Collateral-Based Monetary Policy: Evidence from China*

Hanming Fang† Yongqin Wang‡ Xian Wu§

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Abstract

We estimate the causal effect of collateral-based monetary policy on asset prices and the real economy by exploiting a policy change in which China's Central Bank allowed a class of bonds in the interbank market as eligible collateral for its Medium-Term Lending Facility (MLF), but not the same bonds traded in the exchange market. We find that in the secondary market the policy reduced the spreads of the newly collateralizable bonds in the interbank market by 40-60 basis points, and there is a substantial pass-through to reduce the spreads of the newly collaterizable bonds in the primary issuance in the interbank market.

Keywords: Collateral-based Monetary Policy, Bond Spread, Medium-Term Lending Facility
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†Department of Economics, University of Pennsylvania, Perelman Center for Political Science and Economics, 133 S. 36th St., Philadelphia, PA 19104; and the National Bureau of Economic Research. Email: hanming.fang@econ.upenn.edu

‡School of Economics, Fudan University, Shanghai, China. Email: yongqinwang@fudan.edu.cn

§Department of Economics, University of Wisconsin, Social Science Building, 1180 Observatory Drive, Madison, WI 53706. Email: xwu394@wisc.edu

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, e.g. Federal Reserve's Term Asset-Backed Securities Loan Facility (TALF) and European Central Bank'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 non-financial 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 estimate the causal effect of monetary policy. In this paper, we address the identification problem using a triple-difference 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 on the financial markets and the real economy.

[1] The Federal Reserve launched the Term Asset-Backed Securities Loan Facility (TALF) in late November 2008, through which the Fed lent up to $1 trillion to financial markets against collaterals of asset-backed securities (ABS) and loans guaranteed by Small Business Administration. In March 2008, the European Central Bank launched the Long-term Refinancing Operations (LTROs) aimed to reduce sovereign bond spreads and inject liquidity into the market, where it provides 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.

The unique feature of China's bond market 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 different liquidity in the two markets for example.[3]

On June 1, 2018, 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 MLF.

The sudden collateral-based policy change in the *interbank* market enables us to implement a triple-difference (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 financial market and the real economy. 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 assumption 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 market. The policy leads to an average reduction of the spreads of the newly collateralizable bonds by 40-60 basis points (bps) – which is about 13 to 19 percent of the mean spreads – in the interbank market compared to the dual-listed bonds in the exchange market. Interestingly, we also find that the funding cost reduction in the interbank market is not restricted to the newly collateral-eligible bonds, in fact, the overall funding cost of the interbank market falls due to generally more available collateral in the market. The change of the bond spreads may

[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.

result from an improvement in the market liquidity and/or a repricing of the default risk, because the central bank is a significant bond trader that can improve the market depth (Kyle, 1989). To distinguish these two channels, we further decompose the bond spread into liquidity risk premium and default risk premium, and find that the reduction in the spreads of the treated bonds in the interbank market is mostly attributed to a reduction in the perceived default risk instead of the liquidity risk. This is consistent with the leverage theory à la Geanakoplos (2010), which argues that the lower haircut of the collateral increases the leverage of the optimists, and in turn pushes up the asset prices. It is also consistent with the view that the treated bonds are less likely to default because the funding costs of rolling over these bonds are now lower. The results resonate with the literature on the risk-taking channel of unconventional monetary policy.

We also analyze the pass-through effect of the secondary market policy shock to the primary market (and thus the real ecomony). 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 53 basis points, *ceteris paribus*. That is, the pass-through rate is between about 85% to as high as 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 model implies that collateral-based monetary policy may influence the pledgability of bonds and, consequently, their values. To test this hypothesis, we collected transaction data in the repo market. 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 decreased for the new collateral-eligible bonds in the interbank market after the policy shock, consistent with our earlier finding that collateral-based monetary policy decreases the spreads of eligible bonds by increasing their collateral value. Another hypothesis is that the MLF collateral expansion increases the market liquidity of the newly eligible bonds. We tested this hypothesis 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 but not market liquidity.

Our paper makes three 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, 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. Further, we find that the monetary policy induces more bonds to be issued in the interbank market. Third, while existing works has analyzed China's traditional monetary policy tools, e.g. interest rate adjustments (Chen et al., 2018, 2021), our paper provides detailed documentation and analysis, thus a better understanding, of China's collateral framework and monetary policies in general. In particular, we focuses on MLF, which has played an increasingly significant role in 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., 2022; 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 analyze the secondary bond market; in Section 6 we discuss the primary bond market; in Section 7 we explore the potential mechanisms underlying 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, e.g. 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).[5] There are several empirical works evaluating the effect of collateral-based monetary policies on asset prices. Some studies find a positive effect of collateral-based monetary policy. Ashcraft et al. (2011) find that TALF eligibility effectively increased the investors' valuation for Commercial Mortgage-Backed Securities (CMBS) bonds. Benetton et al. (2018) study the effects of Targeted Longer-Term Refinancing Operations (TLTROs) by the European Central Bank (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 instance, 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 et al. (2018) point out that the effects of TLTROs depend 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

[5] Additionally, within the broader literature on quantitative easing (QE) (e.g. Gertler and Karadi, 2011; Curdia and Woodford, 2011; Joyce et al., 2012; Maggio et al., 2016; Lenel, 2017; Rodnyansky and Darmouni, 2017; Chen et al., 2022; De Fiore et al., 2018; Acharya et al., 2019), a few papers highlight the collateral channel that the QE changes the quantity, the maturity structure, and the quality of collateral in the market (Lenel, 2017; Piazzesi and Schneider, 2017; Araújo et al., 2015; Geanakoplos and Wang, 2018; Araújo et al., 2019).

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 examine the risk-taking channel of monetary policy, i.e., 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 examining the effect of unconventional monetary policy on risk-taking have found a positive effect. 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 U.S. Federal Reserve have increased mortgage origination. Some studies point to some potential distortionary effects. For example, Nyborg (2017) argues that more lax collateral eligibility by 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 ECB lowered RMBS eligibility to BBB- rating, banks issued more low-rated RMBS with higher default rates. Chen et al. (2018, 2021) find that the non-state banks in China increase shadow banking in response to contractionary monetary policy. Acharya et al. (2019) find that the ECB's Outright Monetary Transactions (OMT) program has led banks to maintain zombie lending. Our paper complements the literature by showing that the collateral-based monetary policy leads to a repricing of the default risk of newly collaterizable 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., 2022; Wang and Xu, 2019; Nyborg and Woschitz, 2021). Two papers that are closely related to our paper are Chen et al. (2022) 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 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 Medium-Term Liquidity Facility (MLF), which directly affects the collateral in the *interbank bond market*.[8] In addition, we provide evidence of the impacts of the

[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. (2022) 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 collateral; prior to the policy shift, bonds rated AA or higher were eligible collateral. Both of these papers focus on the policy imposed 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 the 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

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 U.S. interbank bond market. 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.

Participants. The participants in the two bond markets vary, but they overlap in most of the non-bank 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 non-bank 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 non-bank 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 macro-prudential 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.[10]

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*, i.e., traded in both markets. *Enterprise*

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

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-pubic-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 are *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.

Regulators and Clearing Houses. The two markets have different regulators. The main regulator of the interbank bond market is the People's Bank of China (PBOC), which is China's central bank. The regulator of the exchange market is the China Securities Regulatory Commission (CSRC).[11]

In the interbank market, participants trade via 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 China Securities Depository & Clearing Co. Ltd (CSDC).

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 (the 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 the CSDC unilaterally. Specifically, the repo transaction accepts only AAA rated bonds as collateral in 2018.[12]

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 rate, and repo rate, until the agreement is reached. The haircut rate 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, China's Central Depository & Clearing Co. Ltd (CCDC) can serve as the tri-party agent to determine the

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

[12] For example, in Section 2 when we discuss Chen et al. (2022) 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.

eligibility and valuation of the collateral, while the sellers and buyers only need to negotiate the borrowing amount, the maturity period and the interest rate.

Although borrowing bonds for the purpose of short-selling is allowed in the interbank bond market, it is very limited.[13] 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.[14] 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.

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 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.[15]

There are several barriers to arbitrage between the two markets. First, According to Chen et al. (2022), in 2014 it took about three to four working days if investors apply for the transfer of depository from the interbank market (the CCDC) to the exchange (the CSDC); and it took even longer (about four to six working days in 2014) to move depository from the exchange to the interbank. The transfer of depository becomes quicker in recent years but still takes a few days. Second, transferring money from the exchange market to the interbank market is also subject to settlement delays. The interbank market adopts "T+0" settlement, while the exchange market adopts "T+1" settlement. As a result, if an investor wants to transfer deposits from the exchange market to the interbank market, he or she would have to wait for a day. Transferring deposits from the interbank market to the exchange market also takes time. If the transaction is consummated in the interbank market in the morning, the settlement is usually completed in the afternoon. Because the exchange market closes at 3:00 pm in the afternoon, the same-day arbitrage across the two markets is therefore almost impossible to implement. 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 1,300 yuan without considering the settlement delay, while the estimated settlement fee is 170-250 yuan. Compared to other

[13] In 2018, the total bond lending transaction is 2.4009 trillion yuan, the spot transaction is 151.50 trillion yuan, and the total repo transaction in the same year is 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

[14] See People's Bank of China Announcement [2006] No. 15. https://www.chinabond.com.cn/Info/998422

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

strategies, cross-market arbitrage seems 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 People's Bank of China (PBOC), expanded the types of collateral it would allow primary dealers (commercial and policy banks) to use to borrow from its Medium-term Lending Facility (MLF).[16] Launched in September 2014, MLF is a facility managed by PBOC that offers lending to commercial banks and policy banks with eligible collaterals 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.[17]

Before the June 1, 2018 expansion of eligible collaterals, 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*) rated at least AA to be used as collateral for MLF.[18], [19] The total amount of newly pledgeable bonds for MLF was between 400-600 billion yuan (about $80 billion). The PBOC claimed that the move is aimed at lowering funding costs and enhancing support to smaller businesses.

[Table 1 About Here]

It is not the first time for 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, PBOC launched Short-term Liquidity Operation (SLO) and Standing Lending Facility (SLF), providing liquidity to primary dealer banks with a maturity of fewer than 7 days and between 1

[16] See 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.

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

[18] 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."

[19] 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 MLF. Financial bonds are bonds issued by financial institutions, including commercial banks, insurance companies, and security firms.

to 3 months, respectively, backed by high-quality assets. In 2014, PBOC shifted to a longer-term collateral-based monetary policy: Pledged Supplementary Lending (PSL) in April 2014, and MLF in September 2014, respectively. The last row of Table 1 lists the eligible collaterals for each lending facility as of 2018.

[Figure 2 About Here]

The collateral-based lending facilities have gained increasing significance in PBOC's monetary policy since 2014. Figure 2 depicts the growing size of lending through SLF, MLF and PSL by PBOC during the period of March 2013 and January 2019.[20] 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 launches. At the end of 2018, the balance of MLF, SLF and PSL accounted for about 25% of China's monetary base, as is shown in Figure 2. This is especially significant for MLF, which is the largest and most important component of PBOC's collateral-based lending facilities.

[Figure 3 About Here]

Shifting from traditional monetary policy to unconventional monetary policy changes the way China's Central Bank provides liquidity. Figure 3 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 collaterals for the SLF, MLF, or PSL lending facilities. By accepting the relatively illiquid assets as collaterals, China's Central Bank provides liquidity to the primary commercial banks. The liquidity is then transmitted through repo transactions from the primary dealer banks to other non-bank financial institutions in the interbank market, and in turn, these financial institutions provide liquidity to the real economy.

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 MLF as an example. In the expansion of eligible MLF collaterals on June 1, 2018, PBOC made corporate bonds and financial bonds of *Xiaowei* firms, *Green* firms and *Sannong* firms with at least AA ratings to be eligible collaterals, 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.[21] If working effectively, MLF would ease the funding constraints for commercial banks that support small firms,

[20]Since the lending period of 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 SLO is even shorter, of less than 7 days. We do not have quarterly balance data on SLO.

[21]In China, the coupon rate of bonds is determined through a tender process on "tender day", 3 trading days before the bond is listed in the market.

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 long-term refinancing operations (LTROs) by the European Central Bank in the Eurozone, with 6-month to 1-year maturity.[22] The U.S. has also launched Term Asset-Backed Securities Loan Facility (TALF) since 2008. The Federal Reserve Bank of New York (FRBNY) loaned up to $200 billion on a non-recourse basis to holders of certain AAA-rated ABS backed by newly and recently originated consumer and small business loans under the TALF. [23] 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 underlying macroeconomic conditions, it is difficult to isolate the causal impact of these collateral-based monetary policies from other confounding factors.

The unique coexistence and the segmentation of the interbank bond market and the exchange bond market in China offers 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 the 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 3.

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 primary market coupon rate.

Primary Market. The economy has two assets: cash and a risky bond. Suppose that a total of one unit of risky bond is being issued in the primary market. For ease of exposition, we will cast the

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

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

environment in continuous time. Each unit of the risky bond pays coupons at a rate C from time 0 till maturity T. Assume the bond cannot default on its coupon but may default on its principal at the maturity date T. Suppose that there are two possible states in the final period: if the bond does not default it returns the principal 1 in full; if it defaults it only returns $R < 1$ in principal. The price of the bond at issuance is 1, and the coupon rate is determined by competitive bidding among dealers in the primary market where the dealer who bids the lowest coupon rate wins the primary issuance. For simplicity, assume the risk-free rate $i = 0$.

Secondary Market. Assume there is a continuum of investors in the secondary market with heterogeneous beliefs regarding the probability that the risky bond will not default. Suppose that the belief among the investors, denoted by h, is uniformly distributed on $[0, 1]$, and that each investor has 1 unit of cash.

Suppose that the risky bond is eligible as collateral for borrowing and that the exogenous margin on borrowing with the bond is $m \in [0, 1]$. When the margin is m and the price is p, an investor needs a down payment of pm to buy 1 unit of the risky bond.

As in Geanakoplos (2010), the secondary market equilibrium bond price p^* is determined by the *marginal* buyer, whose belief is denoted by h^*:

$$\begin{aligned} p^* &= \int_{t=0}^{T} C dt + h^* \times 1 + (1 - h^*) \times R \\ &= TC + h^* + (1 - h^*) \times R. \end{aligned} \tag{1}$$

where the right hand side is the expected payoffs from purchasing the bond by the marginal buyer. The market clearing condition requires that:

$$\frac{1 - h^*}{p^* m} = 1 \tag{2}$$

where $1 - h^*$ is the measure of investors in the secondary market whose belief that the bond will not default exceeds the marginal investor's h^*. Since each investor has one unit of cash, the left-hand side of Eq. (2) represents their total demand for the bond when the margin is m, and the right-hand side is the total supply of the bond which we exogenously set to 1 for simplicity.

Solving Eqs. (1)-(2), we obtain:

$$p^*(m) = \frac{TC + 1}{1 + m(1 - R)} \tag{3}$$

$$h^*(m) = 1 - p^*(m)m = \frac{1 - m(TC + R)}{1 + m(1 - R)} \tag{4}$$

The equilibrium coupon rate in the primary market can then be determined by the requirement that the secondary market equilibrium price p^* must be equal to the primary market issuance price 1. Solving $p^*(m) = 1$, we have:

$$C^*(m) = \frac{m(1-R)}{T}. \tag{5}$$

Bond Yields and Margin m. The *implied interest rate* for a bond with term-to-maturity τ purchased at price p with per period coupon rate C and principal value of 1, is implicitly determined by the value of r that solves the following equation:

$$p = \int_{t=0}^{\tau} e^{-rt} C dt + e^{-r\tau} \times 1 \tag{6}$$

The yield of a bond is the implied interest rate characterized by (6).

For new bonds with term-to-maturity T issued with price equals to its face value 1, the yield equals to its coupon rate C.[24] Thus, when a bond becomes collateral eligible, i.e., its margin is reduced from $m = 1$ to $m \in (0, 1)$, the changes in the yield of new bonds with the same maturity is:

$$\Delta r_{\mathrm{N}}(m) = C^*(m) - C^*(1) = -\frac{(1-m)(1-R)}{T} \tag{7}$$

where $C^*(\cdot)$ is defined by (5).

Now consider the impact of unanticipated collateral eligibility for an existing bond with term-to-maturity $\tau < T$. When the existing bond was issued in the primary market, it was not collateral eligible, thus $m_{\mathrm{O}} = 1$ where the subscript indicates the bond's original state. Thus, its coupon rate, as determined in the original equilibrium in the primary market is given by $C^*(1)$ where $C^*(\cdot)$ is given by (5), i.e.,

$$C^*_{\mathrm{O}} = C^*(1) = \frac{1-R}{T} \tag{8}$$

When a bond with term-to-maturity τ unexpectedly becomes collateral eligible, its price in the secondary market is:

$$p^*_{\mathrm{O}}(m, \tau) = \frac{\tau C^*_{\mathrm{O}} + 1}{1 + m(1-R)}, \tag{9}$$

and its old price when it was not collateral eligible is simply $p^*_{\mathrm{O}}(1, \tau)$. The implied yield for this existing bond for a given margin m, denoted by $r^*_{\mathrm{O}}(m, \tau)$, implicitly solves:

$$p^*_{\mathrm{O}}(m, \tau) = \int_{t=0}^{\tau} C^*_{\mathrm{O}} e^{-rt} dt + e^{-r\tau} \tag{10}$$

We can show that the yield of existing bond $r^*_{\mathrm{O}}(m, \tau)$ increases with margin m, i.e. $\partial r^*_{\mathrm{O}}(m, \tau)/\partial m >$

[24] To see this, note

$$p^* = 1 = \int_{t=0}^{T} e^{-rt} C dt + e^{-rT} \times 1 = \frac{C}{r}\left(1 - e^{-rT}\right) + e^{-rT} \Rightarrow r = C.$$

0.[25] Thus, the yield of the existing bonds when they become collateral eligible will decrease.

In our empirical analysis, we will also examine the pass-through of the spread reduction from the secondary market to the primary market when bonds are made collateral eligible, thus it is useful to theoretically examine the pass-through rate by comparing the reductions in the bond yields in the primary market with those in the secondary market. Unfortunately, equation (10) does not have an analytical solution; however, we can use equations (8)-(10) to solve for yields $r^*_{\mathrm{O}}(m,\tau)$ numerically for the existing bonds with different term-to-maturity τ and margin m, and calculate

$$\Delta r_{\mathrm{O}}(m,\tau) = r^*_{\mathrm{O}}(m,\tau) - r^*_{\mathrm{O}}(1,\tau) \tag{11}$$

[Figure 1 About Here]

Figure 1 shows the change in spreads for new and existing bonds, i.e., $\Delta r_{\mathrm{N}}(m)$ and $\Delta r_{\mathrm{O}}(m,\tau)$, when we reduce the margin from 1 to $m \in (0,1)$.[26] We have several observations from Figure 1. First, the spread decreases by more if the reduction in margin is larger, i.e. the pledgeability of the bond is higher, which confirms our analytical result; second, existing bonds with shorter term-to-maturity experience larger reductions in their spreads for the same reduction in the margin; third, the reductions in the spread of the new bond can be lower or higher than that of existing bonds, which means the pass-through rate from the secondary market to primary market can be lower or higher than 100%.

In addition, numerical simulations show that, for the same reduction in margin, the reduction in the yield of an existing bond decreases with its term-to-maturity τ, i.e. $\partial \Delta r_{\mathrm{O}}(m,\tau)/\partial\tau < 0$; moreover, for a given T and a reduction of margin $\Delta m \equiv 1-m > 0$, there exist $\tau^*(\Delta m; T) \in (0,T)$, such that the reduction in spreads for existing bonds is larger than that of new bonds if and only if their term-to-maturity $\tau < \tau^*(\Delta m; T)$.

Testable Implications. As we previously mentioned, making bond collateral eligible is akin to reducing the margin m from 1 to less than 1. With the above derivations, we can now describe the testable implications of such a change.

[25] To see this, note that, from Eqs. (9) and (10), $r^*_{\mathrm{O}}(m,\tau)$ implicitly solves:

$$G(r,m,\tau) \equiv \frac{\tau C^*_{\mathrm{O}} + 1}{1 + m(1-R)} - \int_{t=0}^{\tau} C^*_{\mathrm{O}} e^{-rt} dt - e^{-r\tau} = 0.$$

We have:

$$\begin{aligned} \frac{\partial G(r,m,\tau)}{\partial m} &= -\frac{(\tau C^*_{\mathrm{O}} + 1)(1-R)}{(1+m(1-R))^2} < 0 \\ \frac{\partial G(r,m,\tau)}{\partial r} &= \int_{t=0}^{\tau} t C^*_{\mathrm{O}} e^{-rt} dt + \tau e^{-r\tau} > 0 \end{aligned}$$

The claim follows from the implicit function theorem: $\frac{\partial r^*_{\mathrm{O}}(m,\tau)}{\partial m} = -\frac{\partial G(r,m,\tau)}{\partial m} / \frac{\partial G(r,m,\tau)}{\partial r} > 0$.

[26] Because we assumed that the risk-free interest rate is 0 without loss of generality, the bond spread is the same as the bond yield.

First, the price of the existing bonds in the secondary market, i.e., bonds whose coupon rate does not respond to the change because they were already fixed when they were issued, will increase as margin decreases according to equation (3). Moreover, Eq. (4) makes clear that the rise of the bond price in the secondary market when the margin falls is because the marginal investor h^* becomes more optimistic. As the implied interest rate is inversely related to bond price, the difference between the implied interest rate and the risk-free rate, namely the spread, will decrease.

Hypothesis 1 *If the margin decreases, the spread of existing bonds in the secondary market will decrease.*

For new bonds, Eq. (5) shows that the coupon rate of new issuance will be lower than that of otherwise identical bonds issued before the margin reduction. The reason is very simple: 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.

Hypothesis 2 *If the margin decreases, the coupon rate (and thus the bond yield) of new issuance will decrease.*

5 Secondary Market: Data, Methods, and Results

In this section, we describe the data, methods, and results of the impact of the policy shock on the secondary market bond pricing. 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

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

Our sample period is from Jan. 1, 2018 to Sept. 30, 2018, with 5-month window (99 trading days) before the June 1, 2018 policy shock and 4-month window (83 trading days) after the policy shock, respectively. If a bond does not have any trading in 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 Sept. 1, 2017, because newly issued bonds tend to exhibit high markups.

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

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 lower than AA ratings 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 have the same fundamentals.

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, i.e., the bonds in the interbank market that are newly eligible as collaterals 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.

[Figures 4-5 About Here]

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

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

[29] The yield curve of ChinaBond Government Bond 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, then adjusted 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.

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 5-trading day period since the expansion of the eligible collaterals 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 4-5 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.

5.2 Descriptive Statistics

[Table 2 About Here]

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 post-shock 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 a total of 6,057 unique bonds in the full sample, of which 5,650 of them are corporate bonds of various kinds – including 1,880 enterprise bonds, 1,447 exchange-traded corporate bonds, and 2,323 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.

[Table 3 About Here]

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 1,880, 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 market for all bonds hold for dual-listed bonds as well. 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 post 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.

5.3 Evidence for Market Segmentation

[Table 4 About Here]

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. (2022). 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 1,089 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 percent of all the matched trades have absolute spread differences of less than 5 bps; and more than 36 percent of the matched trades differ in spread exceeding 100 bps!

[Figure 6 About Here]

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.

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 are 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 Baseline Regression Specifications and Results

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 triple-difference (DDD) specification:

$$Spread_{ijt} = \beta_1 Post_t \times IB_j \times Treat_i + \beta_2 IB_j \times Treat_i + \beta_3 Post_t \times Treat_i + \delta_i + \theta_{jt} + (BR \times BT)_{it} + \varepsilon_{ijt}, \quad (12)$$

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, i.e. 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's are 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} are 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. Note that θ_{jt} also absorb IB_j and $Post_t \times IB_j$, which would have appeared in a typical DDD setting.
- $(BR \times BT)_{it}$ 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 $(BR \times BT)_{it}$ 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 $(BR \times BT)_{it}$ fixed effects do not fully absorb the $Post_t \times Treat_i$ 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 $Post_t \times Treat_i$ in the regression when using the full sample.[32]
- ε_{ijt} are the bond-market-day specific errors which are two-way clustered at 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 (12), 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: 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*.

[32]When restricting ourselves to dual-listed bonds, the term $Post_t \times Treat_i$ will be dropped because financial bonds are never dual-listed.

[Table 5 About Here]

Table 5 reports the results from the baseline regression as specified by equation (12). 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 $Post_t \times Treat_i$ interaction is subsumed by the Bond Type x Bond Rating x Date fixed effects.

Column (1) shows that the β_1 coefficient estimate of the triple interaction term $Post \times Treat \times IB$ is -0.599 and statistically significant at 1% level. That is, the spread difference between the treated bonds and the control bonds is reduced by 59.9 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 $Post \times Treat$ 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 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 39.8 bps, though because of the smaller sample size, the statistical significance of the estimate is now at the 10% level.

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) points 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 leads to an easing of 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:[33]

$$\begin{aligned} Spread_{ijt} \;=\; & \gamma_1 Post_t \times IB_j + \gamma_2 Post_t \times IB_j \times Treat_i + \gamma_3 IB_j \times Treat_i + \gamma_4 Post_t \times Treat_i \\ & + \delta_i + (BR \times BT)_{it} + \varepsilon_{ijt}, \end{aligned} \tag{13}$$

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

[33]Note that the fixed effects θ_{jt} are not included in equation (13) because it is collinear with $Post_t \times IB_j$.

[Table 6 About Here]

Table 6 reports the results. In Column 1 where the full sample is used in the regression, the coefficient estimate of the interaction term $Post_t \times IB_i$ is negative 11.8 bps but it is not statistically significant; however, in Column 2 where we use the dual-listed bonds only, we find that indeed the policy shock reduced the overall spreads of the dual-listed bonds in the interbank market relative to those in the exchange market, even for the bonds that are not directly treated. The magnitude of the spillover effect is also quite substantial: the average spread of dual listed bonds is reduced by 35.9 bps even if they were not treatment bonds, and this effect is statistically significant at 10% level. Thus the results reported in Table 6 provide some evidence for the predictions from the model of Ashcraft et al. (2011) that a higher supply of collateral in the interbank market eases the overall funding constraints in the treatment market, and lowers the overall spreads, with the caveat that the spillover effect seems to be restricted to the dual-listed bonds only.

5.5 Additional Analysis

Parallel Trends. A requirement for DDD as specified by Equation (12) as 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. In this subsection, we conduct the parallel trend analysis. The model is specified in Equation (14):

$$Spread_{ijt} = \sum_{k=-20,k\neq 0}^{k=17} \alpha_k D_t^k \times IB_j \times Treat_i + \beta_1 IB_j \times Treat_i + \beta_2 Post_t \times Treat_i + \delta_i + (BR \times BT)_{it} + \theta_{jt} + \varepsilon_{ijt}, \tag{14}$$

where we divide our sample period (a total of 184 trading days) into 36 sub-periods, with each period consisting of a 5-day window. The dummies D_t^k equals 1 if the date t falls in the sub-period 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 (12) are included.

[Figure 7 About Here]

Figure 7 plots the point estimate of $\alpha_k, k \in \{-20, ... -1, 1, ..., 17\}$ 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 the pattern of α_k estimated when we use only the transactions of the dual-listed bonds is similar, with slightly larger magnitudes.

Heterogeneous Analysis. One of the policy objectives of 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 and agricultural (*Green*) firms. 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 (12). 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.2 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.

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 post-policy 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. Table A.4 shows the regression results for the specification in equation (12) 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.

Spillover Effect By Bond Types. To examine whether the spillover effects we documented in Subsection 5.4 are heterogeneous across different types of bonds, we also run the following regression:

$$Spread_{ijt} = \sum_{k=-20,k\neq 0}^{k=17} \alpha_k D_t^k \times IB_j \times Treat_i + \sum_{k=-20,k\neq 0}^{k=17} \gamma_k^{Corp} D_t^k \times IB_j \times Corp_i + \sum_{k=-20,k\neq 0}^{k=17} \gamma_k^{Fin} D_t^k \times IB_j \times Fin_i$$
$$+\beta_1 IB_j \times Treat_i + \beta_2 Post_t \times Treat_i + \delta_i + (BR \times BT)_{it} + \varepsilon_{ijt}, \quad (15)$$

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 non-treated 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 non-treated 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 "Xianwei" "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.

[Figure 8 About Here]

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 National Development & Reform Commission (NDRC). The issuer usually has to wait for 2-3 months for 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 2 trading days 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.[34] 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.

6.1 Data

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 Jan. 1, 2018 - Aug. 31, 2018; later we also use data from Jan. 1, 2015 - Aug. 31, 2015 to conduct a placebo test. We choose to focus on the primary bond issued before Aug. 31, 2018 because the applications for such new bond issuance almost certainly would have been submitted

[34] See Ding et al. (2019) for a description of the bond issuance process in China. They document the bond overpricing in the primary bond market in China.

to the NDRC for approval before the policy shock date of June 1, 2018, because as we previously mentioned, it would typically take 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 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 "non-mover" firms. Bond issuance information is obtained from WIND.

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

[Figures 9 and 10 About Here]

We first provide a first glance of 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 five months before the policy change, and the right graph uses data from the three 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 panel 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 five-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.

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; 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, 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 People's Bank of China. Finally, 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 MLF.[35] 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 a series of control variables to account for the RRR cut impact, including $RRRcut_i \times AAA_i$,$RRRcut_i \times AAplus_i$, $RRRcut_i \times AAA_i \times IB_i$, $RRRcut_i \times AAplus_i \times IB_i$, 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 triple-difference (DDD) specification:

$$\begin{aligned} Spread_{it} = {} & \beta_1 Post_t + \beta_2 Treat_i + \beta_3 IB_i + \beta_4 Post_t \times Treat_i + \beta_5 Post_t \times IB_i \\ & + \beta_6 Treat_i \times IB_i + \beta_7 Post_i \times Treat_i \times IB_i + \boldsymbol{\gamma} \mathbf{X}_{it} + \theta_t + \varepsilon_{it} \end{aligned} \tag{16}$$

[35]The reserve requirement ratio (RRR) was 17 percent for large banks, and 15 percent 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 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.

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, i.e. 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 $Post_i \times Treat_i \times IB_i$.

Table 7 presents the summary statistics of the variables used for primary market analysis. Panel A shows that, of the 1,791 new bond issuance in our sample of Jan. 1, 2018 - Dec. 31, 2018, 1,091 (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 vs. 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 About Here]

6.3 Baseline Result, Robustness Checks and Heterogeneous Analysis

Baseline Result. Table 8 presents the baseline results. The coefficient of particular interest is that of the interaction term $Post_t \times Treat_i \times IB_i$, 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, for a firm issuing a 1.4 billion yuan corporate bond (which is the mean bond issuance size of our sample) with semi-annual 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.

[Table Table 8 About Here]

Parallel Trends and Dynamic Effects. In order to examine the parallel trend assumption necessary for the DDD strategy specified in (16) to work, we also estimated the following specification:

$$\begin{aligned} Spread_{it} = \beta_1 Post_t + \beta_2 Treat_i + \beta_3 IB_i + \beta_4 Post_t \times Treat_i + \beta_5 Post_t \times IB_i \\ + \beta_6 Treat_i \times IB_i + \sum_{k=1,k\neq 5}^{k=9} \alpha_k Month_{it}^k \times Treat_i \times IB_i + \boldsymbol{\gamma} \mathbf{X}_{it} + \theta_t + \varepsilon_{it} \end{aligned} \tag{17}$$

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

[Figure 11 About Here]

Figure 11 presents the estimated values of α_k based on equation (17) for $k \in \{1, ..., 9\}$. It shows that, prior to the policy shock, the α_k estimates are small and tend to be statistically insignificant, i.e., before the policy shock, the difference in the spreads in the interbank market and in the exchange market is similar for the treated bonds and for the control bonds. After the policy shock, the spreads of treated bonds in the interbank market are significantly reduced relative to the control bonds. The effect is immediate and persisted for all three months after the policy shock in our estimation sample.

Seasonal Effect? A Placebo Test. We used only the new bond issuance data within three 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 post-policy 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 between Jan. 1st, 2015 and Aug. 31st, 2015 to re-run regression equation (16), setting June 1, 2015, as the factitious policy date.[36] 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 $Post_t \times Treat_i \times IB_i$ in this placebo test tend to be statistically insignificant, and if anything, of a positive sign. This implies that seasonal factors are unlikely the driver for the findings reported in Table 8.

[Table 9 About Here]

[36] We choose the data from 2015 for the placebo test because China Securities Depository & Clearing Co. Ltd (CSDC) introduced important changes to the bond market both in 2017 and 2016.

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 $Post_t \times Treat_i \times IB_i$ 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 2-4 times the impact of an average targeted bond.

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 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 interbank market. We call this phenomenon "*shopping for the venue*." Recall that any new bond issuance application needs to be submitted to NDRC for approval, which takes about two to three 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. This is only for results here, we redefine the $L.Post_t$ variable to take value 1 if t is after August 1, 2018. In addition, we include all new bonds issued before Dec. 31, 2018 in our analysis sample.[37]

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

$$IB_{it} = \alpha_1 Post_t + \alpha_2 Treat_i + \alpha_3 Post_t \times Treat_i + \boldsymbol{\gamma}\mathbf{X}_{it} + \varepsilon_{it}, \tag{18}$$

where the dependent variable $IB_{it} = 1$ if new bond i is issued in the interbank market at date t; $Post_t = 1$ if the bond issuance date t is after August 1, 2018; $Treat_i = 1$ 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 $Post_t \times Treat_i$. 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 NDRC to issue their bonds in the interbank market after the policy shock.

[Table 10 About Here]

Table 10 presents the result from the logistic regressions specified by equation (18). 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 MLF collateral expansion. The coefficient estimates of $L.Post \times Treat$ are positive and

[37] Table A.1 in the online appendix provides the summary statistics of the sample of all bonds issued in 2018 used in the analysis reported in Table 10.

statistically significant. The coefficient estimates implies 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 60 percent more 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. Note that this may also be explained by the risk-taking channel that investors are more likely to hold risky portfolio after the expansionary monetary policy.

7 Exploring the Mechanisms

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

7.1 Repo Haircut

One potential mechanism of the collateral-based monetary policy is through the repo market. 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.

We collected repo haircuts to explore whether the collateral-based policy works through the repo market. There are two repo markets in China, interbank repo market and 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. We collect the repo haircut in the interbank market from CFETS. 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 $t+2$.[38] 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 bond market transactions with their haircuts on the same day in the repo market. Our sample period is from Jan. 1st, 2018 to Sept. 30th, 2018. and the definition

[38]We drop samples with a negative haircut. We drop emergency trading. We also drop X-repo transaction, a facility launched by the PBoC in 2015 to anonymously match interbank repo lenders and borrowers with standardized collateral and haircut requirements.

of variables besides *Haircut* follows from Section 5. Table 11 shows the haircuts in the exchange market and interbank market before and after the policy shocks.

[Table 11 About Here]

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

$$Haircut_{ijt} = \beta_1 Post_t \times IB_j \times Treat_i + \beta_2 IB_j \times Treat_i + \beta_3 Post_t \times Treat_i + \delta_{ij} + \theta_{jt} + (BR \times BT)_{it} + \varepsilon_{ijt} \quad (19)$$

where the dependent variable is the haircut of bond i in market j on date t and the independent variables are the same as the baseline regression in equation (12).

Table 12 column (1) shows the regression results. We find that the haircuts of treated bonds in the interbank market decreased after they become collateral eligible for MLF, which is consistent with the repo market channel. We also conduct a heterogeneous analysis where we further add interaction terms of *Post* × *Treat* × *IB* and *Green*, *Xiaowei* or *Sannong* dummies. Column (2) of Table 12 shows that the *Green*, *Xiaowei*, and *Sannong* bonds receive even lower haircuts than other treated bonds in the interbank market after the MLF collateral expansion.

[Table 12 About Here]

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

$$Haircut_{ijt} = \sum_{k=-10, k\neq 0}^{k=18} \alpha_k D_t^k \times IB_j \times Treat_i + \beta_1 IB_j \times Treat_i + \beta_2 Post_t \times Treat_i + \delta_{ij} + (BR \times BT)_{it} + \theta_{jt} + \varepsilon_{ijt} \quad (20)$$

where we divide our sample period (a total of 184 trading days) into 18 sub-periods, with each period consisting of a 10-day window.[39] The dummies D_t^k equals 1 if the date t falls in the sub-period 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 (12) are included. Figure 12 plots the point estimate of α_k and the corresponding 95% confidence intervals. It indicates that the haircuts for the new eligible collateral were in general in parallel with the control group or even increasing before the policy changes, but decreased after that. The impact lasts for around 3 months, which is consistent with the parallel trend we found for the bond spreads in the secondary market.

[Figure 12 About Here]

7.2 Liquidity vs. 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

[39] We drop the 19th sub-period due to insufficient samples.

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*.

To this end, 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,[40]

$$Amihud_{ijt} = \frac{1}{7}\sum_{s=t-3}^{t+3}\frac{|r_{ijs}|}{Vol_{ijs}}, \tag{21}$$

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 (21), 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:

$$Spread_{ijt} = \alpha_{qj}Amihud_{ijt} + \boldsymbol{\beta}_{qj}\mathbf{X}_{ijt} + BR_{ij} + \theta_t + \varepsilon_{it}, \text{if } t \in \mathcal{D}_q \tag{22}$$

where $Amihud_{ijt}$ is the illiquidity measure constructed in (22), $\mathbf{X}_{ijt}$ 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 $q \in \{1,2,3\}$.[41] By running the regressions of equation (22) separately for each quarter and each market, we generate $\hat{\alpha_{qj}}$. In addition, for each market j, we denote the 1st 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.

Now we follow Schwert (2017), and 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

$$Liquidity\ Spread_{ijt} = \widehat{\alpha_{qj}}(Amihud_{ijt} - Amihud_{1pj}); \tag{23}$$

and its default spread is simply the residual of its spread after subtracting the liquidity spread

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

[41] Recall from Section 5.1, our sample period is from Jan 1, 2018 - Aug 31, 2018, which covers three quarters.

estimated in (23):

$$Default\ Spread_{ijt} = Spread_{ijt} - Liquidity\ Spread_{ijt}. \tag{24}$$

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 Table 2 and Table 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 (12). 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 $Post \times Treat \times IB$ 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 $Post \times Treat \times IB$ 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.[42]

[Table 13 About Here]

Summary. 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 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, e.g., 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 marginal trader's belief (i.e. the leverage cycle theory). We leave it for future research to differentiate these channels.

[42] We also examined the dynamics of the changes in liquidity spread and default spread separately using the regression specification of (14). 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.

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 Medium-Term Lending Facility (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 (the "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 triple-difference 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 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 European Central Bank, as well as many other central banks, have been using collateral-based monetary policy extensively after the Great 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 banks 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 access the effects on corporate financing, evidence on *quantity* adjustment, e.g. issuance of bonds in the primary market, would also be informative. As

important, we should also be cautious about the potential distortions caused by collateral-based monetary policies. For instance, the policy may induce risk-taking of financial institutions towards certain bonds, worsen the quality of the overall collateral, and may also affect bond issuers' capital structure. These 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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Tables and Figures

Table 1: Collateral-based Monetary Policy Tools of People's Bank of China before 2018

Name	**Short-term Liquidity Operation, SLO**	**Standing Lending Facility, SLF**	**Medium-term Lending Facility, MLF**	**Pledged Supplementary Lending, PSL**
Launch time	Jan. 2013	Jan. 2013	Sept. 2014	Apr. 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
Target			Small firms, agriculture	Projects with specific purpose

Note: This table documents collateral that are eligible for the corresponding monetary policy tools as of 2018.

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	9,831	27.77	13,809	31.98
AA+	23,684	30.14	9,974	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

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	2,310	2.940	1,580	4.460	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	5,650	93.28	4,093	92.87	2,083	95.73
- *Enterprise Bond*	1,880	31.04	1,770	40.16	636	29.23
- *Exchange-traded Corporate Bond*	1,447	23.89	-	-	1,447	66.50
- *Medium-term Note*	2,323	38.35	2,323	52.71	-	-
Financial Bond	407	6.720	314	7.130	93	4.270
Total	6,057	100	4,407	100	2,176	100

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 Eq. (21), 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	3,393	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	3,381	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	3,381	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	3,393	0.403	0.491	0	1	13,438	0.428	0.495	0	1
IB	16,831	0.202	0.401	0	1	3,393	1	0	1	1	13,438	0	0	0	0
Treat	16,831	0.765	0.424	0	1	3,393	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	3,393	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	3,393	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	3,393	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	3,393	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	3,381	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	7,176	42.64	1,391	41.00	5,785	43.05
AA+	5,697	33.85	1,278	37.67	4,419	32.88
AAA	3,958	23.52	724	21.34	3,234	24.07
Total	16,831	100	3,393	100	13,438	100

Panel C	**Full Sample**		**Interbank Market**		**Exchange Market**	
Bond Type	Freq.	Percent	Freq.	Percent	Freq.	Percent
Enterprise Bond	16,831	100	3,393	100	13,438	100
Total	16,831	100	3,393	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

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 billion yuan. 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 Eq. (21), 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			
	1,179	109.2	135.4	0.0185	1166			
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	1,179
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. (2022). 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 falls within the $[t-2, t+2]$ trading window, then these transactions are called "simultaneous" exchange transaction. The difference between the spreads is simply the spread of the simultaneous exchange transaction closest to date t minus the interbank spread in date t of the same bond.

Table 5: Impact of MLF Collateral Expansion on Bond Spreads in the Secondary Market

	Full Sample	Dual-listed Bonds Only
Variables	(1)	(2)
Post × Treat × IB	-0.599***	-0.398*
	(0.171)	(0.234)
IB × Treat	-0.355	-0.637
	(0.584)	(0.638)
Post × Treat	0.439***	
	(0.153)	
Bond Type × Bond Rating × Date FE	Yes	Yes
Market × Date FE	Yes	Yes
Bond FE	Yes	Yes
Observations	77,731	16,661
Adjusted R-squared	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. Regression equation is specified by equation (12). 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 MLF Collateral Expansion on the Secondary Interbank Market

	Full Sample	Dual-listed Bonds Only
Variables	(1)	(2)
Post × Treat × IB	-0.600***	-0.431*
	(0.169)	(0.230)
Post × IB	-0.118	-0.359*
	(0.104)	(0.185)
IB × Treat	-0.276	-0.467
	(0.592)	(0.657)
Post × Treat	0.429***	
	(0.149)	
Bond Type × Bond Rating × Date FE	Yes	Yes
Bond FE	Yes	Yes
Observations	77,731	16,661
Adjusted R-squared	0.859	0.811

Note: This table examines whether 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 (13). Standard errors are two-way clustered at the bond and date levels. ***,** , and * represent statistical significance at 1%, 5% and 10%, respectively.

Table 7: Summary Statistics for the Primary Market Data: Jan 1, 2018 - Aug 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	1,791	2.537	1.029	0.503	5.889	1,091	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	1,091	0.347	0.476	0	1	700	0.426	0.495	0	1
	IB	1,791	0.609	0.488	0	1	1,091	1	0	1	1	700	0	0	0	0
	Treat	1,791	0.434	0.496	0	1	1,091	0.487	0.500	0	1	700	0.353	0.478	0	1
Bond Info	Quantity (Billion RMB)	1,791	1.389	1.930	0.0300	40	1,091	1.503	2.321	0.0800	40	700	1.212	1.042	0.0300	7.200
	Term	1,791	4.275	1.846	0.917	15	1,091	4.395	2.017	2	15	700	4.089	1.525	0.917	15
	Guarantee	1,791	0.111	0.314	0	1	1,091	0.104	0.306	0	1	700	0.121	0.327	0	1
	SOE	1,791	0.782	0.413	0	1	1,091	0.858	0.349	0	1	700	0.664	0.473	0	1
	Put	1,791	0.341	0.474	0	1	1,091	0.158	0.365	0	1	700	0.627	0.484	0	1
	Call	1,791	0.0882	0.284	0	1	1,091	0.120	0.325	0	1	700	0.0386	0.193	0	1
Issuer Info	Debt Asset Ratio	1,791	62.33	18.23	0	95.59	1,091	62.16	18.70	0	95.17	700	62.60	17.49	0	95.59
	Liquidity Ratio	1,791	3.795	68.24	0	2887	1,091	5.194	87.41	0	2887	700	1.614	1.771	0	26.46
	Cash Coverage Ratio	1,791	0.501	2.048	-2.571	3.024	1,091	0.428	2.071	-2.571	3.024	700	0.615	2.008	-2.571	3.024
	Log Assets	1,766	24.99	1.394	19.93	30.68	1,079	25.04	1.424	20.76	30.68	687	24.91	1.342	19.93	27.78
	Log Equity	1,766	23.86	1.259	19.35	29.00	1,079	23.90	1.281	19.84	29.00	687	23.80	1.222	19.35	26.64
Market Info	Similar Bond Issuance (Billion RMB)	1,791	4.885	5.037	0.0300	40	1,091	5.358	5.637	0.0800	40	700	4.149	3.812	0.0300	14.60
	CMB Issuance (Billion RMB)	1,791	24.79	34.74	0	176.9	1,091	18.41	22.73	0	88.44	700	34.74	46.06	0	176.9
	CGB Issuance (Billion RMB)	1,791	16.80	61.68	0	500.2	1,091	15.50	50.76	0	250.1	700	18.83	75.61	0	500.2
Macro Info	Δ GDP	1,774	11.63	2.895	-13.58	20.30	1,082	11.65	2.725	-13.58	20.30	692	11.59	3.144	-13.58	20.30
	Δ M2	1,791	8.869	0.276	8.174	9.233	1,091	8.880	0.282	8.174	9.233	700	8.851	0.266	8.174	9.233
	IB $\times$ AA+	1,791	0.180	0.385	0	1	1,091	0.296	0.457	0	1	700	0	0	0	0
	IB $\times$ AAA	1,791	0.263	0.440	0	1	1,091	0.432	0.496	0	1	700	0	0	0	0
	RRRcut $\times$ IB	1,791	0.322	0.467	0	1	1,091	0.528	0.499	0	1	700	0	0	0	0
	RRRcut $\times$ AA+	1,791	0.128	0.334	0	1	1,091	0.142	0.349	0	1	700	0.106	0.308	0	1
	RRRcut $\times$ AAA	1,791	0.294	0.456	0	1	1,091	0.238	0.426	0	1	700	0.380	0.486	0	1
	RRRcut $\times$ IB $\times$ AA+	1,791	0.0865	0.281	0	1	1,091	0.142	0.349	0	1	700	0	0	0	0
	RRRcut $\times$ IB $\times$ AAA	1,791	0.145	0.352	0	1	1,091	0.238	0.426	0	1	700	0	0	0	0

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	1,791	100	1,091	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	1,791	100	1,091	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.	1,791	1,791	1,766	1,766	1,757	1,757
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. Regression equation is specified by equation (16). 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.

Table 9: A 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 × 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 × 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 × 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 × Treat × 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 tables 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 Jan. 1st, 2015 and Aug. 31st, 2015. Regression equation is specified by equation (16). 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.

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.	3,075	3,042	3,042	3,026

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 (18). *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.

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

Table 12: Impact of the MLF Collateral Expansion on Bond Haircuts in the Repo Markets

VARIABLES	(1) Haircut	(2) Haircut
Post × Treat × IB	-2.072**	-1.916**
	(0.937)	(0.941)
Post × Treat	1.162	3.185**
	(1.002)	(1.322)
IB × Treat	-15.31***	-15.33***
	(2.040)	(2.044)
Post × Treat × IB × Green		-2.009**
		(0.979)
Post × Treat × IB × Xiaowei		-4.205***
		(0.455)
Post × Treat × IB × Sannong		-2.472*
		(1.362)
Bond Type × Bond Rating × Date FE	Yes	Yes
Market × Date FE	Yes	Yes
Bond FE	Yes	Yes
Observations	74,936	74,936
Adjusted R-squared	0.976	0.976

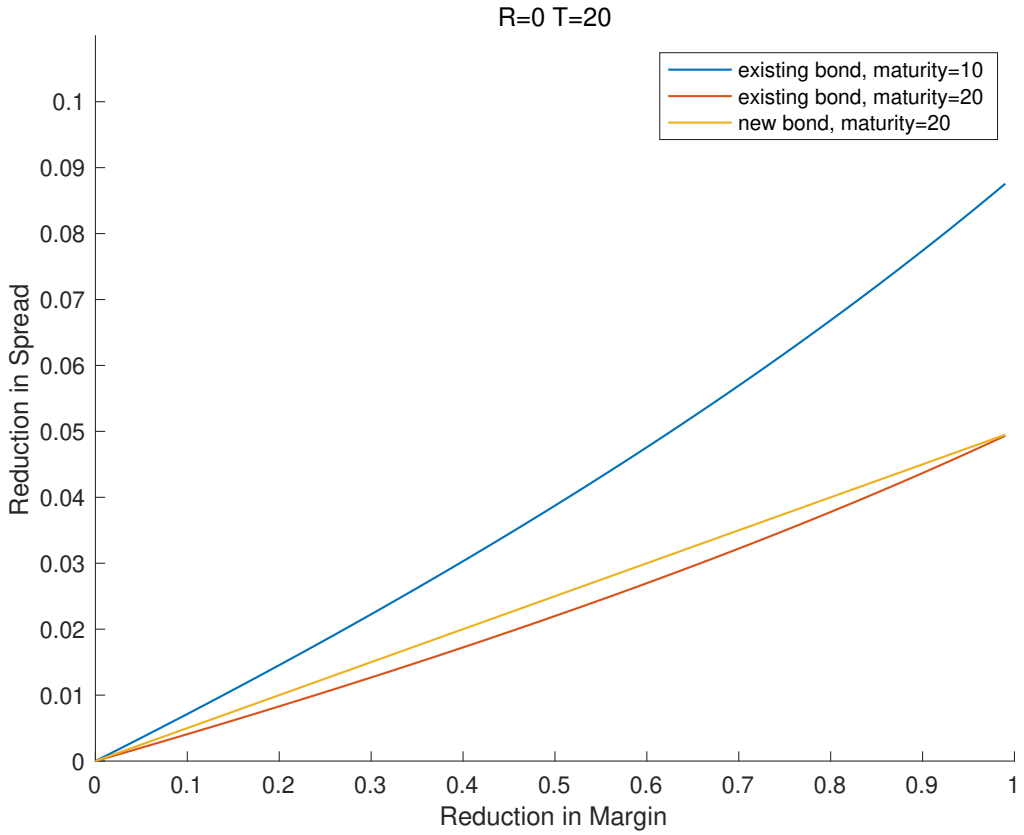
Note: This table examines whether the MLF collateral expansion decreases the haircuts of the newly collaterizable bonds in the repo markets. Results are reported from the regression specified by equation (19). Standard errors are two-way clustered at the bond and date levels. ***,** , and * represent statistical significance at 1%, 5% and 10%, respectively.

Table 13: Liquidity Spread vs. Default Spread in the Secondary Market

Variables	Full Sample			Dual-listed Bonds Only		
	Total Spread	Liquidity Spread	Default Spread	Total Spread	Liquidity Spread	Default Spread
	(1)	(2)	(3)	(4)	(5)	(6)
Post × Treat × IB	-0.599***	0.0696***	-0.666***	-0.398*	-0.00432	-0.392*
	(0.171)	(0.0234)	(0.168)	(0.234)	(0.0398)	(0.226)
IB × Treat	-0.355	-0.0127	-0.339	-0.637	0.0928	-0.730
	(0.584)	(0.0566)	(0.548)	(0.638)	(0.0665)	(0.602)
Post × Treat	0.439***	-0.0508	0.488***			
	(0.153)	(0.0568)	(0.166)			
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-squared	0.860	0.273	0.854	0.809	0.329	0.809

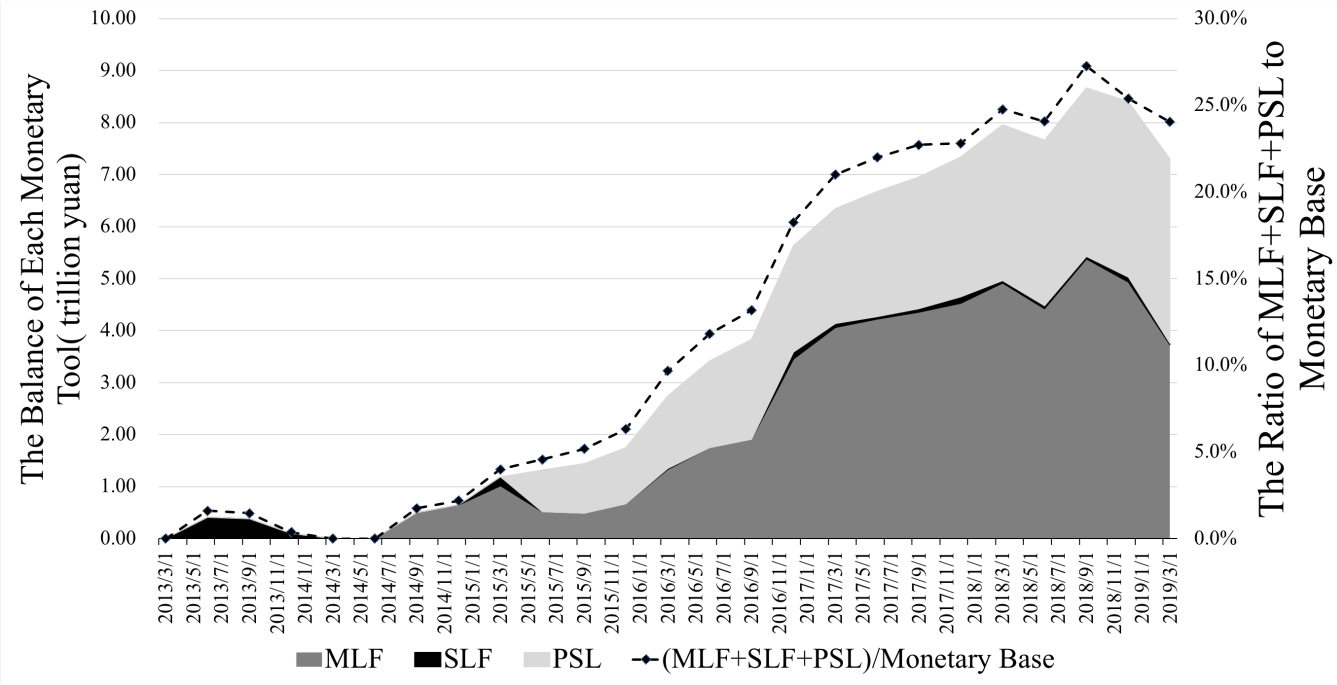
Note: This table shows the impact of MLF collateral expansion on the liquidity spreads and default spreads of the newly collaterizable bonds. Regression equation is specified by equation (12) for Columns (1) and (4); for Columns (2) and (5), the dependent variables are replaced by the liquidity spread constructed in equation (23); and for Columns (3) and(6), they are replaced by the default spread constructed in equation (24). Standard errors are two-way clustered at the bond and date levels. ***,** , and * represent statistical significance at 1%, 5% and 10%, respectively.

Figure 1: Reductions in Bond Spreads in Response to Reductions in Margin



Note: The curve "new bond, maturity = 20" graphs $\Delta r_{\mathrm{N}}(m)$ as in (7) for a new bond with $T = 20, R = 0$, as a function of m; the curves "existing bond, maturity = 10" and "existing bond, maturity = 20" respectively graph $\Delta r_{\mathrm{O}}(m, 10)$ and $\Delta r_{\mathrm{O}}(m, 20)$, where $\Delta r_{\mathrm{O}}(m, \tau)$ is defined by (11), for an existing bond with $T = 20, R = 0$ when first issued.

Figure 2: Balance of PBOC's Collateral-based Lending Facilities



Note: This table shows the balance of PBOC's collateral-based lending facilities in Table 1. Statistic is calculated by authors according to data reported by People's Bank of China, obtained from WIND, as of May 30th, 2019.

Figure 3: Liquidity Transmission Mechanism of Traditional and Unconventional Monetary Policies in China

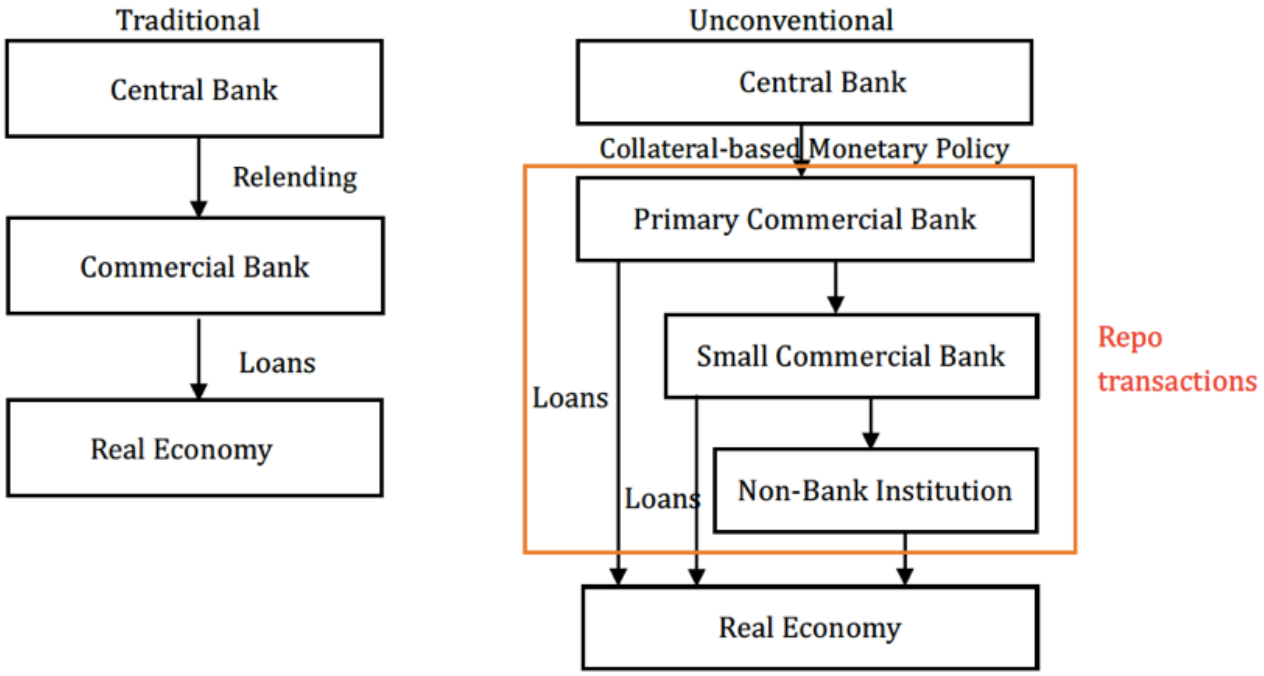
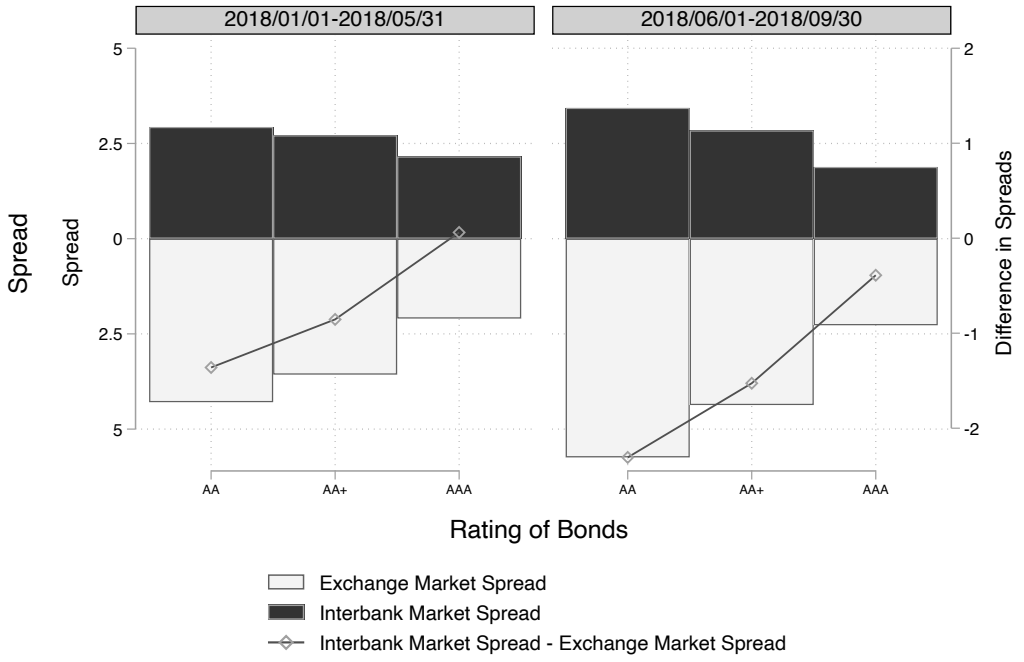
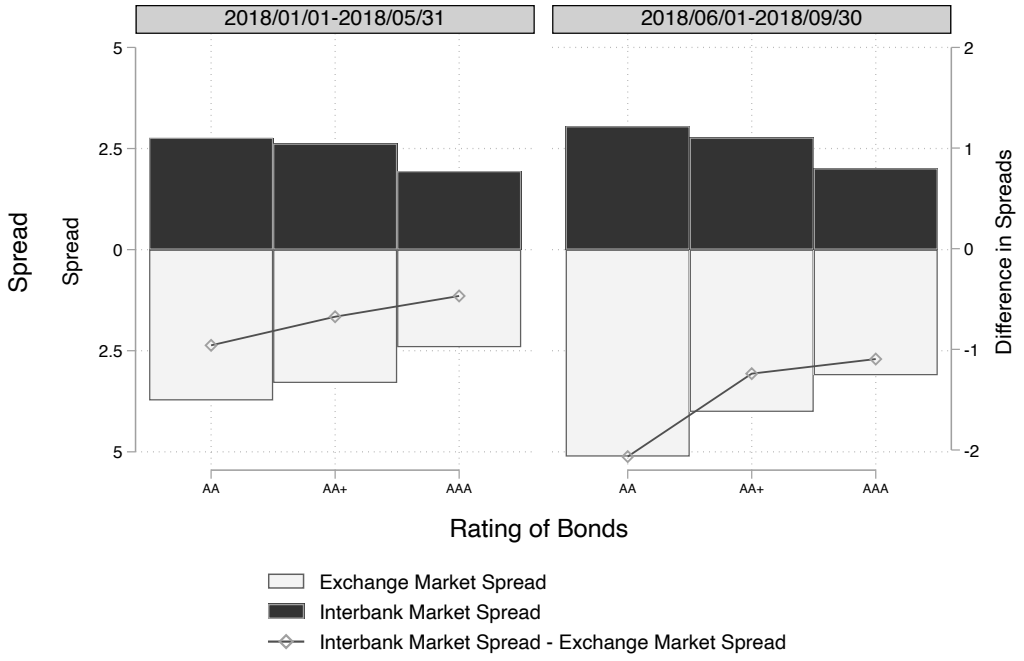


Figure 4: Average Daily Spread of Bonds in the Exchange Market and the Interbank Market Before and After the Expansion of MLF Collaterals on June 1, 2018: Secondary Market



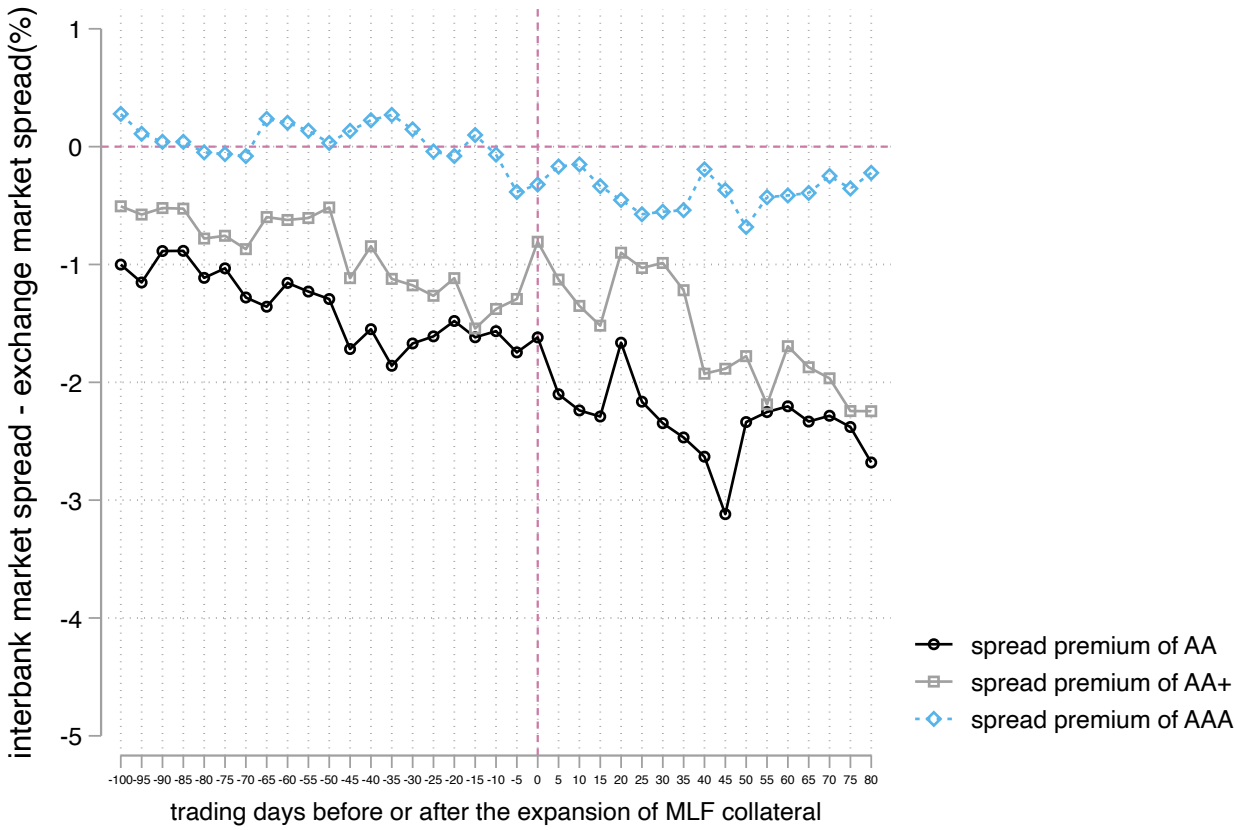
(a) Full Sample



(b) Dual-listed Bonds Only

Note: The sample period of the left graph is Jan 1, 2018 - 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, 2018 - Sept. 30, 2018. The horizontal axis denotes the three ratings of bonds. The darker bar is the average spread in the interbank market, 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 Jan. 1, 2018 - Sept. 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.

Figure 6: Kernal Distribution of Absolute Difference Between Spreads of Dual-listed Bonds in Interbank Market and Exchange Market: Secondary Market

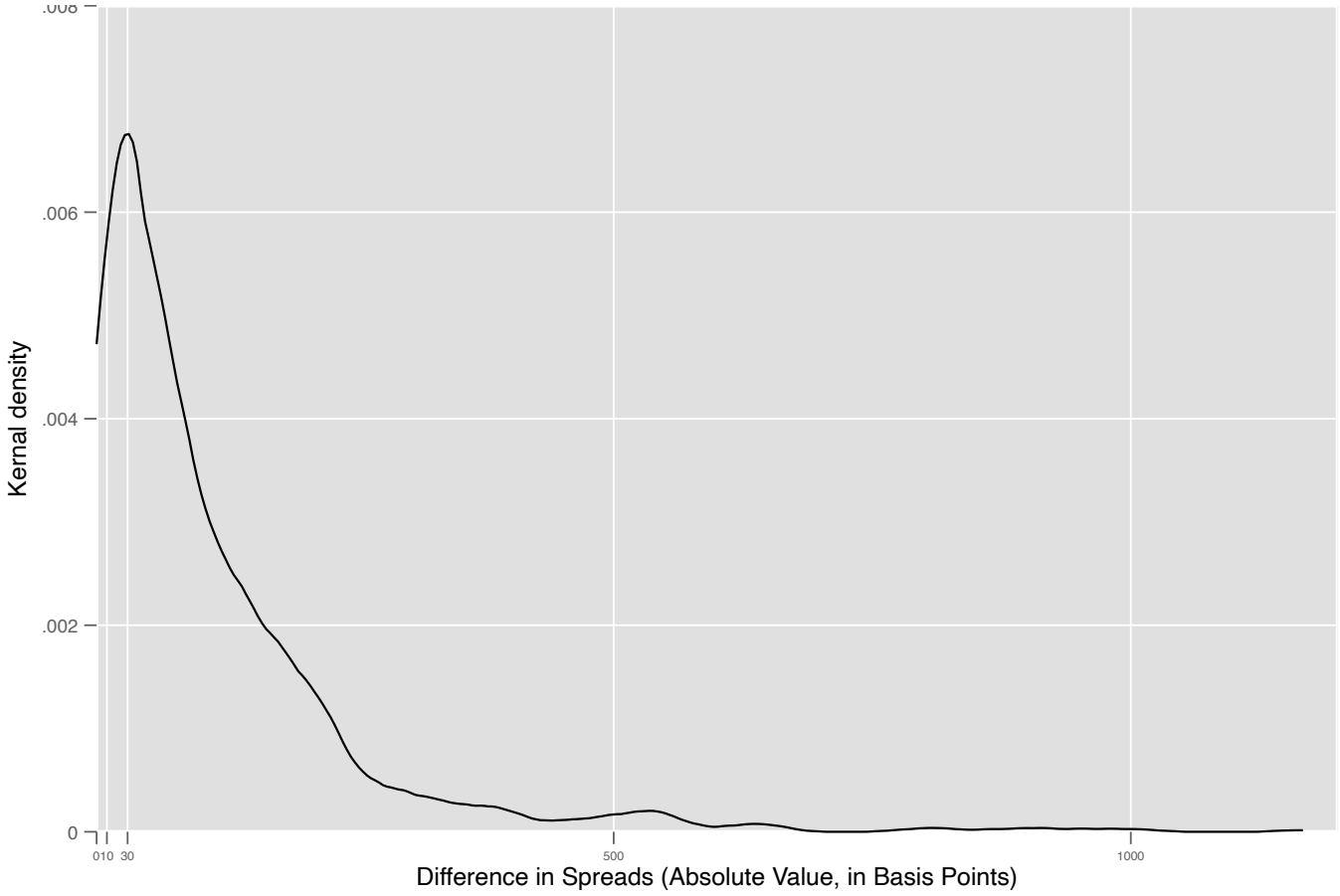
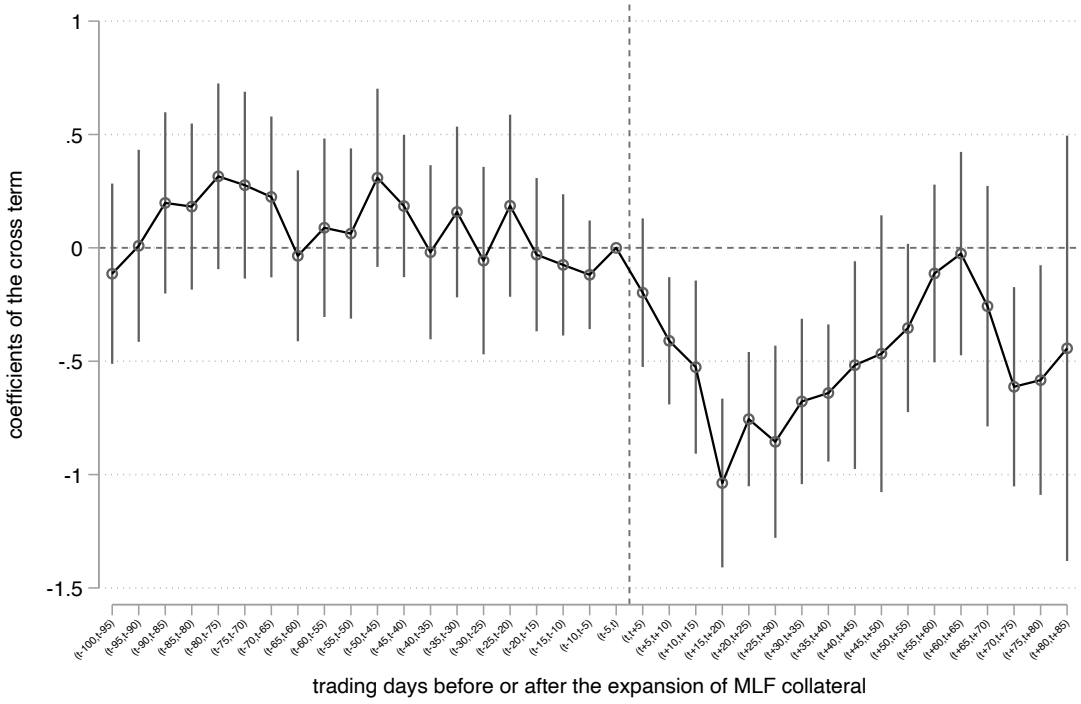
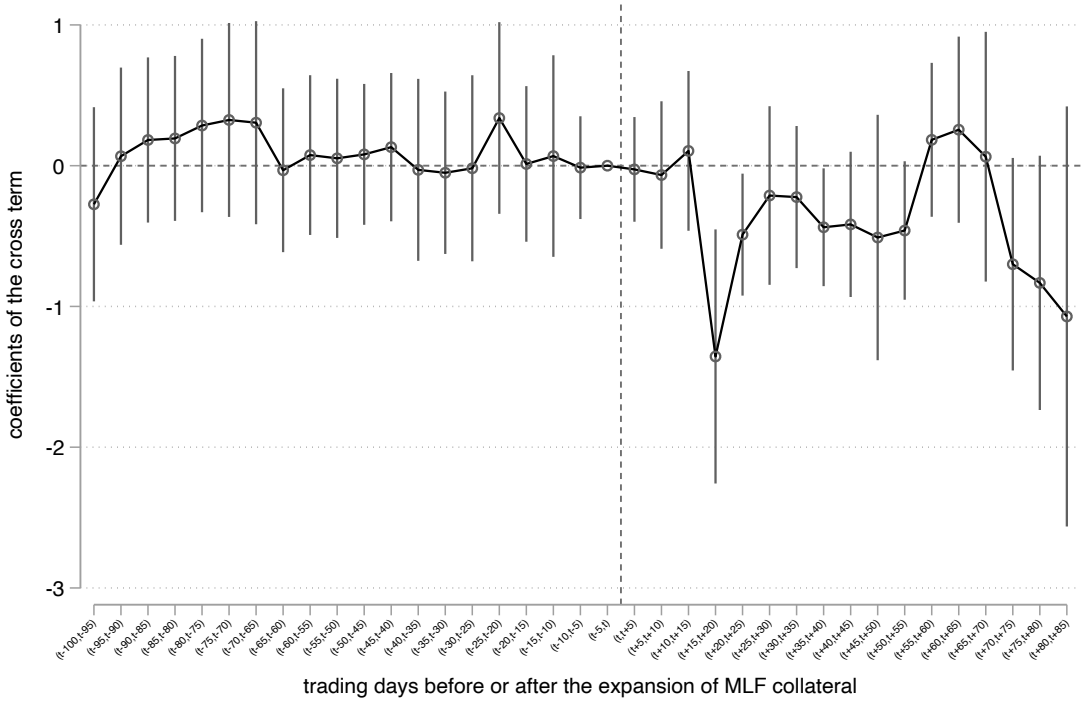


Figure 7: Parallel Trend and Time Patterns of the MLF Collateral Expansion Effects in the Secondary Market



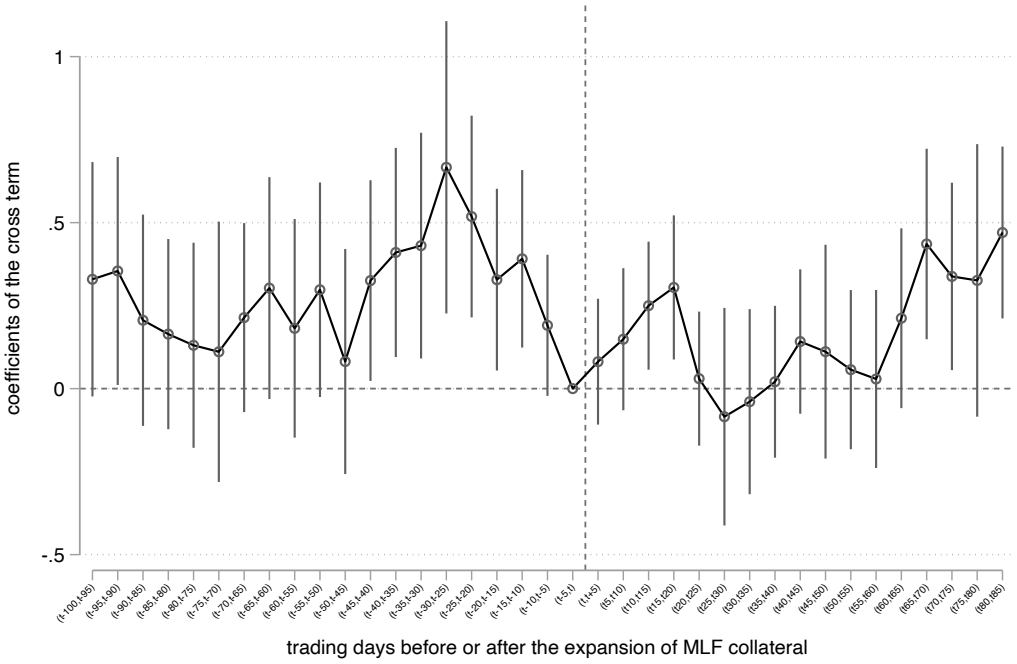
(a) Full Sample



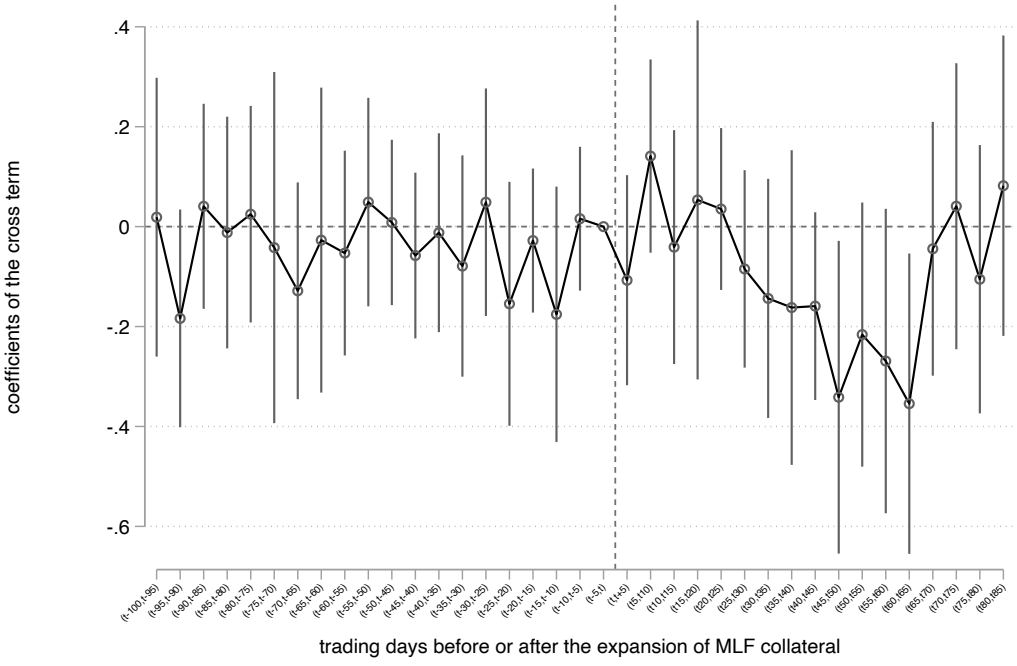
(b) Dual-listed Bonds Only

Note: Each dot in window $[t-5+5k, t+5k]$ stands for the point estimate of coefficient α_k in regression equation (14). The vertical whisk around the point is the associated 95% confidence interval. The point in window $[t-5, t]$ is normalized to 0.

Figure 8: Spillover Effect by Bond Types



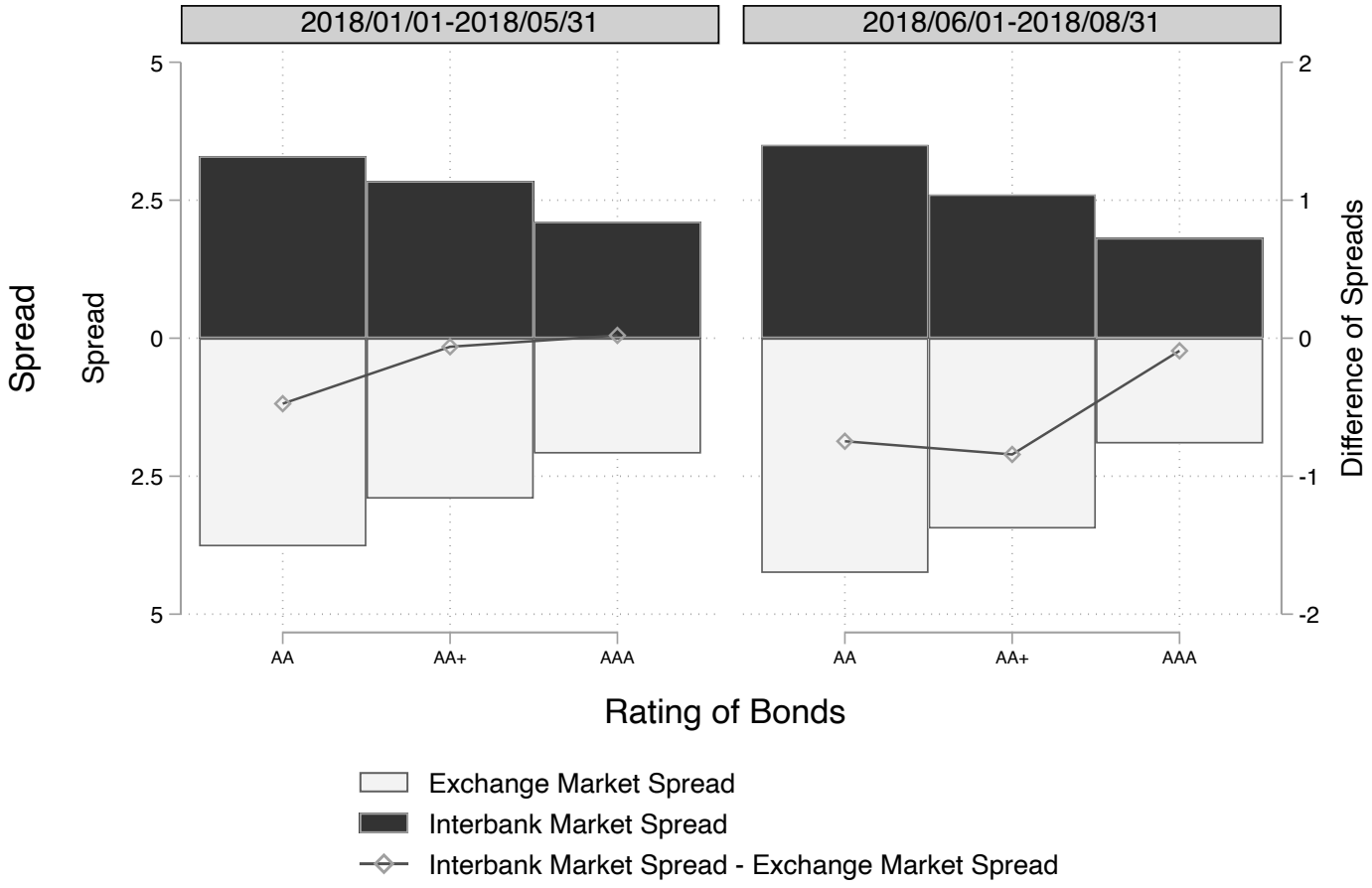
(a) Spillover on Corporate Bonds



(b) Spillover on Financial Bonds

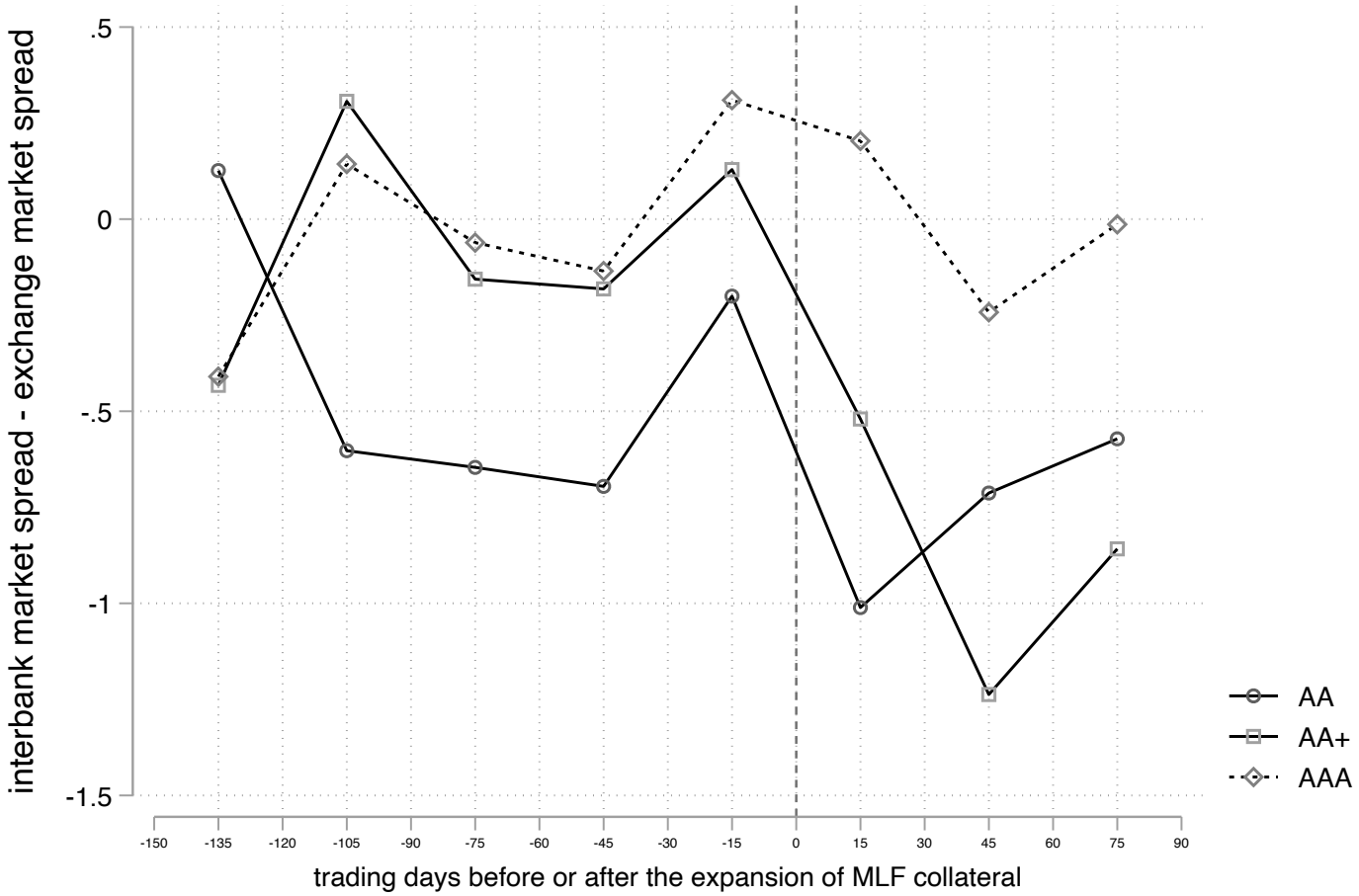
Note: Each dot in window $[t-5+5k, t+5k]$ stands for the point estimate of coefficients γ_k^{Corp} for corporate bonds (or γ_k^{Fin} for financial bonds) in regression equation (15) with full sample. The vertical whisk around the point is the associated 95% confidence interval. The point in window $[t-5, t]$ is normalized to 0.

Figure 9: Spread Differences for Primary Market between the Interbank and the Exchange Markets, by Bond Rating: Primary Market



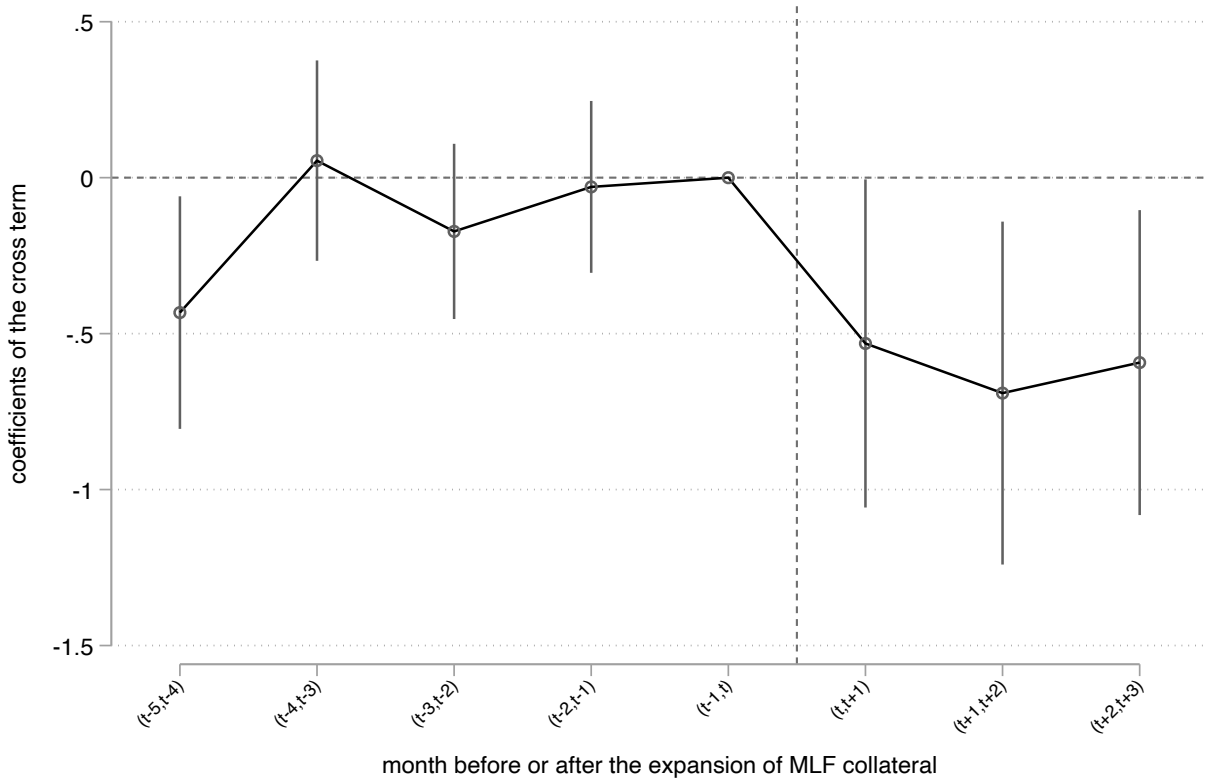
Note: The sample period of the left graph is Jan. 1, 2018 - May. 31, 2018. The sample period of the right graph is June 1, 2018 - Aug. 31, 2018. The horizontal axis denotes the three ratings of bonds. The lighter bar is the average spread in the exchange market, the darker bar is the average spread in 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



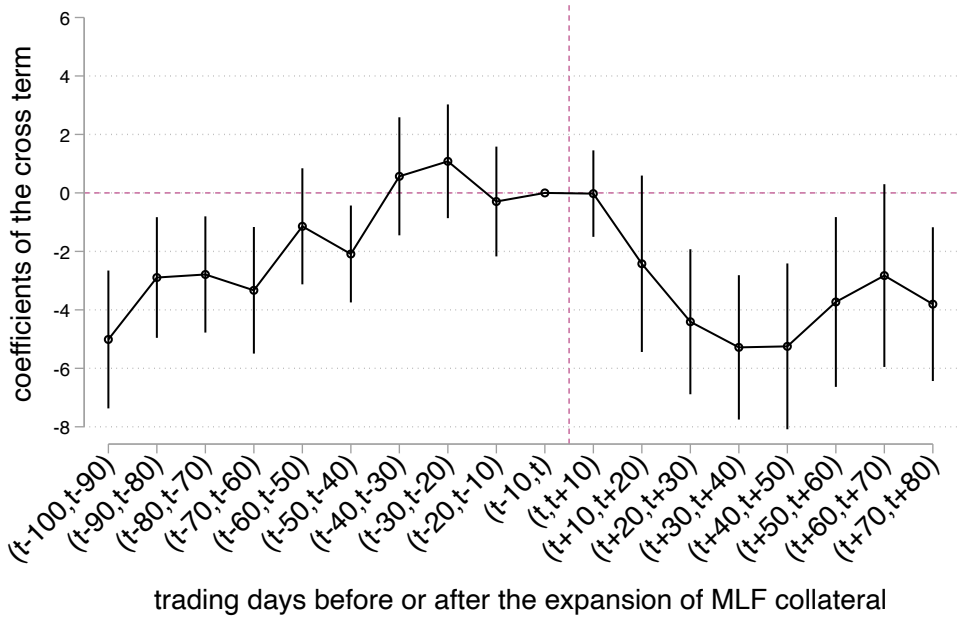
Note: The sample period of the graph is Jan. 1, 2018 - Aug. 31, 2018. Each point represents the average difference of spread at issuance between the interbank market and the exchange market in 5-day windows, where the average spread difference is simply the average spread at issuance of interbank market bonds minus the average spread at issuance of exchange market bonds.

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 (9). The vertical whisk around the point is the associated 95% confidence interval. The point in window $[t-1, t]$ is normalized to 0.

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 (20). The vertical whisk around the point is the associated 95% confidence interval. The point in window $[t-10, t]$ is normalized to 0.

Table A.1: Summary Statistics for the Primary Market Data: Jan. 1, 2018 - Dec. 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	3,076	2.518	1.157	0.232	5.889	1,890	2.474	1.114	0.232	5.461	1,186	2.588	1.219	0.326	5.889
Dummies	L.Post	3,076	0.519	0.500	0	1	1,890	0.522	0.500	0	1	1,186	0.513	0.500	0	1
	IB	3,076	0.614	0.487	0	1	1,890	1	0	1	1	1,186	0	0	0	0
	Treat	3,076	0.414	0.493	0	1	1,890	0.463	0.499	0	1	1,186	0.336	0.472	0	1
Bond Info	Quantity (Billion RMB)	3,076	1.494	2.657	0.00900	43	1,890	1.634	3.280	0.0800	43	1,186	1.271	1.046	0.00900	7.200
	Term	3,076	4.244	1.861	0.917	15	1,890	4.387	2.049	2	15	1,186	4.015	1.487	0.917	15
	Guarantee	3,076	0.114	0.318	0	1	1,890	0.105	0.306	0	1	1,186	0.129	0.335	0	1
	SOE	3,076	0.791	0.406	0	1	1,890	0.863	0.343	0	1	1,186	0.676	0.468	0	1
	Put	3,076	0.323	0.468	0	1	1,890	0.149	0.356	0	1	1,186	0.600	0.490	0	1
	Call	3,076	0.114	0.318	0	1	1,890	0.163	0.369	0	1	1,186	0.0371	0.189	0	1
Issuer Info	Debt Asset Ratio	3,076	63.30	18.11	0	95.59	1,890	63.18	18.66	0	95.38	1,186	63.48	17.20	0	95.59
	Liquidity Ratio	3,076	3.606	54.82	0	2887	1,890	4.392	68.57	0	2887	1,186	2.354	17.31	0	420.6
	Cash Coverage Ratio	3,076	0.531	2.049	-2.571	3.024	1,890	0.448	2.070	-2.571	3.024	1,186	0.664	2.008	-2.571	3.024
	Log Assets	3,045	25.03	1.457	16.09	30.73	1,874	25.04	1.499	16.09	30.73	1,171	25.00	1.388	19.93	29.86
	Log Equity	3,043	23.87	1.276	16.09	29.00	1,872	23.88	1.299	16.09	29.00	1,171	23.87	1.240	19.35	27.71
Market Info	Similar Bond Issuance (Billion RMB)	3,076	5.287	5.757	0.0300	70.50	1,890	5.504	6.462	0.0800	70.50	1,186	4.941	4.386	0.0300	18.32
	CMB Issuance (Billion RMB)	3,076	22.02	37.48	0	259.0	1,890	15.26	23.28	0	129.5	1,186	32.79	50.91	0	259.0
	CGB Issuance (Billion RMB)	3,076	17.00	58.04	0	500.2	1,890	15.73	48.50	0	250.1	1,186	19.02	70.61	0	500.2
Macro Info	Δ GDP	3,050	10.49	3.377	-13.58	20.30	1,874	10.42	3.341	-13.58	20.30	1,176	10.60	3.433	-13.58	20.30
	Δ M2	3,076	8.781	0.243	8.174	9.233	1,890	8.786	0.249	8.174	9.233	1,186	8.772	0.233	8.174	9.233
	IB $\times$ AA+	3,076	0.164	0.370	0	1	1,890	0.267	0.443	0	1	1,186	0	0	0	0
	IB $\times$ AAA	3,076	0.281	0.449	0	1	1,890	0.457	0.498	0	1	1,186	0	0	0	0
	RRRcut $\times$ IB	3,076	0.447	0.497	0	1	1,890	0.728	0.445	0	1	1,186	0	0	0	0
	RRRcut $\times$ AA+	3,076	0.166	0.372	0	1	1,890	0.178	0.383	0	1	1,186	0.147	0.354	0	1
	RRRcut $\times$ AAA	3,076	0.396	0.489	0	1	1,890	0.345	0.475	0	1	1,186	0.476	0.500	0	1
	RRRcut $\times$ IB $\times$ AA+	3,076	0.110	0.312	0	1	1,890	0.178	0.383	0	1	1,186	0	0	0	0
	RRRcut $\times$ IB $\times$ AAA	3,076	0.212	0.409	0	1	1,890	0.345	0.475	0	1	1,186	0	0	0	0

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	1,716	55.79	982	51.96	734	61.89
	Total	3,076	100	1,890	100	1,186	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*	1,060	34.46	-	-	1060	89.38
	- *Medium-term Notes*	1,412	45.90	1,412	74.71	-	-
	Financial Bonds	318	10.34	193	10.21	125	10.54
	Total	3,076	100	1,890	100	1,186	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	3,160.9	68.79	1938.3	62.78	1,222.60	81.09
	- *Enterprise Bonds*	245.9	5.352	244.3	7.913	1.600	0.106
	- *Exchange-traded Corporate Bonds*	1,221	26.57	-	-	1,221	80.98
	- *Medium-term Notes*	1,694	36.87	1,694	54.87	-	-
	Financial Bonds	1,434	31.21	1,149	37.22	285.2	18.91
	Total	4,594.9	100	3087.3	100.00	1,507.80	100.00

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

Table A.2: Robust Heterogeneous Effects on Spreads in the Secondary Market

Variables	(1)	(2)	(3)	(4)
Post × Treat	0.306	0.466***	0.437***	0.245
	(0.195)	(0.153)	(0.154)	(0.207)
IB × Treat	-0.356	-0.356	-0.355	-0.356
	(0.584)	(0.584)	(0.584)	(0.584)
Post × Treat × IB	-0.598***	-0.598***	-0.599***	-0.598***
	(0.171)	(0.171)	(0.171)	(0.171)
Post × Treat × IB × Green	0.159			0.221
	(0.132)			(0.147)
Post × Treat × IB × Xiaowei		-0.222		
		(0.145)		
Post × Treat × IB × Sannong			0.0552	0.238
			(0.208)	(0.233)
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-squared	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 (12), 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.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 × Treat	0.0125	0.101	0.00100	0.166
	(0.164)	(0.177)	(0.162)	(0.182)
Post × Treat	0.828***	0.862***	0.820***	0.875***
	(0.157)	(0.157)	(0.158)	(0.157)
Post × IB	-0.208**	-0.207**	-0.211**	-0.208**
	(0.0946)	(0.0943)	(0.0946)	(0.0942)
Post × Treat × IB	-0.514**	-0.440**	-0.500**	-0.371*
	(0.207)	(0.206)	(0.206)	(0.202)
Post × Treat × IB × Xiaowei	-1.003***			-1.485***
	(0.206)			(0.246)
Post × Treat × IB × Green		-1.030***		-1.209***
		(0.222)		(0.213)
Post × Treat × IB × 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.	1,757	1,757	1,757	1,757
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 (16), with the additional interaction terms of $Post_t \times Treat_i \times IB_i$ 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: 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 × Treat × IB	-0.594***	-0.448*
	(0.156)	(0.260)
IB × Treat	-0.303	-1.652***
	(0.376)	(0.526)
Post × Treat	0.603***	
	(0.139)	
Bond Type × Bond Rating × Date FE	Yes	Yes
Market × Date FE	Yes	Yes
Bond FE	Yes	Yes
Observations	23,248	5,411
Adjusted R-squared	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 tighter event window. The sample is 30 trading days before and after the policy shock. Regression equation is specified by equation (12). Standard errors are two-way clustered at the bond and date levels. ***,** , and * represent statistical significance at 1%, 5% and 10%, respectively.