shift allows us to implement a DDD strategy to estimate the causal impact of the collateral-based unconventional monetary policy.

Our results provide corroborative support for the leverage cycle theory which predicts that the collateral eligibility of an asset for MLF will increase its price (i.e., reduce its spread) in the secondary market. We find that the spreads of treated bonds in the secondary market are reduced by 40–60 bps on average. We also find that the collateral effects pass through to the primary bond market, where the issuance spread of targeted bonds is reduced by 53 bps. These results are consistent with the theoretical predictions we presented in Section 4.

The finding is in support of the effectiveness of collateral-based policy tools in reducing financial costs in the economy. The US Federal Reserve and the ECB, as well as many other central banks, have been using collateral-based monetary policy extensively after the Global Financial Crisis. To the extent that in the modern collateral-based financial system, every financial contract is a pair of a promise and associated collateral to back the promise, the findings in this paper may suggest a stronger case for collateral-based monetary policy. Alongside the traditional interest-rate-based tools, collateral-based tools can make monetary policy more effective in reducing financing costs in targeted sectors, both for economic and social purposes. In this case, the central bank can manage a collateral basket, and by changing the eligibility and haircuts of the collateral in the basket (intensive margin) and changing the composition of the collateral in the basket (extensive margin), the central bank can better navigate and moderate financial cycles and business cycles.

Many interesting questions remain to be answered. This paper provides evidence on *price (spread)* effect of monetary policy. To fully assess the effects on corporate financing, evidence on *quantity* adjustment, for example, issuance of bonds in the primary market, would also be informative.[44] These unconventional monetary policy tools may have broader and longer-term effects. For instance, collateral-based monetary policies targeting *Green* bonds may stimulate eligible issuers' investments in green initiatives, while those aimed at bonds issued by small firms could boost their business activities. As important, we should also be cautious about the potential distortions caused by collateral-based monetary policies. For example, the policy may induce risk taking of financial institutions toward certain bonds, worsen the quality of the overall collateral, and may also affect bond issuers' capital structure, which can increase the fragility of the financial system. The causal effects on these margins, and the design of the collateral-based monetary policy that strikes an optimal balance, are fascinating avenues for future research.

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Data Availability Statement

The bond data that support the findings of this study are available from the permission from Wind Data Service https://www.wind.com.cn/portal/en/WDS/index.html. Restrictions apply to the availability of these data, which were used under license for this study. The repo data used in Section 7.1 is proprietary and cannot be shared due to a confidentiality agreement.

Endnotes

[1] The Federal Reserve launched TALF in late November 2008, through which the Fed lent up to $1 trillion to financial markets against collateral of asset-backed securities (ABS) and loans guaranteed by the Small Business Administration. The ECB launched LTROs in March 2008, aiming to reduce sovereign bond spreads, inject liquidity into the market, and provide low interest rate funding to Eurozone banks collateralized by sovereign debt.

[2] For example, in QE1, the Federal Reserve decided to purchase "housing-related government-sponsored enterprises (GSEs)—Fannie Mae, Freddie Mac, and the Federal Home Loan Banks—and mortgage-backed securities (MBS) backed by Fannie Mae, Freddie Mac, and Ginnie Mae" and listed the following as the reason for its action: "Spreads of rates on GSE debt and on GSE-guaranteed mortgages have widened appreciably of late." See the Fed's announcement of QE1 on November 25, 2008:
https://www.federalreserve.gov/newsevents/pressreleases/monetary20081125b.htm.

[3] See Section 3 for more institutional details and Section 5.3 for direct empirical evidence for the market segmentation.

[4] It is important to allow for the time-varying factors to potentially impact the treatment and control bonds differently because, as we mentioned earlier, the treated bonds are not randomly chosen.

[5] In addition, within the broader literature on quantitative easing (QE) (e.g., Gertler and Karadi 2011; Curdia and Woodford 2011; Joyce et al. 2012; Di Maggio et al. 2019; Lenel 2020; Rodnyansky and Darmouni 2017; Chen et al. 2023; De Fiore et al. 2018; Acharya et al. 2019), a few papers highlight the collateral channel, that is, the QE changes the quantity, the maturity structure, and the quality of collateral in the market (Lenel 2020; Piazzesi and Schneider 2021; Araújo et al. 2015; Geanakoplos and Wang 2020).

[6] Many existing papers focus on the effect of traditional interest-rate based monetary policy tools on risk taking. They suggest that monetary policy can change the financial institutions' risk appetite of holding risky portfolio (e.g., Di Maggio and Kacperczyk 2017), supplying credit (e.g., Jiménez et al. 2014; Ioannidou et al. 2015; Dell'Ariccia et al. 2017; Adrian et al. 2019) and cross-border capital flow (e.g., Bruno and Shin 2015).

[7] Chen et al. (2023) exploit the policy change by China Securities Depository & Clearing Corporation (CSDC) on December 8, 2014 that enterprise bonds with ratings AA+ and AA were no longer accepted as repo collateral in the *exchange market* in China. Wang and Xu (2019) use policy shift by CSDC on April 7, 2017: for bonds whose prospectuses were issued after April 7, 2017, only those with bond ratings at AAA or above can be accepted as repo collateral; before the policy shift, bonds rated AA or higher were eligible repo collateral. Both papers focus on the policy imposed on eligible repo collateral by the regulator of the *exchange market*, which is *not* connected to the central bank's monetary policy. In contrast, our paper exploits the changes in the eligible collateral by the central bank, which itself is a large market participant.

[8] The interbank bond market is a much larger bond market in China than the exchange bond market. According to Amstad and He (2019), at the end of 2019, in the interbank market the value of outstanding bonds reached 86 trillion RMB, and that in the exchange market reached 11 trillion RMB. Commercial banks are active in the interbank market, while they are prohibited from participating in the exchange market before 2022.

[9] Amstad and He (2019) provide an excellent description of the historical and institutional background of the Chinese bond markets.

[10] Chen et al. (2023) used the repo transactions in the interbank bond market and the exchange bond market in their study on the effect of asset pledgeability on haircuts and yields.

[11] See the announcement by the PBOC regarding the establishment of the MLF in September 2014: http://www.pbc.gov.cn/zhengcehuobisi.

[12] The regulatory functions of the CSRC are similar to those of the Securities and Exchange Commission in the United States.

[13] For example, in Section 2 when we discuss Chen et al. (2023) and Wang and Xu (2019), we mentioned that the CSDC suspended the eligibility of the AA+ or AA rated enterprise bonds as pledgeable collateral for repo transactions in the exchange market on December 8, 2014 and that on April 7, 2017, the CSDC further restricted the required minimum rating for repo collateral so that corporate bonds issued after April 7, 2017, must be rated at least AAA in order to be collateral eligible.

[14] In 2018, the total bond lending transaction amounted to 2.4009 trillion yuan, the spot transaction was 151.50 trillion yuan, and the total repo transaction in the same year was 986.12 trillion yuan. See CCDC 2018 China Bond Market Report file: https://www.chinabond.com.cn/cb/cn/yjfx/zzfx/nb/20190117/150727538.shtml.

[15] See PBOC Announcement [2006] No. 15. https://www.chinabond.com.cn/Info/998422.

[16] We provide statistical evidence in the price discrepancies of the same bond in the two markets in Section 5.3.

[17] See the PBOC's announcement of the policy change on June 1, 2018, at http://www.pbc.gov.cn/zhengcehuobisi. The policy took effect immediately upon the date of announcement.

[18] As discussed in the previous subsection, transferring depository from the exchange to the interbank market is time-consuming and costly.

[19] In Chinese, *"Xiaowei"* means "small or micro firms"; *"Sannong"* is the short cut for "three things related to rural issues: peasants, agriculture, and rural areas."

[20] In China, corporate bonds include exchanged-traded corporate bonds, enterprise bonds, medium-term notes, and commercial paper. We focus on the first three types of bonds. Commercial paper usually has less than 1-year maturity and therefore is not popular collateral for the MLF. Financial bonds are bonds issued by financial institutions, including commercial banks, insurance companies, and securities firms.

[21] Since the lending period of the SLF is less than 3 months, as shown in Table 1, the quarterly balance is actually not a very good indicator of its size. The lending period of the SLO is less than 7 days. We do not have quarterly balance data on the SLO.

[22] Besides the liquidity transmission through the bond market, the unconventional monetary policy also shares the same mechanism as traditional monetary policy through loans—liquidity is transmitted from the primary dealer banks to other nonbank financial institutions in the interbank market, and in turn, these financial institutions provide liquidity to the real economy.

[23] In China, the coupon rate of bonds is determined through a tender process on "tender day," three trading days before the bond is listed in the market.

[24] In the fourth round, the ECB launched 3-year maturity LTROs https://www.ecb.europa.eu/mopo/implement/omo/html/index.en.html.

[25] For a description of the TALF, see https://www.federalreserve.gov/monetarypolicy/talf.htm.

[26] In this section, we compare counterfactuals with and without unconventional monetary policy. In the Online Appendix, we provide an alternative model that compares the bond prices and coupon rate before and after a sudden change of unconventional monetary policy. Compared with the baseline model, the alternative model incorporates the wealth effect of holding the risky asset when the policy is implemented. The testable hypotheses in both models are the same qualitatively.

[27] WIND is a major financial data provider in China.

[28] In 2018, many bonds rated under AA defaulted.

[29] The yield curve of CGB is provided by CCDC. http://yield.chinabond.com.cn/cbweb-pbc-web/pbc/more?locale=en_US.

[30] WIND calculates the bond yield of a given day, if there are transactions on the exchange market, based on a volume-weighted transaction price, inclusive of the interest income of the day. See p. 19 of http://net.wind.com.cn/WindNET/Bulletin/page/windnet3.htm. CFETS calculates the bond yield of a given day similarly, but with an extra step of estimating a yield curve predicted yield of the bond, followed by an adjustment using the day's transaction prices and volumes. See http://www.chinamoney.com.cn/.

[31] Individual and mutual funds pay income tax of 20% on all interest incomes, and the tax rate does not vary by bonds, duration of holding, and the bond market.

[32] When restricting ourselves to dual-listed bonds, the term $\text{Post}_t \times \text{Treat}_i$ will be dropped because financial bonds are never dual-listed.

[33] The RRR was 17% for large banks, and 15% for smaller banks. The move injected an estimated 1.3 trillion yuan into the money market, 900 billion of which were used to repay loans via the MLF, and 400 billion yuan were injected into the banking system. See Economic Watch: China's monetary policy unchanged despite reserve requirement cut at http://www.xinhuanet.com/english/2018-04/19/c_137121802.htm.

[34] Note that the market by date fixed effects θ_{jt} in Equation (6) are not included in Equation (7) because it is collinear with $\text{Post}_t \times \text{IB}_j$. As we no longer account for day-by-day average difference of spreads in the two markets, we also included $\text{RRRcut}_t \times \text{IB}_j$ in addition to the existing control variables. This addition accounts for the impact of the RRR cut on the interbank market and removes the related noise to help identify the spillover effects.

[35] The parallel trends assumption in a DDD design extends the logic of the difference-in-differences (DID) method. In DID, the parallel trends assumption requires that in the absence of treatment, the treatment and control groups would have followed the same trend over time. In DDD, the parallel trends assumption requires the *differences* between the treatment and control groups in the two markets to have the same trend before the shock.

[36] See Ding et al. (2022) for a description of the bond issuance process in China. They document the bond overpricing in the primary bond market in China.

[37] We choose the data from 2015 for the placebo test because CSDC introduced important changes to the bond market both in 2017 and 2016.

[38] Appendix Table A.4 provides the summary statistics of the sample of all bonds issued in 2018 used in the analysis reported in Table 10.

[39] We drop samples with a negative haircut, and samples that are labeled as emergency trading. We also drop X-repo transactions, a facility launched by the PBOC in 2015 to anonymously match interbank repo lenders and borrowers with *standardized* collateral and haircut requirements.

[40] We drop the 19th subperiod due to insufficient samples.

[41] As bond transactions are not frequent, we take a weekly moving average to calculate Amihud_{ijt}.

[42] Recall from Section 5.1, our sample period is from January 1 to August 31, 2018, which covers three quarters.

[43] We also examined the dynamics of the changes in liquidity spread and default spread separately using the regression specification of (8). The change in default spread almost explains all the fluctuations in the total spread due to the policy shock. Results are available from the authors upon request.

[44] See Alvarez et al. (2024) for a recent attempt to examine the impact on firms' financing liquidity management policies of the introduction of Liquidity Facility Lines (LFL) in November 2021 by the Brazilian Central Bank, which provides liquidity to financial institutions using corporate bonds as collateral. They find that eligible firms experienced, 1 year into the policy, a 12% increase in corporate bond debt, a decrease in intermediate bank/fund debt by 5%, and a 20 bps reduction in cost of capital.

References

Acharya, V. V., T. Eisert, C. Eufinger, and C. Hirsch. 2019. "Whatever It Takes: The Real Effects of Unconventional Monetary Policy." *Review of Financial Studies* 32: 3366–3411.

Adrian, T., A. Estrella, and H. S. Shin. 2019. "Risk-Taking Channel of Monetary Policy." *Financial Management* 48: 725–738.

Ai, H., J. E. Li, K. Li, and C. Schlag. 2020. "The Collateralizability Premium." *Review of Financial Studies* 33: 5821–5855.

Alvarez, L., V. Orestes, and T. Silva. 2024. "Corporate Effects of Monetary Policy: Evidence From Central Bank Liquidity Lines."MIT Working Paper.

Amihud, Y. 2002. "Illiquidity and Stock Returns: Cross-Section and Time-Series Effects." *Journal of Financial Markets* 5: 31–56.

Amstad, M., and Z. He. 2019. "Chinese Bond Market and Interbank Market."National Bureau of Economic Research Working Paper No. 25549.

Araújo, A., S. Schommer, and M. Woodford. 2015. "Conventional and Unconventional Monetary Policy With Endogenous Collateral Constraints." *American Economic Journal: Macroeconomics* 7: 1–43.

Ashcraft, A., N. Garleanu, and L. H. Pedersen. 2011. "Two Monetary Tools: Interest Rates and Haircuts." *NBER Macroeconomics Annual* 25: 143–180.

Benetton, M., and D. Fantino. 2018. "Competition and the Pass-Through of Unconventional Monetary Policy: Evidence From TLTROS." Working Paper, Bank of Italy, Economic Research and International Relations Area.

Borio, C., and H. Zhu. 2012. "Capital Regulation, Risk-Taking and Monetary Policy: A Missing Link in the Transmission Mechanism?" *Journal of Financial stability* 8: 236–251.

Bruno, V., and H. S. Shin. 2015. "Capital Flows and the Risk-taking Channel of Monetary Policy." *Journal of Monetary Economics* 71: 119–132.

Chakraborty, I., I. Goldstein, and A. MacKinlay. 2020. "Monetary Stimulus and Bank Lending." *Journal of Financial Economics* 136: 189–218.

Chen, H., Z. Chen, Z. He, J. Liu, and R. Xie. 2023. "Pledgeability and Asset Prices: Evidence From the Chinese Corporate Bond Markets." *Journal of Finance* 78: 2563–2620.

Chen, K., J. Ren, and T. Zha. 2018. "The Nexus of Monetary Policy and Shadow Banking in China." *American Economic Review* 108: 3891–3936.

Chen, K., Y. Xiao, and T. Zha. 2022. "China's Monetary Transmission and Systemic Risk: A Role of Interbank Bond Markets." Emory University Working Paper.

Curdia, V., and M. Woodford. 2011. "The Central-Bank Balance Sheet as an Instrument of Monetary Policy." *Journal of Monetary Economics* 58: 54–79.

De Fiore, F., M. Hoerova, and H. Uhlig. 2018. "Money Markets, Collateral and Monetary Policy." National Bureau of Economic Research Working Paper 25319.

Dell'Ariccia, G., L. Laeven, and G. A. Suarez. 2017. "Bank Leverage and Monetary Policy's Risk-Taking Channel: Evidence From the United States." *Journal of Finance* 72: 613–654.

Di Maggio, M., and M. Kacperczyk. 2017. "The Unintended Consequences of the Zero Lower Bound Policy." *Journal of Financial Economics* 123: 59–80.

Di Maggio, M., A. Kermani, and C. J. Palmer. 2019. "How Quantitative Easing Works: Evidence on the Refinancing Channel." *Review of Economic Studies* 87: 1498–1528.

Ding, Y., W. Xiong, and J. Zhang. 2022. "Issuance Overpricing of China's Corporate Debt Securities." *Journal of Financial Economics* 144: 328–346.

Fostel, A., and J. Geanakoplos. 2008. "Leverage Cycles and the Anxious Economy." *American Economic Review* 98: 1211–1144.

Freyaldenhoven, S., C. Hansen, and J. M. Shapiro. 2019. "Pre-Event Trends in the Panel Event-Study Design." *American Economic Review* 109: 3307–3338.

Garleanu, N., and L. H. Pedersen. 2011. "Margin-Based Asset Pricing and Deviations From the Law of One Price." *Review of Financial Studies* 24: 1980–2022.

Geanakoplos, J. 1997. "Promises, Promises." In *The Economy as an Evolving Complex System II*, Sante Fe Institute Studies in the Sciences of Complexity, edited by W. Brian Authur, Steven N. Durlauf and David Lane, CRC Press: 285–320.

Geanakoplos, J. 2010. "The Leverage Cycle." *NBER Macroeconomics Annual* 24: 1–66.

Geanakoplos, J., and H. Wang. 2020. "Quantitative Easing, Collateral Constraints, and Financial Spillovers." *American Economic Journal: Macroeconomics* 12: 180–217.

Geanakoplos, J., and W. R. Zame. 2014. "Collateral Equilibrium I: A Basic Framework." *Economic Theory* 56: 443–492.

Gertler, M., and P. Karadi. 2011. "A Model of Unconventional Monetary Policy." *Journal of Monetary Economics* 58: 17–34.

Gorton, G., and A. Metrick. 2012. "Securitized Banking and the Run on Repo." *Journal of Financial Economics* 104: 425–451.

Hansman, C., H. Hong, W. Jiang, Y.-J. Liu, and J.-J. Meng. 2018. "Riding the Credit Boom." National Bureau of Economic Research Working Paper 24586.

Hattori, M., A. Schrimpf, and V. Sushko. 2016. "The Response of Tail Risk Perceptions to Unconventional Monetary Policy." *American Economic Journal: Macroeconomics* 8: 111–136.

Imbens, G. W., and D. B. Rubin. 2015. *Causal Inference for Statistics, Social, and Biomedical Sciences: An Introduction*. Cambridge University Press.

Ioannidou, V., S. Ongena, and J.-L. Peydró. 2015. "Monetary Policy, Risk-taking, and Pricing: Evidence From a Quasi-Natural Experiment." *Review of Finance* 19: 95–144.

Jiménez, G., S. Ongena, J.-L. Peydró and J. Saurina. 2014. "Hazardous Times for Monetary Policy: What Do Twenty-Three Million Bank Loans Say About the Effects of Monetary Policy on Credit Risk-Taking?" *Econometrica* 82: 463–505.

Joyce, M., D. Miles, A. Scott, and D. Vayanos. 2012. "Quantitative Easing and Unconventional Monetary Policy: An Introduction." *Economic Journal* 122: F271–F288.

Kiyotaki, N., and J. Moore. 1997. "Credit Cycles." *Journal of Political Economy* 105: 211–248.

Krishnamurthy, A., S. Nagel, and A. Vissing-Jorgensen. 2017. "ECB Policies Involving Government Bond Purchases: Impact and Channels." *Review of Finance* 22: 1–44.

Kyle, A. S. 1989. "Informed Speculation With Imperfect Competition." *Review of Economic Studies* 56: 317–355.

Lenel, M. 2020. "Safe Assets, Collateralized Lending and Monetary Policy." Working Papers 2020-66, Economics Department, Princeton University.

Nakamura, E., and J. Steinsson. 2018. "Identification in Macroeconomics." *Journal of Economic Perspectives* 32: 59–86.

Nyborg, K. G. 2017. "Central Bank Collateral Frameworks." *Journal of Banking and Finance* 76: 198–214.

Nyborg, K. G., and J. Woschitz. 2021. "The Price of Money: How Collateral Policy Affects the Yield Curve." Swiss Finance Institute Research Paper, No. 21-74.

Piazzesi, M., and M. Schneider. 2021. "Payments, Credit and Asset Prices." Working Paper, Stanford University.

Rodnyansky, A., and O. M. Darmouni. 2017. "The Effects of Quantitative Easing on Bank Lending Behavior." *Review of Financial Studies* 30: 3858–3887.

B Rubin, D.. 1974. "Estimating Causal Effects of Treatments in Randomized and Nonrandomized Studies." *Journal of Educational Psychology* 66: 688–701.

Schwert, M. 2017. "Municipal Bond Liquidity and Default Risk." *Journal of Finance* 72: 1683–1722.

van Bekkum, S., M. Gabarro, and R. M. Irani. 2017. "Does a Larger Menu Increase Appetite? Collateral Eligibility and Credit Supply." *Review of Financial Studies* 31: 943–979.

Wang, Y., and H. Xu. 2019. "How Leverage Affects Asset Prices: Evidence From a Natural Experiment in China's Bond Markets." [In Chinese.] *Journal of Financial Research* 464, no. 2: 20–39.

Supporting Information

Additional supporting information can be found online in the Supporting Information section.

Online Appendix

Appendix

A.1 Proofs

Proof of Lemma 1. The payment $A \le \tau C + 1$ as the bond with maturity τ pays at most $\tau C + 1$, and the borrower will not repay the debt for sure if $A > \tau C + 1$.

The payment $A \ge \tau C + R$. Suppose they are lower than $\tau C + R$, then the borrowers will repay the debt regardless of whether the bond defaults or not. That means the debt contract is riskless and is priced at A by the marginal trader with belief h_0. The traders can buy $y_0 = \frac{1}{p-A}$ unit of collateral with the debt contract. The payoff for the borrower with a belief higher than the marginal trader $h > h_0$ is

$$\frac{\tau C + h + (1-h)R - A}{p - A},$$

which is increasing in A for $A < \tau C + R$ given that $\tau C + h + (1-h)R > p = \tau C + h_0 + (1-h_0)R$. They would strictly prefer a contract with a higher A as they will be able to borrow more to purchase the bond and get higher expected payoffs.

The remaining possible contracts $A \in [\tau C + R, \tau C + 1]$. The borrower repays A if the bond has a high payoff realization. The borrower does not repay the debt, and the lender gets the collateral of value $\tau C + R$ if the bond has a low payoff realization. The contracts are priced by the marginal trader with belief h_0 at $\pi_0 = h_0 A + (1-h_0)(\tau C + R)$.

The lender with belief $h < h_0$ will get the expected payoff $hA + (1-h)(\tau C + R) \le \pi_0$ for the debt contract, and the equality is taken if and only if $A = \tau C + R$.

If $A > \tau C + R$, the lenders think the debt contract is overpriced and would not be willing to buy the contract. So the unique debt contract that is traded in equilibrium is $A = \tau C + R$.

Intuitively, if A is lower than $\tau C + R$, then borrowers would strictly prefer a contract with a higher A as they will be able to borrow more to purchase the bond and get higher payoffs. If A is higher than $\tau C + R$, the lender will not accept the contract as it is overpriced by the marginal trader. The equilibrium contract that both sides would be willing to trade is $A_0^* = \tau C + R$. □

Proof of Proposition 1. Intuitively, if the central bank sets the haircut to be larger than the equilibrium haircut for traders to borrow from the other traders, then the traders will not borrow from the central bank. So the prevalent haircut rate is the endogenous haircut rate in Lemma 1.

Given Lemma 1, we can show that the equilibrium marginal trader has the belief

$$h_0^* = \frac{1}{2-R}.$$

Given the marginal trader's belief, the equilibrium price of the bond with maturity τ is

$$p_0^* = \tau C + R + \frac{1-R}{2-R}.$$

Given the price at issuance is 1, the coupon rate is

$$C_0^* = \frac{(1-R)^2}{(2-R)T}.$$

In equilibrium, the traders with belief $h \in [h_0, 1]$ hold $\frac{1}{1-A_c}$ units of the bond and owes $\frac{1}{1-A_c}$ unit debt to the central bank, and the trader with belief $h \in [0, h_0)$ holds cash and the debt contract.

Case 1. $A_c < \tau C + R$. If the central bank sets the haircut to be larger than the equilibrium haircut in Lemma 1 for traders to borrow from the other traders ($A_c < \tau C + R$), then the traders will not borrow from the central bank. The prevalent haircut is the endogenous haircut in Lemma 1. And the equilibrium is the same as the equilibrium without the unconventional monetary policy.

Case 2. $A_c \ge \tau C + R$. If the central bank sets the haircut to be smaller than the equilibrium haircut in Lemma 1 ($A_c \ge \tau C + R$), traders will borrow from the central bank, and the prevalent haircut is the exogenous haircut specified by the unconventional monetary policy.

The market-clearing condition is

$$\frac{1-h_c}{p_c - A_c} = 1. \tag{A.1}$$

With the unconventional monetary policy, the new marginal trader prices the bond at

$$p_c = h_c(\tau C + 1) + (1-h_c)(\tau C + R).$$

Given the market-clearing condition in Equation (A.1) and the marginal trader's pricing in Equation (A.1), we can solve the marginal trader's belief

$$h_c^* = \frac{1 + A_c - (\tau C + R)}{2-R}.$$

The equilibrium price of the bond with maturity τ and coupon rate C satisfies

$$p_c^* = \tau C + R + \frac{1 + A_c - (\tau C + R)}{2-R}(1-R).$$

Given the price at issuance is 1, the coupon rate is

$$C_c^* = \frac{(1 - A_c)(1 - R)}{T}.$$

In equilibrium, the traders with belief $h \in [h_c^*, 1]$ hold $\frac{1}{1-h_c^*}$ units of the bond and owes $\frac{1}{1-h_c^*}$ unit debt to the central bank, and the trader with belief $h \in [0, h_c^*)$ holds cash. □

A.2 | Additional Tables

TABLE A.1 | Robust heterogeneous effects on spreads in the secondary market

Variables	**(1)**	**(2)**	**(3)**	**(4)**
$Post \times Treat$	0.271	0.452***	0.421***	0.210
	(0.189)	(0.149)	(0.150)	(0.202)
$IB \times Treat$	−0.310	−0.310	−0.310	−0.310
	(0.596)	(0.596)	(0.596)	(0.596)
$Post \times Treat \times IB$	−0.524***	−0.524***	−0.525***	−0.524***
	(0.142)	(0.142)	(0.142)	(0.142)
$Post \times Treat \times IB \times Green$	0.181			0.242
	(0.135)			(0.149)
$Post \times Treat \times IB \times Xiaowei$		−0.242		
		(0.147)		
$Post \times Treat \times IB \times Sannong$			0.0342	0.234
			(0.211)	(0.236)
Macro factors	Yes	Yes	Yes	Yes
Bond type × Bond rating × Date FE	Yes	Yes	Yes	Yes
Market × Date FE	Yes	Yes	Yes	Yes
Bond FE	Yes	Yes	Yes	Yes
Observations	77,731	77,731	77,731	77,731
Adjusted R^2	0.860	0.860	0.860	0.860

Note: This table restricts the *Xiaowei*, *Sannong*, and *Green* bonds to financial bonds only. In Column (4), the variable Post × Treat × IB × Xiaowei is omitted due to insufficient observations. The regression equation is similar to that specified by Equation (6), with the addition of the quadruple interaction terms of Post × Treat × IB with *Green*, *Xiaowei*, and *Sannong*, respectively, to capture the heterogeneous effects. The full sample is used in the regressions. Standard errors are two-way clustered at the bond and date levels. ***,**, and * represent statistical significance at 1%, 5%, and 10%, respectively.

TABLE A.2 | Impact of MLF collateral expansion on bond spreads in secondary market with tighter event window

Variables	Full sample (1)	Dual-listed bonds only (2)
$Post \times Treat \times IB$	−0.602***	−0.453*
	(0.151)	(0.240)
$IB \times Treat$	−0.533	−1.905***
	(0.481)	(0.672)
$Post \times Treat$	0.648***	
	(0.142)	
Macro factors	Yes	Yes
Bond type × Bond rating × Date FE	Yes	Yes
Market × Date FE	Yes	Yes
Bond FE	Yes	Yes
Observations	23,248	5411
Adjusted R^2	0.910	0.865

Note: This table shows the impact of the expansion of the MLF eligible collateral to include the treatment bonds on their spreads in the secondary market using a triple-difference (DDD) specification with a tighter event window. The sample is 30 trading days before and after the policy shock. Regression equation is specified by Equation (6). Standard errors are two-way clustered at the bond and date levels. ***,**, and * represent statistical significance at 1%, 5%, and 10%, respectively.

TABLE A.3 | Robust heterogeneous effects on spreads in the primary market

Variables	**(1)**	**(2)**	**(3)**	**(4)**
$Post$	0.111	0.105	0.115	0.0940
	(0.0869)	(0.0862)	(0.0868)	(0.0859)
$Treat$	0.588***	0.627***	0.578***	0.636***
	(0.132)	(0.134)	(0.131)	(0.136)
IB	−0.625***	−0.655***	−0.626***	−0.691***
	(0.152)	(0.156)	(0.151)	(0.159)
$IB \times Treat$	0.0125	0.101	0.00100	0.166
	(0.164)	(0.177)	(0.162)	(0.182)
$Post \times Treat$	0.828***	0.862***	0.820***	0.875***
	(0.157)	(0.157)	(0.158)	(0.157)
$Post \times IB$	−0.208**	−0.207**	−0.211**	−0.208**
	(0.0946)	(0.0943)	(0.0946)	(0.0942)
$Post \times Treat \times IB$	−0.514**	−0.440**	−0.500**	−0.371*
	(0.207)	(0.206)	(0.206)	(0.202)
$Post \times Treat \times IB \times Xiaowei$	−1.003***			−1.485***
	(0.206)			(0.246)
$Post \times Treat \times IB \times Green$		−1.030***		−1.209***
		(0.222)		(0.213)
$Post \times Treat \times IB \times Sannong$			−1.765***	−2.057***
			(0.130)	(0.137)
Quarter FE	yes	yes	yes	yes
Bond info.	yes	yes	yes	yes
Bond issuer info.	yes	yes	yes	yes
Market info.	yes	yes	yes	yes
Macro factors	yes	yes	yes	yes
Obs.	1757	1757	1757	1757
Adjusted R^2	0.633	0.636	0.634	0.640

Note: This table restricts the *Xiaowei*, *Sannong*, and *Green* bonds to financial bonds only. The regression equation is specified by Equation (10), with the additional interaction terms of $\text{Post}_t \times \text{Treat}_i \times \text{IB}_i$ with *Green* and *Sannong*. We report only the results with all controls. Robust standard errors are clustered at the bond level. ***,**, and * represent statistical significance at 1%, 5%, and 10%, respectively.

TABLE A.4 | Summary statistics for the primary market data: January 1–December 31, 2018

Panel A		Full sample					Interbank market					Exchange market				
Variables		**Obs**	**Mean**	**Std.Dev.**	**Min**	**Max**	**Obs**	**Mean**	**Std.Dev.**	**Min**	**Max**	**Obs**	**Mean**	**Std.Dev.**	**Min**	**Max**
Dep.var.	*Spread*	3076	2.518	1.157	0.232	5.889	1890	2.474	1.114	0.232	5.461	1186	2.588	1.219	0.326	5.889
Dummies	*L.Post*	3076	0.519	0.500	0	1	1890	0.522	0.500	0	1	1186	0.513	0.500	0	1
	IB	3076	0.614	0.487	0	1	1890	1	0	1	1	1186	0	0	0	0
	Treat	3076	0.414	0.493	0	1	1890	0.463	0.499	0	1	1186	0.336	0.472	0	1
Bond info	*Quantity* (Billion RMB)	3076	1.494	2.657	0.00900	43	1890	1.634	3.280	0.0800	43	1186	1.271	1.046	0.00900	7.200
	Term	3076	4.244	1.861	0.917	15	1890	4.387	2.049	2	15	1186	4.015	1.487	0.917	15
	Guarantee	3076	0.114	0.318	0	1	1890	0.105	0.306	0	1	1186	0.129	0.335	0	1
	SOE	3076	0.791	0.406	0	1	1890	0.863	0.343	0	1	1186	0.676	0.468	0	1
	Put	3076	0.323	0.468	0	1	1890	0.149	0.356	0	1	1186	0.600	0.490	0	1
	Call	3076	0.114	0.318	0	1	1890	0.163	0.369	0	1	1186	0.0371	0.189	0	1
Issuer info	*Debt Asset Ratio*	3076	63.30	18.11	0	95.59	1890	63.18	18.66	0	95.38	1186	63.48	17.20	0	95.59
	Liquidity Ratio	3076	3.606	54.82	0	2887	1890	4.392	68.57	0	2887	1186	2.354	17.31	0	420.6
	Cash Coverage Ratio	3076	0.531	2.049	−2.571	3.024	1890	0.448	2.070	−2.571	3.024	1186	0.664	2.008	−2.571	3.024
	Log Assets	3045	25.03	1.457	16.09	30.73	1874	25.04	1.499	16.09	30.73	1171	25.00	1.388	19.93	29.86
	Log Equity	3043	23.87	1.276	16.09	29.00	1872	23.88	1.299	16.09	29.00	1171	23.87	1.240	19.35	27.71
Market info	*Similar Bond Issuance* (Billion RMB)	3076	5.287	5.757	0.0300	70.50	1890	5.504	6.462	0.0800	70.50	1186	4.941	4.386	0.0300	18.32
	CMB Issuance (Billion RMB)	3076	22.02	37.48	0	259.0	1890	15.26	23.28	0	129.5	1186	32.79	50.91	0	259.0
	CGB Issuance (Billion RMB)	3076	17.00	58.04	0	500.2	1890	15.73	48.50	0	250.1	1186	19.02	70.61	0	500.2
Macro info	ΔGDP	3050	10.49	3.377	−13.58	20.30	1874	10.42	3.341	−13.58	20.30	1176	10.60	3.433	−13.58	20.30
	$\Delta M2$	3076	8.781	0.243	8.174	9.233	1890	8.786	0.249	8.174	9.233	1186	8.772	0.233	8.174	9.233
	$IB \times AA+$	3076	0.164	0.370	0	1	1890	0.267	0.443	0	1	1186	0	0	0	0
	$IB \times AAA$	3076	0.281	0.449	0	1	1890	0.457	0.498	0	1	1186	0	0	0	0
	$RRRcut \times IB$	3076	0.447	0.497	0	1	1890	0.728	0.445	0	1	1186	0	0	0	0
	$RRRcut \times AA+$	3076	0.166	0.372	0	1	1890	0.178	0.383	0	1	1186	0.147	0.354	0	1
	$RRRcut \times AAA$	3076	0.396	0.489	0	1	1890	0.345	0.475	0	1	1186	0.476	0.500	0	1
	$RRRcut \times IB \times AA+$	3076	0.110	0.312	0	1	1890	0.178	0.383	0	1	1186	0	0	0	0
	$RRRcut \times IB \times AAA$	3076	0.212	0.409	0	1	1890	0.345	0.475	0	1	1186	0	0	0	0

(Continues)

TABLE A.4 | (Continued)

Panel B		Full sample		Interbank market		Exchange market	
Bond rating		**Obs.**	**Percent**	**Obs.**	**Percent**	**Obs.**	**Percent**
Rating	AA	540	17.56	357	18.89	183	15.43
	AA+	820	26.66	551	29.15	269	22.68
	AAA	1716	55.79	982	51.96	734	61.89
	Total	3076	100	1890	100	1186	100

Panel C		Full sample		Interbank market		Exchange market	
Bond type		**Obs.**	**Percent**	**Obs.**	**Percent**	**Obs.**	**Percent**
Type	Corporate bonds	2758	89.66	1697	89.79	1061	89.46
	- *Enterprise bonds*	286	9.300	285	15.08	1	0.0800
	- *Exchange-traded corporate bonds*	1060	34.46	-	-	1060	89.38
	- *Medium-term notes*	1412	45.90	1412	74.71	-	-
	Financial bonds	318	10.34	193	10.21	125	10.54
	Total	3076	100	1890	100	1186	100

Panel D		Full sample		Interbank market		Exchange market	
Issuance size (Billion RMB)		**Quantity**	**Quantity/Total**	**Quantity**	**Quantity/Total**	**Quantity**	**Quantity/Total**
Issuance	Corporate bonds	3160.9	68.79	1938.3	62.78	1222.60	81.09
	- *Enterprise bonds*	245.9	5.352	244.3	7.913	1.600	0.106
	- *Exchange-traded corporate bonds*	1221	26.57	-	-	1,221	80.98
	- *Medium-term notes*	1694	36.87	1694	54.87	-	-
	Financial bonds	1434	31.21	1149	37.22	285.2	18.91
	Total	4594.9	100	3087.3	100.00	1507.80	100.00

Note: See text in Section 6 for details of the variables. This summary statistics table include all new bond issued during January 1–December 31, 2018, which are used in the analysis for Table 10 where we test for the hypothesis of venue shopping.