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# PLEDGEABILITY AND ASSET PRICES: EVIDENCE FROM THE CHINESE CORPORATE BOND MARKETS

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## ABSTRACT

We provide causal evidence for the value of asset pledgeability. Our empirical strategy is based on a unique feature of the Chinese corporate bond markets, where bonds with identical fundamentals are simultaneously traded on two segmented markets with different rules for repo transactions. We utilize a policy shock on December 8, 2014, which rendered a class of AA+ and AA bonds ineligible for repo on one of the two markets. By comparing how bond prices changed across markets and rating classes around this event, we estimate that when the haircut increases from 0 to 100%, the bond yields increase in the range of 39 to 85 bps. These estimates help us infer the magnitude of the shadow cost of capital in China.

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# 1 Introduction

It has long been recognized that asset prices depend not only on fundamental cash flows but also on liquidity factors that are broadly related to the frictions prevalent in modern financial markets (Duffie, 2010). Among these liquidity considerations, asset pledgeability, or the ability of an asset to serve as collateral and help reduce financing costs, has arguably been given the most attention because of its central role in the research of borrowing constraints in macroeconomics and finance (see e.g., Kiyotaki and Moore, 1997; Gromb and Vayanos, 2002).

In a setting where collateral helps reduce the costs of borrowing for financially constrained investors, Gârleanu and Pedersen (2011) show that pledgeable assets carry a convenience yield. We refer to this convenience yield as the *pledgeability premium*. This premium is the product of asset pledgeability, which is inversely related to the haircut that an asset faces, and the per-unit value of pledgeability (or value of pledgeability for short), which is the shadow value for relaxing marginal investors' collateral constraints. The goal of our paper is to offer an empirical estimate for the value of pledgeability.

We focus on bonds, which, besides their involvement in spot transactions, are often used in repurchase agreements, or repos. Repos are essentially collateralized loans—except that repos is exempt from an automatic stay in the event of bankruptcy (Adrian, Begalle, Copeland, and Martin, 2013)—with the assets in transaction serving as the collateral. Lenders often set a *haircut* over the market price of the collateral bond to determine the amount of credit extended; the smaller the haircut, the greater the pledgeability of the bond.

Though the theoretical mechanisms through which pledgeability boosts asset values are relatively clear, it is challenging to measure this effect empirically. Asset pledgeability is endogenous and thus, in general, depends on asset fundamentals, various market frictions, and the interactions between the two.

We overcome this endogeneity issue by exploiting a policy shock on asset pledgeability together with a set of unique institutional features in the Chinese bond markets. Two bond markets co-exist in China: the over-the-counter (OTC) interbank market and the centralized exchange market. While commercial banks can only trade in the interbank market and retail investors only in the exchange market, non-bank financial institutions (NBFIs), which include mutual funds, insurance companies, and securities firms, are active investors in both markets. Our study focuses on dual-listed enterprise bonds, an important category of corporate bonds that are simultaneously traded on both markets. Finally, trading frictions such as lengthy settlement delays cause the two markets to be segmented to a large degree.

The two bond markets also differ significantly in their rules for repos. Interbank repos essentially follow the standard tri-party repo system in the U.S.; key transaction terms, such as collateral, haircut, and repo rate, are negotiated bilaterally. In contrast, the exchange acts as the central clearing counterparty (CCP) for all repo buyers and sellers and unilaterally determines the list of eligible collateral bonds as well as their respective haircuts, which are largely based on bond ratings. The differences in pledgeability and market segmentation imply that the prices of the same bond can be different on the two markets.

Our main empirical strategy is to exploit these cross-market valuation differences for dual-listed bonds. Specifically, for the same bond with simultaneous transactions on the two markets, we define the "exchange premium" as the yield on the interbank market minus that on the exchange market. With NBFIs as common marginal investors who apply the same pricing kernel in the two markets, any (unobservable) fundamentals should affect the pricing of the same bond on the two markets the same way. As a result, the exchange premium isolates the pricing effects of the remaining non-fundamental factors, including cross-market differences in pledgeability and potentially other liquidity factors.

To further isolate the value of pledgeability, we exploit a policy shock that significantly changed the pledgeability for a set of bonds on the exchange market. After hours on December 8, 2014, the exchange suddenly announced that enterprise bonds with ratings below AAA would no longer be accepted as repo collateral; in Section 2 we provide further details of the institutional background for this shock. Particularly relevant to our study, this policy was aimed at the exchange market only; effectively it only changed the pledgeability of bonds rated AA+ and AA on the exchange, while AAA bonds were unaffected and AA− bonds were already ineligible for repo before the policy shock. At the same time, AA+ and AA bonds' haircuts on the interbank market were largely unchanged. This, and the fact that the exchange sets haircuts largely based on ratings before the policy shock, makes the rating-based policy shock a strong instrument for haircut changes, which allows us to identify the value of pledgeability.

One potential concern of our identification strategy is that the policy shock could induce fire sales of the treated bonds on the exchange market, which would reduce their exchange premia. We emphasize two important features regarding our empirical setting that help address this concern. First, this policy only applied to bonds that had not been used as collateral at the time of its announcement. In other words, there was no forced deleveraging pressure for investors who had taken a levered position in the affected bonds, as regulators would like to minimize the policy's impact on market stability. This unique institutional feature makes our policy shock particularly suitable to study the value of pledgeability by limiting any temporary price pressure due to forced fire-sales.

Second, our empirical design is also robust to potential panic selling by retail investors in the exchange market. As shown in the theoretical framework developed in Section 3.2, NBFIs would respond to such behavior from retail investors by adjusting their holdings to restore their Euler equations in both markets. Therefore, the difference in equilibrium prices across the two markets in equilibrium only reflects the value of pledgeability to the common marginal investors.

We show that the treatment group (AA+ and AA bonds) shared a similar trend in exchange premia as the control group (AAA and AA− bonds) before the December 2014 shock. After the policy shock, the raw exchange premia of the treatment group fell, while that of the control group did not change. This pattern suggests that this rating-dependent pledgeability shock adversely affected the exchange market prices of bonds with AA+ and AA ratings only. We highlight that our control group consists of both higher- (AAA) and lower-rated (AA−) bonds, a structure further helps us rule out many alternative fundamental-based explanations: typically, these alternative mechanisms generate asset pricing reactions that are monotonic in asset qualities, which are captured by credit ratings in our setting.

Using the rating-dependent policy shock as an instrument in a two-stage least squares regression, we find that raising the haircut from 0 to 100% leads to a 39 bps (0.39%) increase in the bond yield, which provides an estimate of the value of pledgeability, i.e., the shadow value in relaxing the financial constraints of NBFIs.

While the exchange premia–based estimate helps address the issue of unobservable bond fundamentals, it could still underestimate the value of pledgeability. One leading concern is cross-market arbitrages; despite significant trading frictions, arbitrage forces will prevent the exchange premia of any dual-listed bond from drifting too far from zero, which could potentially bias the estimate of the value of pledgeability downward. The reason is that, in the absence of any arbitrage frictions, the exchange premium will always be zero regardless of haircut changes, thus resulting in an estimate of zero for the value of pledgeability. Second, to the extent that the policy shock triggered a "flight-to-quality" event in the interbank market, such "flight-to-quality" would push up the interbank prices of AAA bonds relative to other bonds and hence lower the exchange premia of AAA bonds following the shock. This economic force could also bias downward the estimate of the value of pledgeability when we use AAA-rated bonds as part of the control group.

We address this concern by providing an alternative IV estimate that likely overstates the price impact of changes in pledgeability; in this way, our two sets of IV estimates together plausibly bound the magnitude of $\lambda$. Specifically, we compare the price changes of the treated bonds against those of the matched-AAA bonds on the exchange market. These matched AAA bonds have similar haircuts and credit spreads in the pre-event sample as those treated AA+/AA bonds, but their pledgeability is not affected by the policy shock. This alternative IV estimate is likely to be upward biased, as these matched AAA bonds might have better unobservable fundamentals relative to the treated bonds, e.g., the regulator has unfavorable private information on AA+/AA bonds. The resulting IV (over)estimate suggests that raising the haircut from 0 to 100% leads to a 85 bps increase of yield, compared to the exchange premia–based estimate of 39 bps. The range for the value of pledgeability provided by our two estimates is admittedly large. We provide some preliminary evidence suggesting that the true value is likely closer to the exchange premia–based estimate of 39 bps, because the negative bias induced by cross-market arbitrage is likely small.

In our framework, the value of pledgeability reflects the shadow value of relaxing financial constraints for NBFIs. Equating shadow value with shadow cost faced by NBFIs, and taking into account that financial constraints may not be always binding, we find that our estimates of $\lambda$ ranging between 39 and 85 bps correspond to a shadow cost of capital at a range of 1.1% to 2.4%. We discuss the economic magnitude in the broad context of international financial market in the literature review.

**Literature review.** Equilibrium asset pricing with financial constraints is an active research field. Gârleanu and Pedersen (2011) consider a general equilibrium model with two assets that have identical cash-flows but may differ in their margins/haircuts, and tie their equilibrium pricing differences (bases) to margin differences modulated by the shadow cost of capital. Their model provides the closest theoretical framework to our empirical study.[1]

There is no doubt that margin constraints or haircuts are endogenously determined by aggregate conditions in financial markets as well as by asset characteristics. Influential theoretical contributions include Fostel and Geanakoplos (2008) and Geanakoplos (2010), in which riskless lending arises endogenously due to heterogeneous beliefs; extensions include Simsek (2013) and He and Xiong (2012), among others. Brunnermeier and Pedersen (2009) relate the haircut of assets to a value-at-risk constraint and highlight the downward spiral in a general equilibrium model with endogenous leverage constraints.

Our paper contributes to the literature that connects pledgeability to asset prices. Related empirical studies include Gorton and Metrick (2012), Copeland, Martin, and Walker (2014), and Krishnamurthy, Nagel, and Orlov (2014), among others, with a focus on the failure of

[1] Early theoretical contributions include Detemple and Murthy (1997) who study the role of the short-sale constraint, which is intrinsically linked to margin requirements or haircuts in equilibrium. Other general equilibrium models with financial constraints include Basak and Cuoco (1998), Gromb and Vayanos (2002), Danielsson, Shin, and Zigrand (2002), He and Krishnamurthy (2013), Chabakauri (2015), and Rampini and Viswanathan (2019). For recent empirical studies on intermediary asset pricing, see Adrian, Etula, and Muir (2014), He, Kelly, and Manela (2017), and He, Khorrami, and Song (2021). More generally, equilibrium asset pricing terms can also be endogenously determined in a framework with over-the-counter search markets (Duffie, Gârleanu, and Pedersen, 2005; He and Milbradt, 2014; Chen, Cui, He, and Milbradt, 2018, among others), of which the Chinese interbank market is one. Based on this framework, Vayanos and Wang (2007) and Vayanos and Weill (2008) study the premia of on-the-run Treasuries as a symptom of the failure of the law of one price. Previous studies have also documented empirically how price dispersion arises in the OTC municipal and corporate bond markets due to dealers' market power (Green, Hollifield, and Schürhoff, 2007a,b), bond characteristics (Harris and Piwowar, 2006), selling pressure (Feldhütter, 2012), and more recently, trading networks (Di Maggio, Kermani, and Song, 2017; Hendershott, Li, Livdan, and Schürhoff, 2020; Li and Schürhoff, 2019).

the law of one price and its connections to margin constraints and liquidity.[2] Utilizing a policy shock that hits different dealers in a heterogenous way, Macchiavelli and Zhou (2021) demonstrate that a dealer's funding liquidity causally affects the liquidity that the dealer provides to the market. Our identification strategy of exploiting price variations across two markets has a similar flavor to theirs.

The value of pledgeability we estimate in the Chinese bond markets, which ranges from 39 to 85 bps, is somewhat higher than those found in other major markets; we take these comparisons with caution since the value of pledgeability depends on the shadow value of relaxing the funding constraint, which can vary over time and across countries. Ashcraft, Gârleanu, and Pedersen (2011) empirically examine the price impact of lowering the haircuts of some eligible mortgage-backed securities by exploring one of the Term Asset-Backed Securities Loan Facility (TALF) programs in March 2009, arguably the worst time during the Great Financial Crisis. Based on market reactions of bonds that were rejected by the program (which might carry some additional information other than pledgeability), they find that an increase in the haircut from 0 to 100% would result in an increase of 28 to 52 bps in bond yields. Pelizzon, Riedel, Simon, and Marti (2019) also find a somewhat smaller estimate—13 to 59 bps decrease in yields for a 100% drop in haircut—by exploiting the haircut reduction resulting from a corporate bond's inclusion into the European Central Bank's eligible list of collateral for its open market operations.[3] Our paper is different because Chinese enterprise bonds are dual listed and our setting has two control groups—one with higher credit quality than the treatment group and another with lower. These features help us identify the causal effect of asset pledgeability on asset prices by ruling out the impact of changes in (unobservable) asset fundamentals that are often correlated with changes in asset pledgeability.

Finally, our paper also contributes to the burgeoning literature on the Chinese bond markets, which includes Fan and Zhang (2007), Ang, Bai, and Zhou (2019), Wang and Xu

[2] Examples include Longstaff (2004) and Lewis, Longstaff, and Petrasek (2021), who document the premium of Treasury securities over agency or corporate bonds that are guaranteed by the US government; Krishnamurthy (2002), who documents the on-the-run Treasury premium; Bai and Collin-Dufresne (2019), Choi, Shachar, and Shin (2019), and Siriwardane (2019), who study the CDS-bond basis which is the pricing difference between a corporate bond and its synthetic replicate (buying Treasury and selling CDS). In a recent study, Ai, Li, Li, and Schlag (2020) examine the link between pledgeability and asset pricing in the US equity market. Zevelev (2021) exploits a constitutional amendment in Texas to identify the impact of collateral service flows on house prices.

[3] We have scaled the estimated effect by Ashcraft et al. (2011) proportionally. For instance, the lower bound effect of rejection by the TALF is estimated to be around 20 bps; but because the TALF rejection essentially raised the bond haircut by 75% (25% to 100%), the effect of a 100% rise in haircut should be around 28 bps. Similarly, we have also scaled the lower and upper bounds of the estimates using the haircut schedule of assets eligible for the use as collateral in Eurosystem market operations in Pelizzon et al. (2019), who find that the average yield reaction to be 11-24 bps for lendable bonds and 30-50 bps for non-lendable bonds.

(2019), Chen, He, and Liu (2020), Geng and Pan (2021), and Ding, Xiong, and Zhang (2022). In a closely related paper, Fang, Wang, and Wu (2021) study the effect of non-conventional monetary policy, i.e., the expansion of the collateral eligibility list from government bonds and AAA corporate bonds to corporate bonds with ratings above AA− for the Medium-term Lending Facility (MLF, a frequently used lending program by People's Bank of China, or PBoC) on June 1, 2018. Because the MLF haircuts of these newly eligible bonds are unobservable, we cannot directly compare their policy-induced price changes to our estimated value of pledgeability.[4]

# 2 Institutional Background

This section provides a brief overview of the key features of the Chinese bond markets that are relevant for our study. For more details on the history of the Chinese bond markets, see Amstad and He (2020).

## 2.1 Chinese Bond Markets and Dual-Listed Enterprise Bonds

Over the past decade, China has taken enormous strides to develop its bond markets as an integral step of financial reforms. Chinese bond market capitalization scaled by GDP rose from 35% in 2008 to almost 100% in 2019; in comparison, the U.S. bond market has remained slightly above 200% of U.S. GDP during the same time period (Appendix Figure A2).

**Enterprise bonds.** There are three major categories of fixed-income securities in the Chinese bond markets based on issuing entities: government bonds, financial bonds, and non-financial corporate bonds.[5] Our paper focuses on enterprise bonds, a type of corporate bond that is mainly issued by non-listed state-owned enterprises (SOEs) and regulated by

[4]Asset pledgeability also matters for the stock market in China, e.g., Bian, Da, He, Lou, Shue, and Zhou (2020) show the role of leveraged margin trading in the 2015 crash of the Chinese stock market. And, complementary to our angle of rating-dependent pledgeability, Liu, Wang, Wei, and Zhong (2019) find that retail investors play a significant role in explaining the pricing wedge between the interbank and exchange markets for the dual-listed bonds. Several papers also look at the implicit government guarantee in the Chinese bond markets. Among them, Liu, Lyu, and Yu (2017) investigate the role of implicit local government guarantees for the above mentioned MCBs; Jin, Wang, and Zhang (2022) study the event of the first bond default by a central SOE in 2015 to estimate the real effects of implicit guarantees; and Huang, Huang, and Shao (2018) are after the same question by looking at financial bonds issued by commercial banks.

[5]This classification follows Amstad and He (2020). Government bonds, which account for 55% of bonds outstanding in 2019, are issued by formal government agencies. Financial bonds (18% of bonds outstanding in 2019) are issued by financial institutions, and corporate bonds (25% of bonds outstanding in 2019) are issued by nonfinancial firms. There is also another widely used classification among practitioners in China, which groups financial bonds and corporate bonds together as "credit bonds," as opposed to "interest rate" bonds, which are government bonds in the classification we use.

the National Development and Reform Commission (NDRC). Enterprise bonds accounted for 25% of total corporate bonds outstanding by 2014 when the policy shock in question occurred.

**Exchange and interbank markets and dual-listed enterprise bonds.** There are two distinct and largely segmented markets that co-exist in contemporary Chinese bond markets: the over-the-counter interbank market and the centralized exchange market. Our study focuses on dual-listed enterprise bonds, which are traded on both the exchange and interbank bond markets.

The interbank market, after its establishment in 1997, was the only market where enterprise bonds were issued and traded. In 2005, to expand the potential investor base, the NDRC granted non-listed SOEs access to the exchange market; consequently about 78% of the enterprise bonds outstanding were dual-listed by the end of 2014 when the policy shock in question took place. However, around that time the interbank market—as opposed to the exchange market where the policy shock in question took place—was still the "home" market for dual-listed enterprise bonds. Almost all enterprise bond issuances were still initially placed in the interbank market; in 2014, 562 out of 568 newly issued dual-listed enterprise bonds were first listed on the interbank market (see Figure IA1 in the Internet Appendix for the depository amount and issuance of dual-listed enterprise bonds by market).

**Default risk.** During our sample period of mid-2014 to mid-2015, the default risk for Chinese enterprise bonds as a whole was negligible, simply because enterprise bonds are issued predominantly by SOEs with either larger size or stronger government guarantee. As we later explain in Section 2.4, this fact implies that it is unlikely that the policy shock on December 8, 2014 was due to the regulator's rising concern about the default risk of enterprise bonds.

Although the first corporate bond default in China, by a publicly traded non-SOE Shanghai Chaori Solar Engergy, took place in March 2014, credit spreads of enterprise bonds in our sample period remained at a level that is similar to that in 2010 when the practice of "rigid payment" was still widely expected in Chinese bond markets (Zhu, 2016). There was no dual-listed enterprise bond default until May 2016, which was almost one year after our sample period, when a non-SOE Inner Mongolia Nailun failed to deliver its interest payment in that month. Across both exchange and interbank markets, the reactions to the first default of dual-listed enterprise bonds were largely muted. It was not until the U.S.-China trade war and Beijing's New Asset Management Rules hit the market in 2018 that default incidents and credit spreads started to climb in a noticeable way (see e.g., Geng and Pan, 2021; J.P. Morgan Asset Management, 2018).[6]

[6]The RMB value of defaulted corporate bonds in China is RMB 1.3, 13.4, 39.5, and 38 billion from 2014

## 2.2 Exchange and Interbank Bond Markets in China

We now explain some institutional details about the two bond markets that are relevant to our study.

**Trading protocols and liquidity.** The Chinese interbank bond market, similar to those in developed economies like the U.S., adopts a quote-driven over-the-counter trading protocol in which the terms of trades are finalized through bilateral bargaining between relevant parties. In contrast, the trading protocol on the exchange market, which resides within the Shanghai and Shenzhen stock exchanges, is facilitated by an order-driven mechanism, with electronic order books aggregating orders from all participants who observe all these orders publicly. Matched trades are settled via China Securities Depository & Clearing Corporation (CSDC), an entity that provides depository and settlement services for the exchange market.

Both bond markets in China are quite active (see, e.g., Figure A1 in the Appendix); they differ in that the interbank market satisfies infrequent but large transaction needs (wholesale) while the exchange accommodates frequent but small trades (retail). This feature is in sharp contrast to the bond markets in the U.S., where the exchange attracts very limited trading in corporate bonds (Biais and Green, 2019).[7]

**Market participants and common institutional investors.** The interbank market mainly serves institutional players, with participants including commercial banks, policy banks, pensions, and NBFIs such as mutual funds, insurance companies, and securities firms. In contrast, the exchange market hosts NBFIs, corporate investors, and high net-worth retail investors with ample investment experience.

We emphasize that NBFIs, a group of sophisticated institutional investors, have access to and are marginal in both markets in China. For instance, almost all securities firms, one key set of NBFI investors, are active in both markets in terms of trading and market making. There are many reasons for them to be active in both markets; an obvious one is their need to participate in the primary market distribution of different bonds in these two markets. We

to 2017; it soared to RMB 127.8 and 147.8 billion in 2018 and 2019. Nevertheless, most of defaults are not with enterprise bonds; during 2018 and 2019 the annualized default rate is only around 0.1% for enterprise bonds while the number is much higher at 0.7% for all other types of corporate bonds. For comparison, the global counterpart during 2008–2017 is 1.8%, according to a 2017 report by Moody's (see Section 6.1 in Amstad and He, 2020). In a recent paper, Li and Ponticelli (2021) study the role of "specialized bankruptcy court," which sheds light on how China is dealing with the recent increase in corporate defaults following a decade-long debt boom.

[7] Appendix Table A1 provides a more detailed comparison of the secondary market liquidity in the two Chinese bond markets and in the U.S. corporate bond market. Market (il)liquidity is comparable between the interbank market and the exchange market in China based on the fraction of bonds that do not trade on a given day. Compared to the U.S. corporate bond market, China's bond markets are slightly less liquid based on non-trading days, but are more liquid in terms of turnovers.

formalize this premise in Section 3.2 which provides a theoretical framework for our study.

By the end of 2014, the aggregate holdings of NBFIs accounted for 76% and 57% of the enterprise bonds deposited on the exchange and interbank markets, respectively. These numbers are quite similar by mid-2014 and mid-2015 (see, e.g., Panel A of Figure IA2 in the Internet Appendix). In contrast, retail investors hold about 0.6% of enterprise bonds on the exchange, while commercial banks hold about 35% on the interbank market.

**Limits to arbitrage.** Despite having identical fundamentals, the two market prices of a dual-listed bond can differ, thanks to market frictions that prevent "textbook" cross-market arbitrages. The most significant friction is settlement delays. Suppose an investor wants to sell some interbank market–acquired bonds on the exchange or use it to do repo on the exchange. To do so, she needs to apply for transfer of custody from the interbank market to the exchange market, which took more than five working days in 2014. A transfer in the opposite direction is slightly faster and took two to three working days. Such delays expose an arbitrageur to significant price risks. Moreover, simultaneously buying and selling a large quantity of the same bond on the two markets is difficult due to market illiquidity.

The limits to arbitrage explains why the prices of the same bond on the two markets may remain distinct. We argue that the differences in pledgeability on the two "repo" markets are a major factor that causes the prices to differ in the first place, which we will explain in more detail in Section 4.2.

## 2.3 Repos on the Exchange and the Interbank Market

As a form of collateralized borrowing with the security serving as collateral, repurchase agreements—or simply repos—are quite active on both the exchange and interbank markets. We now explain different mechanisms of repo transactions on these two markets.

**Repos on the interbank market.** In a repo transaction on the Chinese interbank market, a seller (the borrower) contacts a buyer (the lender), and both parties reach an agreement on the terms of trade based on bilateral bargaining.[8] As explained in Section 2.2, the interbank market is dominated by large institutions with institution-specific funding needs and constraints, and hence each repo contract tends to be highly customized, including the

[8]Two types of repo transactions are available for China's interbank market participants: pledged repo, where bonds are used as a pledge of rights; and outright repo, where bonds are sold to a reverse repo party. Unlike the U.S. where outright repos are more popular, in China, pledged repos account for the majority (94.2% in our one-year sample period) of interbank repo transactions, so that the collateral takers cannot reuse the collateral for another repo transaction. In the context of our paper, if collateral cannot be reused (rehypothecated), this should effectively decrease the supply of collateral and raise the premium earned by pledgeable assets in equilibrium, as shown by the theoretical analysis in Bottazzi, Luque, and Páscoa (2012).

specification of collateral, the repo rate, and the method of delivery. These terms reflect the risks of the underlying securities and that of the counter-party, and large state-owned commercial banks are typically in an advantageous position.

The China Foreign Exchange Trade System (CFETS) reports daily aggregate transaction volume and volume-weighted repo rates for the interbank market, but there is no such aggregate information on haircuts. While lacking access to trade-level repo data on the interbank market, we obtain some proprietary information on average interbank haircuts for enterprise bonds before and after the policy shock in question based on transactions conducted by an anonymous major financial institution in China (see Section 4.1 for details).

**Repos on the exchange market.** For repos on the exchange market, the exchange not only facilitates transactions but also acts as the CCP for all repo buyers and sellers. Unlike the third-party agent in tri-party repos in the U.S., the CCP guarantees that obligations are met to all non-defaulting parties regardless of whether obligations to the CCP have been met or not. This market mechanism is similar to some CCP-based European electronic platforms (see, e.g., Mancini, Ranaldo, and Wrampelmeyer, 2016).

On a daily basis, the CSDC unilaterally sets the collateral pool, i.e., the list of securities eligible as collateral, and their conversion rates ($CR$), which is the borrowed amount quoted as a fraction of the face value of the security. As an example, imagine that the CSDC sets the conversion rates for Treasuries and AAA corporate bonds to be 1 and 0.9, respectively. Then, an investor posting one unit of each bond as collateral, each with face value of 100 RMB, will be able to borrow $190 = 100 \times 1 + 100 \times 0.9$ RMB from the exchange.

Given a bond with face value $FV$ and market price $P$, one can translate its conversion rate $CR$ into the haircut using the following formula:

$$(1 - \text{haircut}) \cdot P = CR \cdot FV \Rightarrow \text{haircut} = 1 - \frac{FV \cdot CR}{P}. \tag{1}$$

The haircut is negatively correlated with conversion rate; a haircut of 100% implies zero pledgeability for that security. Essentially, all eligible securities become completely fungible after adjusting for their respective conversion rates. This feature is necessary for the exchange market, which relies on standardization to function. Even though repo lenders and borrowers have limited information about each other and the actual composition of the collateral pool as the exchange does not publish such information, counterparty risk is negligible due to the exchange's implicit government backing. Finally, the repo rates at various maturities are set by the market via a central limit order book aggregating all bids and asks from repo sellers (borrowers) and buyers (lenders) in continuous double auctions. One-day repo transactions account for about 90% of total exchange market repo transactions.

## 2.4 The Policy Shock in the Exchange Market

To identify the effects of changes in pledgeability on bond pricing, we exploit a policy shock on the exchange market. In a nutshell, after market closing on December 8, 2014, the exchange suspended the repo eligibility of all enterprise bonds rated below AAA. In this section, we describe the background and nature of the policy shock.

**The local government debt problem.** The background of this policy shock is related to the local government debt problem in China (Chen et al., 2020). In 2009, Beijing responded to the 2007/08 global financial crisis with a four-trillion RMB stimulus package, in which local government financing vehicles (LGFVs, which are local SOEs) funded heavy infrastructure investment mainly through loans extended by commercial banks. Three to five years later, the back-to-normal credit policy forced LGFVs to turn to the bond market and to aggressively issue municipal corporate bonds (MCBs), mainly in the form of dual-listed enterprise bonds by that time.[9] As a result, the enterprise bond market became flooded with MCBs; the share of MCB-type enterprise bonds rose from 30% in 2010 to 67% by the end of 2014, and 87% of enterprise bonds that enter our final sample are MCBs (Panel A Table 1).

Increasingly concerned about local government debt problems, the Central Economic Work Conference in 2014, the China's highest-profile annual meeting, convened in Beijing each January to set the national agenda for economic development, added "controlling local government debts" as one of its major agenda items for that year. This prompted many follow-up policies, such as a pilot program started in May 2014 that allowed a number of selected local governments to issue municipal bonds, and on October 2, 2014, the State Council of China released the tone-setting guideline Document No. 43 (hereafter Doc. 43). In a nutshell, Doc. 43 outlined the legal framework of local government debts, aiming to gradually replace MCBs with standard municipal bonds and to reclassify existing MCBs to ones with/without full government support.

**The CSDC and the policy shock.** Under the broad agenda of "reining in local government debt," various layers of Chinese financial regulators, including the CSDC, had been coordinating to support Beijing, even *before* the release of Doc. 43. MCBs were popular on the exchange market, for their low perceived credit risk and relatively high pledgeability, thanks to transparent conversion rates published by the CSDC. Starting from May 2014, the CSDC disqualified a small list of AA+ and AA-rated bonds as collateral for repo transactions on the

[9] An MCB, also known as an Urban Construction Investment Bond or Chengtou Bond, is a perfect examples of the mixture between planning and market in the contemporary Chinese economy. In a strictly legal sense, MCBs are issued by LGFVs which are regular corporations, yet MCBs are viewed by the market as being implicitly backed by the corresponding local governments. As shown in Chen et al. (2020), LGFVs issue MCBs to refinance maturing bank loans and continue ongoing infrastructure projects during 2012–2015, fueling the shadow banking sector in China.

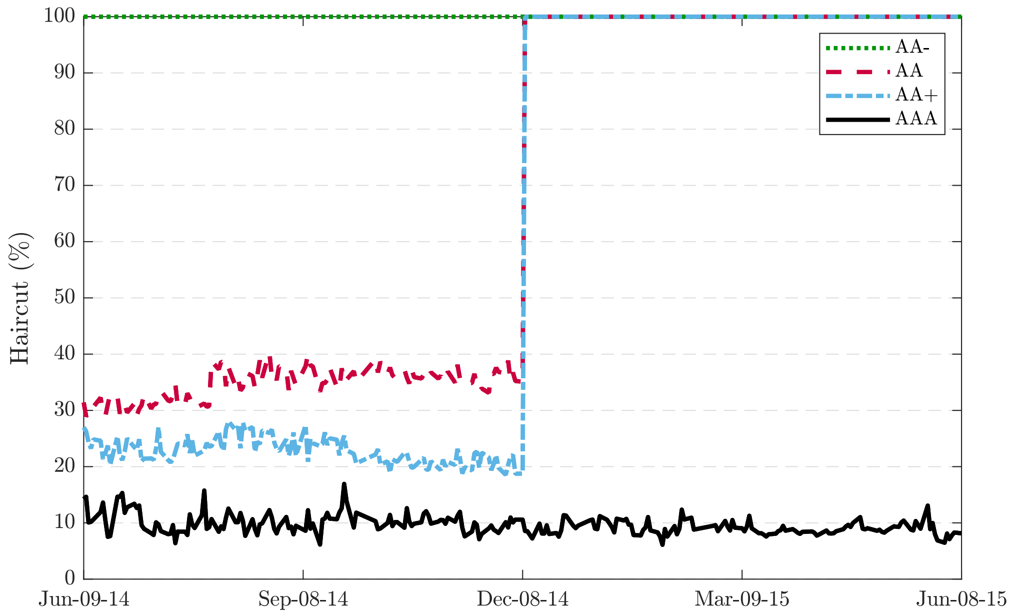


Figure 1: **Average repo haircut on the exchange market.** This figure plots the average daily haircut on the exchange market for dual-listed enterprise bonds in each of the four rating categories. The sample period is from 6/9/2014 to 6/8/2015.

exchange market; see Section 3.1 for details. It is important to note that the CSDC retained great discretion in deciding the exact composition of these blacklists. Not surprisingly, these confined, small-scale, and often idiosyncratic regulatory moves triggered little market-wide response from financial investors; see Section 4.1 for their associated market reactions.

To curb the demand of MCBs in a more effective way, the CSDC decided to slash the conversion rates for all enterprise bonds with ratings below AAA. After hours on December 8, 2014, the CSDC issued "Circular on Relevant Measures for Strengthening Risk Management of Enterprise Bond Repo" to immediately disqualify sub-AAA–rated enterprise bonds from being used as collateral in repo transactions in both the Shanghai and the Shenzhen exchanges. In this document, the CSDC raised concerns about the risk of enterprise bonds that were mainly issued by local governments, echoing the Doc. 43 issued two months earlier by the State Council of China.

As shown in Figure 1, the policy change led to immediate and significant increases in the haircuts for AA+ and AA enterprise bonds on the exchange. In contrast, the average haircut for AAA bonds on the exchange remained steady after the event. Finally, since AA− bonds were already ineligible as repo collateral on the exchange six months before the event, their haircuts were also unaffected by the new policy.

This sudden move by the CSDC, which affected about 80% of enterprise bonds, surprised exchange market investors to a large extent. Widely known as the "Zhong-Zheng-Deng" event among Chinese investors, bond market participants viewed this policy tightening as a "black swan" event, as they had expected a tightening in the competing interbank market instead around that time.[10] We will analyze market reactions in Section 4.1, but as a piece of preliminary supporting evidence, we do not observe any bond rating changes in our sample during the [-1, 0] month window, suggesting that market participants did not "expect" this policy shock that targeted on rating directly.

There is another unique feature of this policy worth emphasizing. In order to minimize the potential negative market impact, regulators drafted the policy change on December 8, 2014 in such a way that it only applied to bonds that had not been used as collateral yet; roughly a third of the outstanding enterprise bonds were pledged as collateral at the time of the policy shock. In other words, there was no immediate deleveraging pressure for investors who had already taken a leveraged position in these affected bonds, though the secondary market spot prices for the affected bonds should go down immediately due to their fully eliminated pledgeability. This makes our policy shock particularly suitable to study the value of pledgeability as it is free from temporary fire-sale pressure due to forced deleveraging. It is worth noting that a more general form of "fire-sale," which reflects certain portfolio rebalancing activities in response to shocks, could still occur. For example, an investor might sell some affected bond holdings given their lower pledgeability, or her bond holdings more broadly if she interprets the policy shock as a signal of weaker fundamentals. The first channel is what this paper tries to capture (see more in Section 3.2). For the second, as we explain in the next section, by exploiting the unique feature of dual-listed bonds, our estimation strategy is not affected by such fundamental shocks.

# 3 Data and Economic Framework

In this section, we describe the data and then lay out our theoretical framework. Guided by this theory, we examine the empirical properties of the exchange premium, which is the price gap for dual-listed enterprise bonds on the exchange and interbank markets.

[10] It is well documented that the local government debt problem is rooted in commercial banks (Bai, Hsieh, and Song, 2016; Chen et al., 2020), which are active only in the interbank market; and recall that almost all enterprise bond issuances were initially placed in the interbank market which was still the "home" market for enterprise bonds (Section 2.1). Indeed, just one week before the policy shock we study, the National Association of Financial Market Institutional Investors (NAFMII, the regulator of the interbank market) issued a notice on December 1, 2014, pressing MCB underwriters to strictly abide by the Doc. 43.

## 3.1 Data and Variable Construction

We obtain enterprise bond characteristics and exchange-market trading data from Wind Information Co. (WIND). Data on interbank market trading are from CFETS, the interbank market's trading platform. Our sample period is from June 9, 2014, to June 8, 2015, a twelve-month window around the event date. During this sample period, our dual-listed enterprise bond sample covers 82.7% of the total trading volume of all the enterprise bonds (78.3% in terms of outstanding notional), or 22.0% of the total volume of all corporate bonds (20.8% in terms of outstanding notional). Table 1 reports the detailed coverage of our sample.

For each bond-day observation, we obtain the conversion rates quoted by the exchange and convert them into haircuts based on Eq. (1). We use the RMB volume-weighted average clean prices to calculate the enterprise bond yields, which are winsorized at 0.5% and 99.5%. The credit spreads of the enterprise bonds are calculated relative to the matched China Development Bank (CDB) bond yields following the procedure of Ang et al. (2019) and Liu et al. (2017).[11]

Bond rating information is from WIND. Rating agencies provide ratings at bond as well as issuer level. Our study focuses on four rating categories: AAA, AA+, AA, and AA−, with the AA− category including AA− and below.[12] Following the industry standard, we take the lowest rating if a bond receives multiple ratings (Amstad and He, 2020). As mentioned in Section 2.4, a small list of AA+- and AA-rated bonds had been disqualified as collateral for repo transactions on the exchange market before the 12/08/2014 policy shock. To the extent that we link ratings to pledgeability, we reclassify these AA+ and AA bonds to be grouped with AA− ratings accordingly. More specifically, on 5/29/2014, the CSDC disqualified a bond's repo eligibility if its *issuer* rating was either below-AA, or with an AA issuer rating but *a negative outlook*, with some degree of discretion determined by the CSDC. In the appendix of this document, the CSDC included a list of four affected enterprise bonds. After that, the CSDC issued four additional lists of affected bonds that were disqualified due to their low issuer ratings. From all five of these lists, a total of 109 enterprise bonds (84.4% of them being MCBs) were disqualified as collateral for repo transactions, even though their bond ratings were AA or above. We hand collected such information based on the detailed CSDC announcements, and adjust bond ratings of these affected bonds to AA− after their first inclusion date. See Appendix A.1 and Appendix Table A2 for details.

[11]The CDB yield curves are commonly used as the risk-free benchmark by the bond market participants in China thanks to its state-backing, non-tax-exempt status (unlike Treasuries), and superior liquidity. We first compute the implied prices of the CDB bonds with matching cash flows, i.e. the NPV of the same cash flows as promised by an enterprise bond discounted at the CDB bonds' zero-coupon rates, and then calculate the matching CDB yields. All of our empirical results are robust to using Treasury yields instead of CDB yields.

[12]Bonds with ratings below AA− are extremely rare in China during our sample period; on the day of the policy shock there was only one bond rated A+ out of the full sample of 1613 enterprise bonds.

We further exclude bonds that i) were issued after the policy event to rule out the possibility that issuers may engage in rating shopping (for AAA ratings); ii) experienced rating changes after the event to reduce the contamination caused by (potentially endogenous) changes in post-event rating grouping; and iii) that had matured before the event date. These three filters affected our sample in a minor way, removing 32, 41, and 4 bond-day observations from 15, 6, and 2 unique bonds, respectively.

As the main empirical object, we construct "exchange premium" as the yield difference for the same bond between the two markets. Specifically, the exchange premium measure, $EXpremium_{ijt}$, is defined as the cross-market difference in the yields for bond $i$ from rating category $j$ on day $t$:

$$EXpremium_{ijt} = yield_{ijt}^{IB} - yield_{ijt}^{EX}, \tag{2}$$

where $j \in \{\text{AAA, AA+, AA, AA}-\}$. A positive exchange premium means the price of a bond is higher on the exchange than on the interbank market.

We compute the exchange premia for all dual-listed enterprise bonds that satisfy the simultaneous trading criterion defined as follows (see Appendix A.2 for more details). On a given day $t$ when there is at least one transaction for a bond on one of the two markets, we use the nearest transaction data from the other market within the time window $[t-2, t]$ to form a pair. We refer to this sample as the "simultaneous trading sample," which contains about 10,000 bond-day observations from 978 unique bonds. The simultaneous trading sample covers 54% of all dual-listed bonds in our sample period (Table 1).[13] The exchange premium for each pair is calculated as the yield on the interbank market minus the exchange market counterpart. In a robustness test, we also repeat our empirical exercises with the smaller sample of observations using the stricter "same-day trading" criterion.

We also conduct analysis on an alternative spread measure, called "spread over matched AAA," which is the difference between the credit spreads of AA+/AA-rated dual-listed enterprise bonds and those of the matched AAA-rated ones but with similar pre-shock haircuts and yields, based on their trading prices on the exchange market (see Section 5.3 for details).

Other market variables from WIND include the ten-year spot yield of CDB bonds, the spread between the one-day Shanghai exchange repo rate and the one-day Shanghai interbank offering rate (SHIBOR), the term spread between ten-year Treasury yield and three-month

[13] Since our observations are at the bond-day-rating level, we treat the same bond with different ratings at two points in time as different bonds for the purpose of reporting the summary statistics in this table. The number of unique dual-listed enterprise bonds is 1,771 and the simultaneous trading sample (978 unique bonds) covers 55.2% of all these dual-listed enterprise bonds. Among all bonds in the simultaneous trading sample, 851 of them are MCBs.

Treasury yield, and aggregate stock market returns.

Table 2 reports the summary statistics for the simultaneous trading sample, including the summary statistics for exchange premia, conversion rates, and haircuts before and after the policy shock (see Table A3 for the detailed definitions of variables). The summary statistics for the same-day trading sample are reported in Internet Appendix Table IA1.

## 3.2 The Economic Framework

Suppose a one-period corporate bond $i$ with unit face value has rating $j$ and random payoff $\widetilde{Y}_{i,t+1}$ at time $t+1$ (maturity). It is traded on two markets indexed by $m \in \{EX, IB\}$, but market segmentation prevents investors from buying this bond on one market and selling it on the other, a point we will come back to shortly. Let $h_{ijt}^m$ and $p_{ijt}^m$ be the haircut per unit of face value and price of the bond in market $m$ at time $t$, respectively. We discuss the possibility of investor-dependent haircuts later in footnote 21.

Consider any marginal investor in market $m$, denoted by $I_m \in \mathbb{I}_m$, where $\mathbb{I}_m$ is the set of all marginal investors in market $m$. The investor chooses optimal consumption and asset holdings while facing a collateral constraint. The Euler equation for this investor reads:[14]

$$p_{ijt}^m = \underbrace{\mathbb{E}_t[\widetilde{M}_{t+1}^{I_m}\widetilde{Y}_{i,t+1}]}_{\text{fundamental value}} + \underbrace{\overbrace{\lambda_t^{I_m}}^{\text{value of pledgeability}} \times \overbrace{(1-h_{ijt}^m)}^{\text{pledgeability units}}}_{\text{pledgeability premium}}. \tag{3}$$

The first term on the right-hand side of Eq. (3) is standard: $\widetilde{M}_{t+1}^{I_m}$ is the pricing kernel for this marginal investor, which is determined by the ratio of marginal utility of consumption between $t+1$ and $t$; together, the first term captures the fundamental value of the bond from the perspective of the investor group $I_m$.

The second term on the right-hand side of Eq. (3), which is related to "specialness" in Duffie (1996), captures the pledgeability premium due to the collateral constraint. It is the product of the value of pledgeability $\lambda_t^{I_m}$ and the bond's degree of pledgeability $1 - h_{ijt}^m$, i.e., the amount financed per unit of face value. The value of pledgeability $\lambda_t^{I_m}$, which represents the shadow value of relaxing the collateral constraint, is the Lagrange multiplier associated with the collateral constraint scaled by the marginal utility of the investor at time $t$.

Several points are worth emphasizing. First, Eq. (3), which is based on a standard optimal portfolio decision, applies to both markets. Our framework hence matches well with Chinese

[14]The investor chooses consumption $c_t$, collateralized borrowing $B_t$ (or riskless saving if $B_t < 0$), and defaultable bond holding $\pi_{ijt}^m$ in the two markets to maximize a time-separable utility, $\mathbb{E}\left[\sum_{t=0}^{\infty}\beta^t u(c_t)\right]$. In each period, she faces a standard budget constraint plus a collateral constraint $B_t \leq \sum_{m\in\{EX,IB\}}(1-h_{ijt}^m)\pi_{ijt}^m$. The first-order condition with respect to $\pi_{ijt}^m$, if the solution is interior, implies Eq. (3).

financial institutions that actively trade in both the exchange and interbank markets and are constantly engaged in asset allocation decisions with various layers of risk management mandates, e.g., exposure to interest rate risk, dollar duration, and value-at-risk.

Second, our theoretical framework allows for multiple marginal investors in each market. As explained in Section 2.2, different investors participate in the two largely segmented bond markets in China. Using the notation from our setting, $\mathbb{I}_{EX} = \{Retail, NBFI\}$, i.e., both wealthy retail investors and NBFIs, including securities firms, mutual funds, and insurance companies, all of whom are sophisticated institutional investors, are marginal in the exchange market; while $\mathbb{I}_{IB} = \{Bank, NBFI\}$, i.e., both commercial banks and NBFIs are marginal in the interbank market. Thus, NBFIs are common marginal investors in both markets. We offer empirical evidence for this point in Internet Appendix IA1 by showing that NBFIs kept positive holdings and actively traded throughout our sample period, i.e., both before and after the 2014 policy shock. From here, we analyze Eq. (3) from the perspective of a representative NBFI investor.

Suppose that the representative NBFI investor has a pricing kernel $\widetilde{M}_{t+1}^{NBFI}$ and a scaled Lagrange multiplier $\lambda_t^{NBFI}$; note that in a standard asset pricing framework both the pricing kernel and Lagrange multiplier are associated with the agent, not assets or markets. For clarity of exposition, in our main empirical analysis, we assume $\lambda_t^{NBFI} = \lambda$ to be a constant within the event window and leave the discussion of time-varying $\lambda_t^{NBFI}$ to Section 5.4.2. Then, Eq. (3) implies that the exchange premium in terms of the price differential for the same bond on the two markets is:

$$p_{ijt}^{EX} - p_{ijt}^{IB} = \lambda \left( h_{ijt}^{IB} - h_{ijt}^{EX} \right), \tag{4}$$

where the asset fundamental component from Eq. (3), $\mathbb{E}_t[\widetilde{M}_{t+1}^{NBFI} \widetilde{Y}_{i,t+1}]$, drops out. We are interested in estimating the scaled Lagrange multiplier $\lambda$. Eq. (4) shows that one can identify $\lambda$ based on how the exchange premium in Eq. (2) changes in the data in response to relative changes in haircuts across the two markets. We will provide further discussions about other economic factors in Section 5.1.

### 3.3 Determinants of Haircuts and Exchange Premia

Before estimating the value of pledgeability, we first use kitchen sink regressions to examine how observed exchange premia and haircuts correlate with various bond- and market-level characteristics in the pre–policy shock period. This exercise has two goals. First, raw empirical patterns are important to inform us about how the two key variables—exchange premia and haircuts—are determined in the data. Second, in light of Eq. (4), we are essentially using exchange-market haircuts to proxy for a bond's pledgeability differential across two markets to infer the value of pledgeability based on the OLS method. As discussed later in Section 5.2.3, which shows the full-sample OLS result, this approach suffers certain endogeneity concerns, e.g., unobservable but endogenous interbank haircuts changes; nevertheless, this exercise provides a benchmark for our IV estimation, which exploits the policy shock as an instrument.

**Exchange haircuts.** We first examine the empirical pattern of exchange-market haricuts, which are inversely related to asset pledgeability. The exchange conversion rates published by the CSDC, which can map one-to-one to haircuts as shown in Eq. (1), are tightly linked to the securities' credit ratings. The CSDC adopted a formula for how the conversion rates were set, which involves the bond's credit rating, market price, and volatility. However, the CSDC also made it clear that the formula was only suggestive; by inserting an opaque term called "discount factor," the CSDC effectively reserved discretion in setting the conversion rate for each bond.

As shown in the Columns (1) and (2) of Table 3, rating dummies explain 90% of the total variation in conversion rates, while a kitchen sink regression—including market prices, volatilities, and other bond/issuer characteristics—only raises the $R^2$ to 91%. There are many reasons why the CSDC relies primarily on credit ratings in setting conversion rates, chief among which are third-party objectiveness in credit risk assessment and poor secondary market liquidity. For our study, the fact that bond haircuts largely depend on credit ratings implies that the policy shock that explicitly targeted AA+ and AA bonds will result in significant changes in exchange haircuts across bonds, i.e, a strong first stage for the policy shock as an IV for the changes of exchange-market haircuts.

**Exchange premia.** Eq. (4) suggests that, with common fundamentals, exchange premia should primarily reflect the differences in pledgeability premia on two markets, after controlling for other nonfundamental factors, e.g., trade size and frequency. As shown in Table 3, in both specifications (haircuts only, Column 3; or including ratings and other potential determinants, Column 4), exchange premia are negatively related to the exchange haircuts with 1% significance level. This is consistent with exchange premia being driven by pledgeability, a premise that forms the basis of our economic framework in Section 3.2.

Column (4) in Table 3 shows that bonds with higher prices, MCBs, shorter maturity, and higher turnover have larger exchange premia before the shock. Importantly, it is reassuring that Column (4) demonstrates that once we include exchange-market haircuts and relevant characteristics variables, ratings no longer possess additional explanatory power relative to the benchmark AAA group. Because we are exploiting a policy shock that directly targets bond ratings, one particular concern would be that our specification misses some "omitted variables" that matter significantly to exchange premia and yet are captured by the categorical rating variables. Column (2) suggests that this is not the case.

# 4 The Policy Shock and Exchange Premia

The policy shock serves as the instrument variable for our paper to estimate the value of pledgeability. To this end, we devote this section to document the market reactions of exchange premia to the policy shock, together with those for other policy events.

## 4.1 Market Reactions to the Policy Shock

We first present evidence on market reactions that support the premise that the policy shock on December 8, 2014, is unexpected. We also compare them to the market reactions to a series of blacklisting announcements and the release of Doc. 43 before the policy shock.

**Market reactions to the policy shock.** What are the reactions from both markets? As a first pass, we examine the average credit spreads for all dual-listed enterprise bonds in four rating categories around the event, across two bond markets. Due to illiquidity, these credit spreads are based on observed transactions which are not necessarily matched with the same bonds; therefore the evidence here should be interpreted with caution. The simultaneous trading sample will be used in Sections 4.2 and 4.3, as well as Section 5 where we conduct our formal IV regression–based empirical analysis.

As shown in Panel A row "Event 12/8" of Table 4, the average credit spreads for AA+ and AA bonds on the exchange market jumped up on the event date by 62 and 38 bps, respectively; both of them are significant at the 1% significance level. This is in sharp contrast to the market reactions on the interbank market where the average credit spreads for AA+ and AA bonds actually *fell* on the event date by 8 and 9 bps. For AAA bonds, on the event date average credit spreads fell in both the exchange and interbank markets by 15 and 24 bps, respectively; credit spreads of AA− bonds rose on both markets by 61 and 24 bps. The exchange market reaction of AA− bonds (61 bps) is large at a first glance. In a relative sense, this is about 20% of AA− bonds' credit spreads, comparable to that of AA bonds (17%) and much smaller than that of AA+ bonds (37%). This market reaction, however, was temporary; in a longer $[-3, 3]$-day window the exchange market reaction of AA− bonds went down to 31 bps. More importantly, in this longer $[-3, 3]$-day window the interbank market reaction caught up (40 bps), suggesting that the market reactions on AA− bonds were likely to be driven by investors' adjusting their perceived fundamental of these bonds.

These market reactions are consistent with the premise that the policy shock hit AA+-

and AA-rated bonds on the exchange market in a particularly hard way. The last two columns highlight these different reactions across the treatment (AA+/AA) and control (AAA/AA−) groups in two bond markets: the relative increase in credit spreads for treated bonds on the exchange market is 55 bps (significant at 1% significance level) larger than that in the interbank market, while the number is 31 bps but insignificant for control bonds.

**Comparison with market reactions to other events before the policy shock.** As mentioned in Section 2.4, before the aggressive move by the CSDC on December 8, 2014, there were two sets of events relevant to our study: the release of Doc. 43 which provided a legal framework for dealing with China's local government debt problem, and the five blacklists in which the CSDC denied certain individual bonds from repo eligibility.

We follow the similar procedure as above to calculate the market reactions from the official release of Doc. 43, which are reported in row "Doc. 43" in Panel A of Table 4. Consistent with the view that Doc. 43 hit the enterprise bond market with an adverse fundamental shock by casting doubt on the implicit guarantee, we find that overall the credit spreads of our dual-listed sample on both markets rose across all rating groups, though none of these changes were statistically significant, except for AAA bonds on the exchange market but of which credit spreads actually fell. The same exercises for the five blacklist announcements are conducted, and the row "Five Blacklists" in Panel A of Table 4 reports overall small and insignificant market reactions on credit spreads.[15]

We emphasize that the exchange premia remained almost unchanged in response to both events. For instance, the last two columns in Panel A of Table 4 reports a small and insignificant one-day reaction of 4 bps (8 bps) for the exchange premia of AA+/AA (AAA/AA−) bonds following the release of Doc. 43. This is in great contrast to the change of exchange premia observed in "Event 12/8," and is crucial to our empirical framework: unlike the 12/8/2014 policy shock that hit the "liquidity" of one market, Doc. 43 largely affected the fundamental of the asset—if there was any—and hence left the exchange premia largely intact.

There are well-grounded reasons for the sharp contrast between the significant market reactions towards the "Event 12/8" policy, which represents a detailed regulatory measure that was laser targeted to one specific market, and those subdued ones on other events. For Doc. 43, as mentioned in Section 2.4, "local government debt" had become the theme of

[15] In this exercise, we exclude bonds that were affected directly by the announcements; for those affected bonds, on the exchange the market reaction is −12 bps (insignificant) for AA+ and 20 (significant at 5% level) bps for AA bonds, consistent with a lower pledgeability premium once blacklisted. It is challenging to calculate the interbank market reactions due to lack of liquidity. Detailed market reactions for each of the five announcements are reported in Internet Appendix Table IA2, and results are similar for a wider event window, e.g., $[-1, 1]$-day, in consideration of potential information leakage.

economic and political agenda in 2014, and therefore Chinese investors might have anticipated the release of Doc. 43. Besides, it is likely that this document did not materially alter the market expectation about the implicit government support for the existing MCBs.[16]

Regarding the lack of market reactions on the five blacklists, we stress that it is a routine job for various bureau-level regulators in China (e.g., the CSDC) to issue small-scale notices here and there;[17] and there is quite a distance from blacklisting individual bonds with inferior issuer ratings, a practice that seems more idiosyncratic, to a sweeping ban of pledgeability for AA+- and AA-rated bonds which is more systematic. Both reasons render the unexpectedness of the policy shock in our study, supported by the sharp market reactions in the data.

**Haircut reactions on the interbank market.** In contrast to the dramatic changes in haircuts on the exchange, there were only relatively small changes in the interbank haircuts during the same period. Based on a sample of repo transactions conducted by an anonymous major financial institution in China, Panel B of Table 4 reports the average haircuts for enterprise bonds on the interbank market during the one-month and six-month windows before and after December 8, 2014. Based on the six-month window that is the same as our estimation window, the average interbank haircuts for the AA+ and AA group were essentially unchanged. The average interbank haircut for the AAA group did rise more, from 8.4% to 13.8%, but this 5.4 percentage-point increase only amounts to a 5.9% reduction in the degree of pledgeability, which was originally $1 - 8.4\% = 91.6\%$. In the one-month window, the tightening of collateralized funding in the interbank market is more evident, consistent with some temporary liquidity effects from the policy shock. For this reason, we will examine the sensitivity of our estimates to the exclusion of the first post-event month. We will discuss these issues in detail in Section 5.2.1.

In addition, the release of Doc. 43 did not cause any reactions of the interbank market haircut. According to the same proprietary data source that provided the data in Panel B Table 4, the average interbank market haircut barely moved across all ratings for the one-month subperiod before and after the Doc. 43: the average haircut of the four ratings (high to low) are 7.73%, 11.36%, 30.81%, and 30.32% for the one-month subperiod before the release of Doc. 43 on October 2, 2014; the numbers are 8.15%, 13.13%, 30.54%, and 31.87%

[16]For the former view, recall that Chinese regulators started the pilot municipal bond program from May 2014 as mentioned Section 2.4. The latter view is supported by that several industry research reports commented at the time about the impact of Doc. 43 and argued that, at least in the short run, the emphasis on stable transition meant that implicit government support for existing MCBs would likely continue. In fact, it took six more years until October 2020 for the first MCB default, i.e., two private placement notes issued by Shenyang Shengjing, to finally take place.

[17]During the six-month pre-event period (6/9/2014–12/8/2014), there were 35 circulars issued by bureau-level (Ting-Ji in Chinese) financial market regulators in China, among which 11 were issued by CSDC. We do not see any significant market reaction for exchange premia on these circular announcement days by the CSDC and results are available upon request.

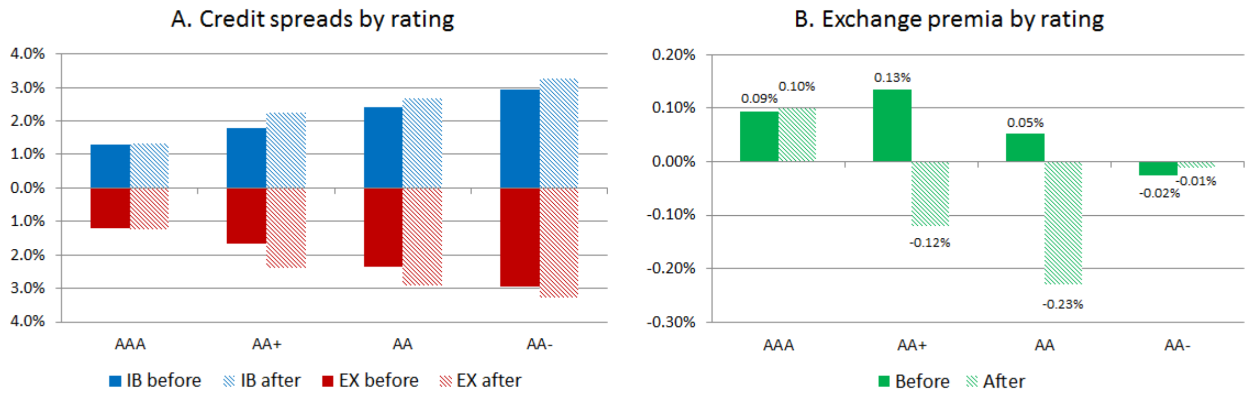


Figure 2: **Exchange premia six months before and after the 12/8/2014 event.** This figure plots the average credit spreads for each of the four rating categories on the interbank market and the exchange market (Panel A) and the average exchange premia (Panel B).

for the one-month subperiod after. Consistent with the market reactions of credit spreads, the lack of interbank haircuts reactions following the release of Doc. 43 suggests that investors either had anticipated the release of Doc. 43, or remained optimistic on the long-standing implicit guarantee at least for existing MCBs. To sum up, Doc. 43 — if anything affecting enterprise bonds — should be a fundamental shock that hit both markets.

## 4.2 Exchange Premia across Ratings

We now examine the changes in exchange premia around the policy shock. Across four ratings, we first plot the average credit spreads on the two markets (Panel A of Figure 2) and the average exchange premia (Panel B of Figure 2) in the six-month window prior to the policy shock. We observe that AAA, AA+, and AA bonds enjoy positive exchange premia of 9 bps, 13 bps, and 5 bps respectively, while there is a negative exchange premium, or in other words exchange discount, of −2 bps for AA− bonds.

The pattern of average exchange premia across ratings is related to how pledgeability differs on the two markets. On the exchange, the pledgeability of a bond is solely determined by its haircut, which largely hinges on bond rating as shown in Section 3.3. In addition, the conversion rates, with a one-to-one relation with haircuts as shown in Eq. (1), set by the CSDC are nondiscriminatory to all exchange investors.

Bond haircuts on the interbank market depend on ratings as well, as shown in Panel B of Table 4. However, even for the same bond, its haircut can vary significantly across counter-parties. Large state-owned banks receive favorable haircuts, while NBFIs and smaller banks often complain about the difficulty of using even AAA bonds as collateral for repo transactions. Thus, although AAA bonds receive an average interbank haircut (about 8%, see Panel B of Table 4) that is lower than their exchange one (about 10%, see Figure 1), AAA bonds are actually more pledgeable on the exchange from the perspective of typical NBFIs. Furthermore, due to tighter financial constraints, NBFIs should value asset pledgeability more than large commercial banks. These factors contribute to a higher valuation for AAA bonds on the exchange relative to that on the interbank market, hence a positive exchange premium. On the other end of the rating spectrum, AA− bonds never had pledgeability on the exchange, while in the interbank market OTC-based bilateral bargaining allows some large players, e.g., state-owned institutions, to borrow against AA− bonds. Panel B of Table 4 shows an average interbank haircut of 36% for AA− bonds for the anonymous institution. This explains a negative exchange premium for AA− bonds of −2 bps with 10% significance level. These observed patterns before the policy shock are consistent with our hypothesis of exchange premia being driven by the bond pledgeability developed in Section 3.2.

Since the policy shock in question sharply alters the rating-haircut relationship as shown in Figure 1, we expect corresponding changes in rating-dependent exchange premia afterwards. Panel B of Figure 2 shows that exchange premia indeed turned negative for bonds with both AA+ and AA ratings, consistent with them losing their pledgeability edge on the exchange. In contrast, exchange premia did not change much for AAA bonds (9 bps before vs. 10 bps after) and rose slightly for AA− bonds (−2 bps before vs. −1 bps after).

To formally examine the significance of the changes in exchange premia post policy shock, we first average daily exchange premia by ratings and then test for the statistical significance of the changes in exchange premia based on Newey-West standard errors with 10 lags. This method allows us to account for both cross-correlational and time-series correlation (see, e.g., Bertrand, Duflo, and Mullainathan, 2004). The changes in exchange premia for AA+ and AA bonds are both significant at 1% level, but insignificant for AAA and AA− bonds.

## 4.3 Dynamic Treatment Effects of the Policy Shock

We now study the dynamics of policy impact in a more formal regression-based approach. Let $D_{jt}$ be the dummy variable for the treatment-group rating categories in the post–policy shock period, i.e.,

$$D_{jt} = \begin{cases} 1, & j \in \{\text{AA+, AA}\} \quad \& \quad t > 12/08/2014 \\ 0, & \text{otherwise} \end{cases} \tag{5}$$

To ensure a sufficient number of observations for each rating group, we divide our sample period into 14 subperiods (with 28 calendar days or 4 weeks in each subperiod), which are indexed by $k$, with $k \in \{-6, \cdots, 0, 1, \cdots, 7\}$. The dummy variable $D^k_{jt}$ equals 1 for the treatment group bonds $j \in \{AA+, AA\}$ in the subperiod $k > 0$ and 0 otherwise; $k = 0$ indicates the subperiod right before the policy shock. We run the following standard regression to obtain the policy's dynamic treatment impact, which helps us assess the key identification assumption of a common trend shared between treatment and (either one of) control groups:

$$EXpremium_{ijt} = \sum_{k=-6}^{7} d_k D_{jt}^k + a_i + b_j + c_t + X_{it}' e + u_{ijt} \quad (6)$$

In Eq. (6), we include both bond fixed effects and rating fixed effects, as a bond's rating may change over time. We add weekly time fixed effects, as daily fixed effects are too stringent given the low frequency of bond trading in our sample; and for this reason, we include daily market-level controls including CDB spot rates, term spreads, the spread between the one-day exchange repo rate and interbank lending rate, and stock market returns. Besides, because the policy hit the exchange during the after hours on Monday (Dec. 8, 2014), we define the weekly fixed effects based on "event week," i.e., a seven-day interval from Tuesday to the following Monday. Four bond-level time-varying controls, i.e., time-to-maturity, turnover, price, and volatility, are also included.

Figure 3 shows the point estimate, $d_k$, of each subperiod and the associated 95% confidence interval by normalizing the coefficient immediately before the event date to zero (i.e., $d_0 = 0$). As Panel A of Figure 3 shows, the average exchange premia for the treated AA+/AA and control AAA/AA− bonds share a common trend before the policy shock. The diff-in-diff coefficients before the event are insignificantly different from the one immediately before the event. After the event, exchange premia for the treated group become significantly lower relative to the control group. Consistent with Figure 2, the gap ranges between −16 to −36 bps and remains significant half a year after.

We repeat the same exercise for two different control groups separately, i.e., excluding either AAA or AA− bonds. We find quantitatively similar results as reported in Panels B and C of Figure 3. Both panels with low- and high-rating control groups show insignificant pre-event trends, suggesting that the common trend assumption largely holds in our study.

We stress that Figure 3 rules out many alternative mechanisms in which the policy change represents some aggregate fundamental shock, to which the treatment and control groups differ in their sensitivities. The implied responses under those mechanisms tend to be monotonic in ratings, which are not what the data show: relative to the middle-rating treatment group, Figure 3 shows that exchange premia of AA− and/or AAA bonds dropped in response to the policy shock.[18]

[18] Figure A3 in Appendix also shows the raw time series of average exchange premia without any control for three rating groups: AAA, AA+/AA, and AA−, with a qualitatively similar pattern: the treatment shares a

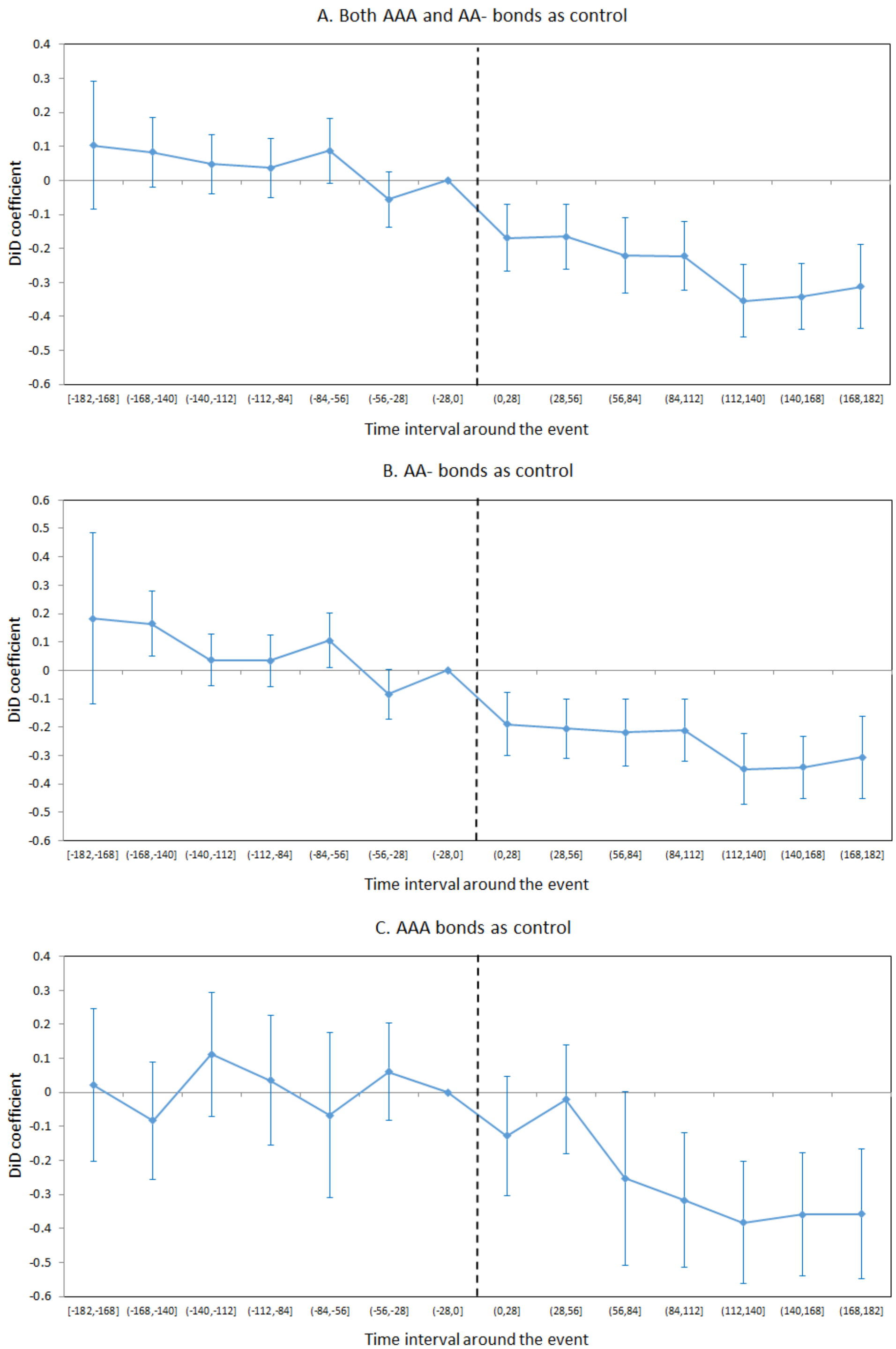


Figure 3: **Diff-in-diff estimation of exchange premia.** This figure plots the estimated coefficients $\hat{d}_k$ along with their confidence intervals calculated from heteroscedasticity-robust standard errors in the diff-in-diff specification of Eq. (6). The point estimate immediately before the event date is normalized to zero (hence a zero standard error). The dotted line indicates the event on 12/8/2014. The sample is from 6/9/2014 to 6/8/2015, which is divided into fourteen 28-day subperiods. The event-week fixed effects are included where Tuesday to the following Monday is defined as one week. Panel A is for the control group combining both AAA and AA− bonds, and panel B (C) is for the control group with only AA− (AAA) bonds.

# 5 Estimating the Value of Pledgeability

We present the standard 2SLS estimation procedure in this section. After revisiting the theoretical framework, we explain the empirical design. We then estimate the value of pledgeability based on two different methods, both of which use the policy shock as an instrument for asset pledgeability changes.

## 5.1 Economic Framework Revisited and Research Design

In the economic framework that we lay out in Section 3.2, the NBFIs' Euler equation (3) implies that the exchange premium satisfies Eq. (4), which is reproduced here:

$$p_{ijt}^{EX} - p_{ijt}^{IB} = \lambda \left( h_{ijt}^{IB} - h_{ijt}^{EX} \right).$$

We aim to estimate $\lambda$ which captures the funding constraint faced by the common marginal NBFI investors.

A couple of points are noteworthy before we proceed to estimation. First, in deriving the key Eq. (4), we have been assuming that market segmentation completely prevents investors including the NBFIs from arbitraging away the exchange premium. In Section 2.2, we have discussed in detail the significant arbitrage frictions—in particular the long settlement delays in the process of transferring custody across the two markets. Nonetheless, at least in theory, arbitrage forces tend to bring the exchange premium inside certain arbitrage bound, which could affect our estimation. We discuss the potential implication in Section 5.2.4.

Second, we stress the significance of NBFIs as common marginal investors for our study. They help make our empirical design robust to the presence of non-common investors, including retail investors in the exchange market and commercial banks in the interbank market, and their reactions to the policy shock, regardless of whether they are fundamental-driven or not.

To see this, suppose that retail investors were previously less informed about the risks of AA-rated enterprise bonds than the institutional investors and were awakened by the policy shock. This could lead them to revise downward their beliefs on AA bonds and sell them. In response to a depressed price in the exchange market, NBFIs will start buying the affected bonds in this market. Such purchases, if significant enough, could change the NBFIs' pricing

similar trend with both the higher and lower rating groups before the event; treated AA+/AA bonds fell while control groups rose in response to the policy shock; and three groups return to a similar trend again afterwards. The advantage of the regression-based approach is that the added fixed effects and controls not only absorb the aggregate trend but also address the concern of changing bond characteristics before and after the event. For robustness, we present an alternative version of Figure 3 and Figure A3 based on the sampling frequency of 14 days, which are shown in Figure IA4 and Figure IA5 in the Internet Appendix.

kernel that applies to both markets,[19] which could lead them to sell their AA holdings in the interbank market at the same time. The NBFIs would keep adjusting their holdings until their Euler equations are restored on both markets. As a result, it is easy to see from Eq. (4) that the reactions of the retail investors would not have affected the exchange premium either before or after the policy shock.

The remainder of this section carries out two empirical approaches to estimate the value of pledgeability based on Eq. (4). As the main result of this paper, the first strategy exploits the exchange premium of simultaneously traded bonds. In addition, to address the potential downward bias of exchange-premium-based estimators due to cross-market arbitrage, we consider another diff-in-diff estimation using nontreated AAA enterprise bonds with matched pre-event characteristics as controls. Because AAA-matched estimates are likely upward biased under almost all plausible mechanisms that could contaminate the identification, the two sets of estimates together provide a range for the magnitude of the value of pledgeability in the context of Chinese corporate bond markets.

## 5.2 Pledgeability and Asset Prices: Exchange Premia

In this section, we estimate the shadow cost of capital using exchange premia, based on a standard 2SLS estimation procedure.

### 5.2.1 2SLS Estimation Procedure

The key equation (4) lays the foundation for us to empirically estimate the value of pledgeability $\lambda$, and we have explained that Eq. (4) is robust to market reactions of non-common investors, i.e., retail investors in the exchange market and banks in the interbank market, to the policy shock. Nevertheless, there could be additional factors besides changes in pledgeability that affect bond pricing in each market, such as market liquidity. While the simple model above does not consider these factors, we summarize them in reduced form by adding a residual term $\mu_{ijt}^{m}$ to the Euler equation (3). The exchange premium in Eq. (4) then becomes:

$$p_{ijt}^{EX} - p_{ijt}^{IB} = \lambda \left( h_{ijt}^{IB} - h_{ijt}^{EX} \right) + \mu_{ijt}^{EX} - \mu_{ijt}^{IB}. \tag{7}$$

We make two additional assumptions for estimating $\lambda$ from Eq. (7). First, we assume

[19]The NBFIs' scaled Lagrange multiplier $\lambda_t$ could change as well, a concern we address later in Section 5.4.2. However, any equilibrium effects of such portfolio rebalancing are likely to be quite small, since retail investors only held 0.6% of enterprise bonds on the exchange market by 2014, compared to 18% for securities firms. Also, in this example we are implicitly assuming that NBFIs are buying when retail investors are selling on the exchange market; the logic is the same if NBFIs are also selling.

that $\mu^m_{ijt}$, which captures non-pledgeability-related liquidity effects, satisfies:

$$\mu^m_{ijt} = \mu_{ijt} + \mu^m_i + \mu^m_j + \mu^m_t + \epsilon^m_{ijt}, \tag{8}$$

where $\epsilon^m_{ijt}$ are i.i.d. across bond, rating, and time. The assumption in Eq. (8) rules out rating-time variations in the residuals that differ across the two markets. One mechanism that potentially violates this assumption is a market-specific "flight-to-quality" effect, in which the policy shock might trigger the purchase of high-quality AAA bonds in the two markets to a different degree. We provide a thorough discussion regarding the issue of market-specific "flight-to-AAA" in Section 5.2.4. Another potential concern is that retail investors may panic and sell in the exchange.[20] As discussed in Section 3.2, this concern is addressed by having NBFIs as common marginal investors.

Next, since we do not directly observe the haircuts on the interbank market, we follow in a similar spirit as Eq. (8) and assume that the interbank haircuts satisfy:[21]

$$h^{IB}_{ijt} = h^{IB}_i + h^{IB}_j + h^{IB}_t, \tag{9}$$

that is, any time-variation in haircuts on the interbank market is common across bonds with different ratings. Consistent with this assumption, the interbank haircuts of enterprise bonds in the four rating groups appear to have largely experienced a parallel shift in their haircuts after the policy shock (Panel B of Table 4). Although the average interbank haircuts for AAA bonds rose relatively more than the other rating categories, especially in the first month after the policy shock, the economic magnitude of the difference is relatively small.[22] Nevertheless, we connect this rise of interbank AAA haircuts to potential "flight-to-quality" effect in Section 5.2.4, and explain why this contributes to a potential downward bias of our estimate $\hat{\lambda}$.

Denoting $\Delta\mu_u \equiv \mu^{EX}_u - \mu^{IB}_u$, where $u \in \{i, j, t\}$, the price differential can be expressed as:

$$p^{EX}_{ijt} - p^{IB}_{ijt} = \underbrace{-\lambda \cdot h^{EX}_{ijt}}_{\text{identifies } \lambda} + \underbrace{\left(\lambda \cdot h^{IB}_i + \Delta\mu_i\right)}_{\alpha_i\text{: bond fixed effect}} + \underbrace{\left(\lambda \cdot h^{IB}_j + \Delta\mu_j\right)}_{\alpha_j\text{: rating fixed effect}} + \underbrace{\left(\lambda \cdot h^{IB}_t + \Delta\mu_t\right)}_{\alpha_t\text{: time fixed effect}}. \tag{10}$$

[20] As mentioned in Section 2.4, the new CSDC policy did not force investors to delever; it still allowed them to roll over all existing repos on the exchange. Hence our empirical setting should be free from the textbook version of "fire sales" of AA/AA+ bonds.

[21] Given the over-the-counter nature of the interbank market, the interbank haircut could be investor-specific. Because we focus on NBFIs only, our setting assumes that NBFIs as a group receive similar haircuts in the interbank market.

[22] Recall that Eq. (4) shows that the degree of pledgeability depends on $1 - h$, which captures the funding available per unit of bond. Thus, if we want to gauge the *relative* change in pledgeability, we should normalize the change in haircuts by $1 - h$, i.e., $(h_{post} - h_{pre})/(1 - h_{pre})$. Thus, an increase in AAA haircut from 8.38% to 13.76% is a 5.9% reduction in pledgeability.

In other words, the value of pledgeability, $\lambda$, can be identified from the responses of exchange premia to the rating-time dependent haircuts on the exchange market by a standard 2SLS regression. More specifically, recall that for each bond $i$ with rating $j$, we construct its exchange premium $EXpremium_{ijt}$ on some trading day $t$, in Eq. (2), and $D_{jt}$ as the dummy variable for the treatment group in the post–policy shock period in Eq. (5). To use $D_{jt}$ as an instrument to estimate the impact of changes in haircuts on the exchange premium, we estimate the first stage as following:

$$haircut_{ijt} = \beta\, D_{jt} + \rho_i + \kappa_j + \eta_t + X_{it}'\gamma + v_{ijt}. \tag{11}$$

The second stage of the 2SLS is:

$$EXpremium_{ijt} = \delta\, \widehat{haircut}_{ijt} + \alpha_i + \alpha_j + \alpha_t + X_{it}'\theta + \xi_{ijt}, \tag{12}$$

where $\widehat{haircut}_{ijt}$ are the first-stage fitted values for exchange market haircuts. The coefficient of interest is $\delta$, which equals the negative Lagrange multiplier $-\lambda$ in Eq. (10).

As in Eq. (6), the regression includes bond fixed effects, rating fixed effects, weekly time fixed effects, and other relevant controls; see the discussion after Eq. (6) in Section 4.3. Effectively, the 2SLS identifies the value of pledgeability $\lambda$ through a diff-in-diff approach. It compares the average change in the exchange premium for the treated bonds after the policy shock against the average change for the control group; and this relative difference in the average change of exchange premium is then scaled by the average change in the exchange haircut for the treated bonds to determine $\delta = -\lambda$.[23]

### 5.2.2 IV Estimation Results: Exchange Premia

Table 5 reports the results of IV estimation following the procedure outlined in Section 3.2, based on different samples. Overall, the coefficient estimates are statistically significant across different samples and specifications, although the economic magnitude varies somewhat depending on the control group.

For ease of exposition, exchange premia as well as the estimated coefficients in the first stage are quoted in percentage, while explanatory variables are quoted in raw values. For the full sample, we report the results based on two different specifications, one with bond fixed effects and other bond- and market-level controls (Column 2), and the other without (Column 1); while for other subsamples we only report the results with all control variables.

[23] More formally, the estimated $\hat{\delta}$ in the second-stage 2SLS regression is equivalent to the haircut change–adjusted pricing effect of the policy shock in a reduced-form diff-in-diff regression, i.e., replace time-varying dummies $D_{jt}^k$ with $D_{jt}$ in Eq. (6), and then scale the coefficient of $D_{jt}$ by the first-stage coefficient in the 2SLS regression (see, e.g., Pischke, 2018).

The standard errors in parentheses are clustered by week.[24]

The first stage, which regresses exchange haircuts on the policy shock dummies and other controls as in Eq. (11), is quite strong across various samples. This result is expected given the sharp dependence of bond-level haircuts on credit ratings (see Table 3) and the nature of the policy shock, which specifically targeted at ratings.

In the second stage, Columns (1) and (2) report the estimation results based on the full simultaneous trading sample, without and with other control variables. Both columns report the same estimated $\hat{\lambda} = 0.39$, implying that an increase in the haircut from 0 to 100% would raise the bond yields on the exchange by 39 bps; recall that we are always concerned with the estimated $\hat{\lambda}$, which is $-\hat{\delta}$ reported in Table 5.

Column (3) reports the result with the subsample that excludes AAA bonds, i.e., using only AA− bonds as the control group, while Column (4) reports the result with the subsample excluding AA− bonds, i.e., using only AAA bonds as the control group. As emphasized in Section 4.3, a unique feature of our empirical setting is that the control group consists of both higher- and lower-rating bonds relative to the treated group. We find these two subsamples yield different estimates for $\hat{\lambda}$, but only slightly. Column (3), which uses only AA− bonds as control, produces a similar estimated $\hat{\lambda}$ compared to the full sample (0.40 vs. 0.39). The magnitude of $\hat{\lambda}$ in Column (4), which uses only AAA bonds as control, is a bit smaller (0.33), and as we explain shortly this difference is likely due to a standard "flight-to-quality" effect.

Finally, Column (5) is the subsample excluding AA bonds (i.e., using only AA+ bonds as the treated group), while Column (6) excludes AA+ bonds (i.e., using only AA bonds as the treated group). It is informative to compare their implied estimates as their corresponding first-stage results (Panel A of Table 5) show that the AA+ groups have experienced a greater haircut shock (75%) than the AA group (64%). However, we obtain essentially the same estimation of $\hat{\lambda}$ across these two subsamples (0.38 and 0.40) as well as the full sample (0.39), suggesting not only the robustness of our result but also a potential linear relation between the pledgeability premium and haircut (as our theoretical framework has imposed in Eq. 3).

### 5.2.3 Robustness and Other Tests

**Robustness tests** Table 6 presents the results of several robustness checks of our IV estimations based on the 2SLS procedures, with Panel A (B) reporting the first (second) stage results. Column (1) uses the MCB subsample only; the estimate is slightly smaller ($\hat{\lambda} = 0.34$)

[24]The clustered standard error estimator is consistent as the number of clusters increases (Angrist and Pischke, 2008) and a simple rule-of-thumb is to have more than 50 clusters (Cameron and Miller, 2015). Meanwhile, for two-way clustering, the number of clusters should be counted independently for two dimensions (Cameron, Gelbach, and Miller, 2011). The small number of bond ratings in our exercise makes the two-way clustered standard error less applicable.

but within the one-standard-error band of the estimate in the full sample. Since our policy shock was part of the broader government agenda to "rein in local government debt," one might be concerned that the shock also represents a fundamental shock, especially to MCBs, which are the bonds issued by LGFVs. However, the fact that we obtain similar estimates for the value of pledgeability based on the full and MCB sample shows the robustness of our empirical design to such concerns.

Column (2) uses the subsample with long-maturity bonds, which are defined as those with time-to-maturity above median as of the day of trade, and reports a greater second-stage estimate ($\hat{\lambda} = 0.46$) than the full sample does, consistent with He and Milbradt (2014) and Chen et al. (2018)'s finding that long-term bonds with worse endogenous secondary market liquidity are more sensitive to their pledgeability.

Column (3) uses the subsample without the first post-event month; this addresses the concern of potential temporary selling pressure, temporary tightening of interbank collateralized funding resulting from the policy shock, or temporary changes in settlement delays.[25] However, as we have stressed in the last paragraph of Section 2.4, the policy drafted by the CSDC was designed to forestall fire sales of AA/AA+ bonds, which had already been in a levered position. Consistent with this policy intention, we find a slightly larger effect ($\hat{\lambda} = 0.43$) by excluding the first post-event month.

Columns (4) and (5) are based on slightly modified versions of 2SLS. In Column (4), we apply the two-stage weighted least squares (2SWLS) method in both stages with the weight being the inverse of the number of observations of each bond. The resulting estimate of $\hat{\lambda} = 0.41$ is similar to that estimated using the 2SLS method.

Column (5), which we dub as "Continuous," uses $D_{jt} \times (1 - haircut_{ij}^{pre})$ as our instrument variable, as opposed to the treatment-rating-post-policy dummy $D_{jt}$ defined in Eq. (5). Here, $haircut_{ij}^{pre}$ is the average haircut for bond $i$ rating $j$ before the policy shock, which essentially captures (potentially) endogenous within-rating haircut variations. This continuous version of instrument variable, which produces an estimate of 0.34, is used in Macchiavelli and Zhou (2021) and shares a similar spirit to the Bartik instrument (Goldsmith-Pinkham, Sorkin, and Swift, 2020).

We prefer our dummy instrument as it does not rely on endogenous within-rating haircut variations, which could potentially cause identification issues. In fact, the "Continuous" 2SLS method is close to a standard OLS method that delivers $\hat{\lambda}_{OLS} = 0.37$ (Table IA3 in the Internet Appendix; the OLS method uses within-bond time-varying haircuts further

[25]One potential concern is that the length of settlement delays could have changed for the treatment group following the policy shock. For example, it is possible that transfer of despository across markets might take longer due to an influx of transfer requests immediately after the policy shock. but the transfer process is likely to revert back to normal shortly afterwards.

for identification). Relative to 2SLS, both methods produce a somewhat lower estimate, which is potentially driven by unobservable interbank haircuts.[26] To see this, following a deteriorating credit quality of some dual-listed bond in any given day, the exchange would adjust its haircut $h_{ijt}^{EX}$ upward. The bond's interbank haircut $h_{ijt}^{IB}$, which we do not observe, should also rise in response. As a result, the observed exchange haircut change tends to be greater than the actual change of $h_{ijt}^{IB} - h_{ijt}^{EX}$, which determines exchange premia according to Eq. (4). The OLS regression that ignores the response in the interbank market haircuts then leads to an under-bias for $\hat{\lambda}$. Our method, which only relies on rating-level haircut changes as opposed to within-rating bond-level variations, largely avoids this concern thanks to the interbank haircut information as reported in Panel B in Table 4. There, we observe almost zero rating-level interbank haircut changes post the policy shock, except AAA-rating with the caveat of flight-to-quality effect that will be discussed in Section 5.2.4.

**Secondary market liquidity.** Does the shock on pledgeability affect an asset's secondary market liquidity? Chen et al. (2018) argue that this is the case. Under that mechanism, reduced pledgeability raises the opportunity costs of holding an illiquid asset, which in turn raises its liquidity premium; and our empirical methodology estimates the total value of pledgeability.[27] Our setting of dual-listed enterprise bonds again provides an ideal setting to test this theoretical prediction. One can compare how the liquidity of the treated bonds changes differentially on the two markets while the fundamentals are exactly the same.

Due to data limitation issues, we cannot construct commonly used liquidity measures such as market-specific turnover or bid-ask spreads; we instead measure the cross-market difference in liquidity by computing the difference in daily price ranges, which captures price volatilities, across two markets.[28] With the same fundamental, the excess price volatility in one market versus the other can arguably be attributed to difference in liquidity. As reported in Table 7, following the policy shock the daily price ranges of the treated bonds rose relative

[26] This result is consistent with Column (4) in Table 3, which uses an OLS method and produces an even lower OLS coefficient based on the pre-policy subsample.

[27] Empirically, controlling for the rating-level turnover by market leads to a similar but slightly lower (0.008) $\hat{\lambda}$ estimate; see Table IA4 and Table IA5 in the Internet Appendix. This is consistent with Chen et al. (2018), who suggest that controlling for bond/rating-level liquidity measures may lead to underestimation of $\hat{\lambda}$ due to over-controlling.

[28] While the total amount outstanding is available, we do not observe the quantity of a given bond that is registered in a specific market; this makes cross-market turnover comparison less reliable. With that said, we find that the relative turnover decrease between the exchange and interbank markets is larger for treated bonds after the policy shock (Table IA6 in the Internet Appendix). For bid-ask spreads, they are not available on the interbank market; it is also infeasible to estimate the effective spreads based on Roll (1984) due to limited transactions. In the Internet Appendix IA2, we also repeat the analysis for the same-day trading sample and under different methodologies to clean outliers. The findings are quantitatively similar. Lastly, the Internet Appendix Figure IA7 plots time series of RMB value of enterprise bonds and Treasury bonds in custody for the interbank and exchange markets.

to the control group, suggesting a deteriorating exchange market liquidity relative to that of the interbank market. This is consistent with the prediction of Chen et al. (2018). The result based on the full sample (Column 2) implies that if the haircut increased from 0 to 100%, the daily price range would have gone up by 0.41%, or 29% of a standard deviation of an individual bond's daily exchange price range.

#### 5.2.4 Discussions on Potential Biases

**Flight-to-quality effect: Exchange or interbank?** A smaller estimated $\hat{\lambda}$ (about a difference of 6 bps) with AAA bonds as the control is likely due to a "flight-to-quality" effect—upon the policy shock, it is plausible that institutional investors started increasing the holdings of AAA bonds on both markets. As we explain below, given the unique institutional structure in China, the "flight-to-quality" effect is likely to be stronger on the interbank market. Consequently, the exchange premium of AAA bonds would decline after the event as the interbank prices of AAA bonds rose relative to their exchange counterparts. This would bias the estimate of $\lambda \, (= -\delta)$ downward, as suggested by Table 5.

What drove a stronger "flight-to-quality" effect in the interbank market in this episode? First of all, recall that the policy shock still allowed investors to continue rolling over existing repos on the exchange market and thus did not directly force investors to delever those affected AA and AA+ bonds, which limited the temporary selling pressure of AA/AA+ bonds on the exchange market. Second, the exchange market is more "retail" oriented while the interbank market is a "wholesale" market. When financial institutions scrambled for liquidity following the policy shock, they tended to turn to the interbank market to cover any large-scale liquidity shortages.

In fact, this might be the underlying force that drove up the AAA bonds' interbank haircuts documented in Panel B of Table 4. While we do not have detailed enterprise bond holding data for NBFIs in the two markets, we are able to obtain data on the enterprise bond holdings from an anonymous institutional investor around the policy shock. Their average daily holdings of AAA enterprise bonds on the interbank market increased by 61.6% from the month before to the month after the policy shock, while the increase was only 16.8% on the exchange. These statistics are consistent with our interpretation of the stronger "flight-to-quality" effect in the interbank market.

**Cross-market arbitrage: Implication on $\lambda$ estimation.** Suppose that investors face a fixed transaction cost of $C > 0$ to transfer bonds across two markets (for simplicity, we assume the same cost for cross-market transfers in either direction); $C$ takes into account all potential illiquidity costs and time delays as mentioned in Section 2.2. That is to say, NBFIs have the option of spending $C$ to enhance the pledgeability of a bond by transferring it to one of the markets.

Recall that the value of pledgeability $\lambda$, which is a deep structural parameter linked to the NBFIs' Lagrange multiplier, captures the pricing difference of two bonds with identical fundamentals—one with full pleadgeability while the other with none. Our theoretical framework in Section 3.2 has so far assumed that $C = \infty$, as investors cannot enhance the pledgeability of the one with zero pledgeability, i.e., an AA+/AA bond on the exchange post the policy shock. In essence, to estimate $\lambda$, we take advantage of the dual-listing feature of the Chinese bond markets that helps us isolate asset fundamental factors, but ignores the option of enhancing pledgeability (at some cost).

As mentioned toward the end of Section 3.2, we rely on the key equation (4) for our empirical design. When $C$ is finite, costly arbitrage across two markets essentially places a bound on the absolute value of exchange premia. We hence need to modify Eq. (4) to respect the arbitrage bound:

$$\underbrace{p_{ijt}^{EX} - p_{ijt}^{IB}}_{\text{exchange premia}} = \max\left[\min\left[\underbrace{\lambda\left(h_{ijt}^{IB} - h_{ijt}^{EX}\right)}_{\text{Eq. (4), wedge in pledgeability premia}}, C\right], -C\right]. \tag{13}$$

As a result, the equilibrium exchange premia after taking arbitrage into account differs from the wedge in pledgeability premia across two markets. Since we are ultimately interested in the value of pledgeability $\lambda$, as opposed to the equilibrium exchange premia $p_{ijt}^{EX} - p_{ijt}^{IB}$, this introduces biases to our exchange premia–based estimator $\hat{\lambda}$.

One can formally show that the exchange premium–based estimation tends to produce an underestimate of $\lambda$ due to the binding constraints in Eq. (13); see Internet Appendix IA3 for the proof. The arbitrage force squeezes the equilibrium price wedge, which then only partially reflects $\lambda$. Intuitively, the option to enhance pledgeability, as well as the possibility to do so in the future, tends to counter the negative shock to exchange haircuts, and market prices should reflect this option. To the extreme of $C = 0$, investors can avoid the exchange policy shock perfectly by exercising the costless option; we should observe $p_{ijt}^{EX} - p_{ijt}^{IB} = 0$ always and hence $\hat{\lambda} = 0$. To the other extreme of $C = \infty$, the option of enhancing is always out of the money, and Eq. (4) holds always yielding an unbiased $\hat{\lambda}$. In Section 2.2, we have discussed the significant frictions of cross-market arbitrages, particularly the settlement delays. Though it is beyond the scope of this paper to estimate the effective arbitrage cost $C$ that these frictions imply, we have some empirical evidence suggesting that $C$ is indeed large, which explains the negative bias of the exchange premia–based estimate of $\hat{\lambda}$ is likely small.[29]

[29]Exchange premia of large magnitudes occur relatively frequently in our sample, with 12% of our sample having absolute exchange premia exceeding 50 bps, which is consistent with the presence of significant arbitrage costs. One way to quantify these arbitrage costs is through back-testing the cross-market arbitrage

## 5.3 Pledgeability and Asset Prices: Matched-AAA Bonds

This section proposes a method to partially address the potential downward-bias problem in the exchange premium–based approach. Recall that the unexpected policy shock hit the exchange market by only disqualifying AA/AA+ enterprise bonds' pledgeability without affecting AAA bonds. We hence construct the pricing wedges of AA+ and AA enterprise bonds over "similar" AAA enterprise bonds using their yields on the exchange market only.

### 5.3.1 Premia over Matched-AAA Exchange Bonds

The question is how to choose "similar" exchange AAA bonds. For each treated enterprise bond, we match it with exchange-traded AAA enterprise bonds with similar pre-event haircut and credit spreads. Note, this "matching" approach, which shares the same spirit as Hand, Holthausen, and Leftwich (1992) and Bao, O'Hara, and Zhou (2018), is widely used in the literature on the implications of ratings on bond pricing.

Under the framework established in Section 5.2, $h^{EX}_{\text{treated},t} - h^{EX}_{\text{matched-AAA},t} = 0$ for $t \leq$ 12/8/2014, while after the policy shock $h^{EX}_{\text{treated},t} - h^{EX}_{\text{matched-AAA},t}$ increases. Hence one can express the matched-AAA premium as:

$$p^{EX}_{\text{treated},t} - p^{EX}_{\text{matched-AAA},t} = \underbrace{\lambda\left(h^{EX}_{\text{matched-AAA},t} - h^{EX}_{\text{treated},t}\right)}_{\text{identifies }\lambda} + \underbrace{\mathbb{E}_t\left[\widetilde{M}^{NBFI}_{t+1}\left(\widetilde{Y}_{\text{treated},t+1} - \widetilde{Y}_{\text{matched-AAA},t+1}\right)\right]}_{\text{fundamental residual: 0 if matched well}} + \underbrace{\mu^{EX}_{\text{treated},t} - \mu^{EX}_{\text{matched-AAA},t}}_{\text{liquidity residual}}. \tag{14}$$

In Eq. (14), the first righthand term identifies $\lambda$, which is the focus of our study. The second righthand term, the "fundamental residual," captures the fundamental difference between the matched-bond-pair; if the "matching" is perfect, this term should be exactly zero, or more precisely, we only need the difference to stay constant. The final term "liquidity residual" captures the liquidity differential between the treated and control bonds, which could be

strategy. We find that when the trading threshold for the exchange premium is 50 bps, the realized annualized Sharpe ratio is only 1.04 and 0.56 in the pre- and post-policy sample, respectively, once the effects of settlement delays and market liquidity are taken into account. We also note that the effects of cross-market arbitrage should be taken into account if researchers are interested in estimating the predicted change of exchange premium $p^{EX}_{ijt} - p^{IB}_{ijt}$ given an exogenous change of exchange haircuts, which is different from the value of pledgeability that we are estimating. Our arbitrage strategy is to buy RMB 10 million of the bond on the interbank market (based on the typical minimum trade size in this market) whenever the exchange premium of a dual-listed bond is above a pre-specified trading threshold (say 50 bps); we then sell the bond as quickly as possible on the exchange, subject to the settlement delay for change of depository (five working days) and a restriction on the pace of selling (the amount of selling is capped at 20% of the daily volume). A similar strategy in the opposite direction is implemented when the exchange premium is sufficiently negative. See Internet Appendix Figure IA8 for details.

affected by the policy shock. Since "matching" is never ideal, both the second and third terms might be correlated with the policy shock.

Since our first exchange-premium approach in Section 5.2 has provided a lower bound for $\hat{\lambda}$, we aim to design the above "matched-AAA" approach to deliver an upper bound, or overestimation, of $\hat{\lambda}$. That is to say, we are more tolerant of potential mechanisms that produce a positive correlation between the terms in the second line of Eq. (14) and the policy-induced change in exchange haircuts in the first line.

Indeed, all plausible economic mechanisms in this context that could contaminate our estimate in the "matched-AAA" approach seem to satisfy this "positive correlation" condition. Recall that the policy shock represents a negative shock to pledgeability; all three of the following leading endogeneity concerns generate a negative shock to the second line in Eq. (14):

1. The CSDC has some private information about the deteriorating quality of AA+/AA bonds, and hence releases liquidity-tightening rules on these bonds. The market views the policy shock as the negative signal of the treated AA+/AA bonds, leading to a negative shock to the "fundamental residual" term.
2. The matched AAA bonds with better fundamentals have a smaller beta than those of treated AA/AA+ bonds, so that the "fundamental residual" term has a positive beta. Because the liquidity-tightening policy shock is likely to represent a negative aggregate market shock, this again implies a negative shock to the "fundamental residual" term.
3. The policy shock represents a liquidity-tightening event, and the resulting flight-to-liquidity effect raises the prices of matched AAA bonds, perhaps due to better uncontrolled fundamentals, i.e., beyond the observable controls we add in the regressions. This effect also leads to a negative shock to the "liquidity residual" term.

### 5.3.2 IV Estimation Results: Matched-AAA Premium

We match each bond-day observation of AA+/AA bonds on the exchange market with AAA bond-day observations that have the same haircut and credit spread during the pre-event window. Our matching procedure, which is detailed in Appendix A.3, results in very similar pre-event haircuts and credit spreads for the treatment group (AA+ and AA) and the matched AAA benchmarks. Figure 4 shows the differences in haircuts and credit spreads of the bonds in the treatment and matched groups. Before the event date, the average haircuts are 13.7% and 13.5% for treatment and control bonds, respectively; the average credit spreads are 1.30% and 1.25% for treatment and control bonds. After the policy shock the haircuts and credit spreads of these two groups diverge, as expected.

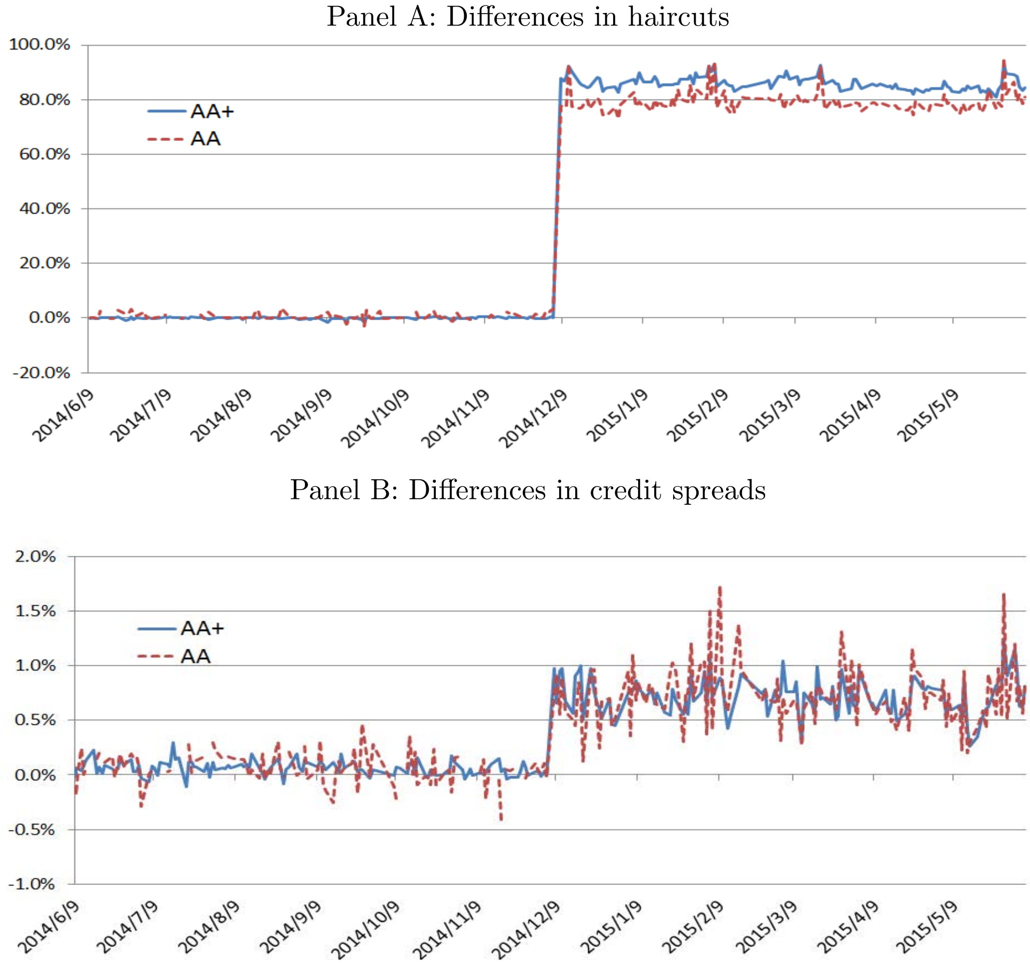


Figure 4: **Differences in haircuts and exchange credit spreads between the AA+/AA and matched AAA bonds.** This figure plots differences in AA+/AA dual-listed enterprise bonds' haircut and exchange market credit spread with respect to matched AAA bonds. Panels A and B plot the differences in haircut and credit spread for AA+/AA bonds with matched AAA bonds, respectively. The matching variables include the pre-event exchange market credit spread and haircut with the details in Appendix A.3. The sample period is 6/9/2014 to 6/8/2015.

We follow the same two-stage IV estimation method laid out in Section 5.2.1, but replace the exchange premium with the difference between a treatment bond's exchange yield and the average yields of all matched exchange AAA bonds on the same day of trade. Table 8 reports the results.[30] The first-stage is reported in Panel A and confirms that the policy shock is a strong instrument variable. The estimated coefficients of the second-stage regressions

[30]To be consistent with the definition of exchange premium and the interpretation of the economic magnitude, the dependent variable is defined as the yields of matched AAA enterprise bonds minus those of AA+/AA enterprise bonds. And, since our sample includes only treated AA/AA+ bonds (and their premia over the AAA benchmarks), we do not include the weekly time fixed effects as our treatment dummy only reflects the time series variation coming from before and after the event.

are consistent with our conjecture (Panel B of Table 8): a 100% increase in the haircut of AA+/AA bonds translates to a 85 bps decrease in the pledgeability premium, the effect of which is larger than the estimate of 39 bps from the exchange-premia approach (Column 2 of Table 5).

Overall, our IV estimation provides a lower bound of 39 bps and an upper bound of 85 bps on bond yields when the haircut increases from 0 to 100%. Taking the two numbers together, the average impact on credit spread for a 100% increase in the haircut is around 62 bp, which translates to a 3.29% price change for an average dual-listed enterprise bond as we will discuss with more details in the next section.

## 5.4 Discussions on Estimated $\hat{\lambda}$

This section examines two further questions: What is the economic magnitude of the estimated $\hat{\lambda}$? And what if the Lagrange multiplier $\lambda$ of the representative marginal investor is time-varying?

### 5.4.1 Economic Magnitude of $\lambda$

To examine the economic significance of the value of pledgeability $\lambda$, we first translate the impact of changes in the haircut on bond yield to dollar terms. Consider a bond with a face value of 100 RMB. The average enterprise bond in our sample has a coupon rate of 6.81% and a maturity of 7.33 years. The yield to maturity is 6.46%. When the haircut increases from 0 to 100%, the yield to maturity would increase by 39 bps based on the exchange premium estimate, and the price would drop from 106.5 to 104.3 RMB, which is 2.2 RMB or 2.1%. Based on the estimate of premia over matched AAA bonds, the yield increase would be 85 bps, and the price drop would be 4.8 RMB or 4.5%.

Second, in practice, the marginal NBFI investor is not always financially constrained; as modeled in Chen et al. (2018), agents are financially constrained only when hit by liquidity shocks. We hence extend the formula in Eq. (3) to take into account the probability of liquidity shocks:

$$\text{Pledgeability premium} = \underbrace{\text{Freq. of liq. shocks} \times \text{Shadow cost of capital}}_{\text{value of pledgeability, } \lambda} \times (1 - \text{haircut}).$$

The pledgeability premium will be higher when the marginal investor is more frequently in a liquidity-constrained state, and/or when she faces a higher shadow cost of capital in the constrained state. The shadow cost of capital can be measured by the gap between the interest-rate spread of collateralized and uncollateralized financing—that is, a form of

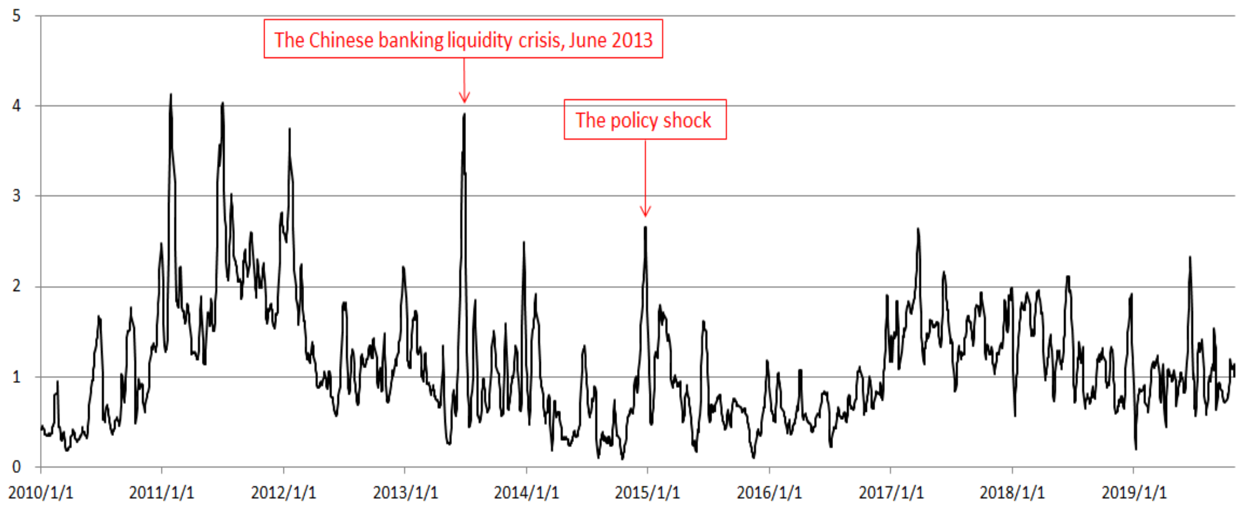


Figure 5: **Spread between the interbank market repo rate and the CDB bond yield.** This figure plots the daily spread in percentage between the one-month interbank market repo rate for all financial institutions and the CDB bond yield calculated from CDB bonds with one-month maturity. Two events, the CDSC policy shock on 12/8/2014 studied by this paper and the Chinese banking liquidity crisis during June 2013 analyzed in Hachem and Song (2021), are indicated. The sample period is from 1/1/2010 to 10/31/2019.

financing risk premium (n.b., uncollateralized financing is default adjusted as in, for example, Gilchrist and Zakrajsek, 2012). Finally, the premium is higher for assets with smaller haircuts.

Through the lens of the formula above, we can infer the shadow cost of capital for NBFIs in the exchange market. Before the policy shock, about 35% of the enterprise bonds on the exchange were used as repo collateral on a typical day. If we interpret this number as the frequency of a typical bond investor being liquidity constrained,[31] then the value of pledgeability estimates of 39 to 85 bps, which are for a bond with a 0% haircut, imply a shadow cost of capital of 1.1% to 2.4% per annum.

Finally, to put into perspective our estimate of the value of pledgeability and shadow cost of capital during the historical episode around the end of 2014, we plot the time series of the spread between the interbank market repo rate for all financial institutions and the risk-free CDB yield in Figure 5; this spread is a widely used indicator of funding constraints in the Chinese bond markets. Consistent with the policy shock tightening the funding constraints faced by financial institutions, the spread did spike up on the day of the policy shock as indicated in Figure 5. In the longer sample, we also see other periods, e.g., the June 2013

[31] This interpretation is consistent with the notion of "liquidity shocks" being idiosyncratic, such as in the framework of Chen et al. (2018). One can also take a more "aggregate" perspective and gauge the frequency of liquidity shock based on the time-serious evolution of the repo-CDB spread shown in Figure 5. If one interprets liquidity events as those with a repo-CDB spread above the three-sigma cut-off, then the annual frequency is about 40%, similar to our estimate of 35% above.

Chinese banking liquidity crisis indicated in the figure, with even higher repo spreads. The value of pledgeability is likely to be higher during these crisis episodes.

#### 5.4.2 Time-Varying $\lambda_t$

We have so far assumed $\lambda_t = \lambda$ as in Eq. (4). Nevertheless, in light of the discussion toward the end of Section 3.2, it is plausible that the Lagrange multiplier with respect to the collateral constraint of our representative NBFIs spiked after the policy shock, given the noticeable negative market reactions following the unexpected move by the CSDC. More specifically, $\lambda_t$ was likely to rise in response to the policy shock, i.e., $\lambda_{pre} < \lambda_{post}$, where $\lambda_{pre}$ is the average Lagrange multiplier before the shock and $\lambda_{post}$ is that after.

As we show in the Internet Appendix IA4, our inferences remain unchanged, as long as we focus on $\lambda_{post}$—our two approaches deliver an underestimate of $\lambda_{post}$ (39 bps) and an overestimate of $\lambda_{post}$ (85 bps), respectively. The first part is intuitive; after all, our exchange premia–based procedure in Section 5.2 produces some weighted average of $\lambda_{pre}$ and $\lambda_{post}$, hence an underestimate of $\lambda_{post}$. For the potential upward bias based on the second method using matched-AAA bonds as benchmark, Internet Appendix IA4 shows that the estimated $\hat{\lambda}$ not only reflects the effect of elevated haircuts of treated AA+/AA bonds, but also the rising $\lambda_t$, both as a result of the policy shock. That is to say, our empirical methodologies and their resulting estimations are robust to a rising $\lambda_t$ following the shock, to the extent that one is interested in the higher post-shock Lagrange multiplier $\lambda_{post}$.

## 6 Conclusion

The equilibrium price of an asset not only depends on its fundamental but also its pledgeability. The Chinese corporate bond markets provide an ideal laboratory to study the effect of pledgeability empirically given that some bonds with identical fundamentals are simultaneously traded in two parallel markets—the centralized exchange market and the decentralized OTC interbank market. The differences in pledgeability lead to identical corporate bonds having different prices on the two markets. By exploiting a policy shock that dramatically reduced the pledgeability of bonds rated below AAA and above AA− on the exchange market, we are able to establish a causal effect of asset pledgeability on prices. Estimates based on instrumental variables imply that a 100% increase in the haircut increases credit spreads by 39–85 bps.

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Table 1: Sample coverage

This table reports the sample coverage by rating. Panel A presents the number of bonds for the dual-listed enterprise bond sample, the simultaneous trading sample, and the simultaneous trading sample with MCB only. Panel B presents the dual-listed enterprise bond sample coverage over all enterprise bonds. Panel C presents the enterprise bond sample coverage over all corporate bonds. Sample coverage measures in Panels B and C include number of bonds, notional RMB value, number of nonzero trading days, and RMB trading volume.

Panel A: Dual-listed sample and simultaneous-trading sample

| | All | AAA | AA+ | AA | AA− |
|---|---|---|---|---|---|
| $N_{dual-listed}$ | 1912 | 234 | 578 | 981 | 119 |
| $N_{simultaneous}$ | 1028 | 83 | 318 | 536 | 91 |
| $N^{mcb}_{simultaneous}$ | 894 | 49 | 279 | 490 | 76 |

Panel B: Dual-listed sample relative to all enterprise bonds

| | All | AAA | AA+ | AA | AA− |
|---|---|---|---|---|---|
| Number of bonds | 81.7% | 60.5% | 82.5% | 87.8% | 88.1% |
| Notional value | 78.3% | 59.2% | 83.6% | 88.5% | 90.1% |
| Days with trades | 92.1% | 83.3% | 92.2% | 93.0% | 97.2% |
| RMB trading volume | 82.7% | 55.1% | 78.8% | 90.9% | 90.6% |

Panel C: Enterprise bonds relative to all corporate bonds

| | All | AAA | AA+ | AA | AA− |
|---|---|---|---|---|---|
| Number of bonds | 28.0% | 21.6% | 38.8% | 48.8% | 5.5% |
| Notional value | 26.5% | 18.8% | 37.6% | 56.4% | 5.5% |
| Days with trades | 41.5% | 25.5% | 53.0% | 57.9% | 19.7% |
| RMB trading volume | 26.7% | 13.1% | 29.8% | 66.8% | 4.6% |

Table 2: Summary statistics

This table reports the summary statistics of the simultaneous trading sample from 6/9/2014 to 6/8/2015. The table presents number of observations, the mean, the standard deviation, the 10th percentile, the median, and the 90th percentile. Panel A presents the summary statistics of key variables. Panel B presents the summary statistics of exchange premia by rating. Panel C presents the summary statistics of haircuts by rating.

Panel A: All variables

| | N | Mean | STD | P10 | Median | P90 |
|---|---|---|---|---|---|---|
| EX premium | 10235 | -0.04 | 0.48 | -0.63 | -0.02 | 0.50 |
| EX $\text{premium}_{pre}$ | 5069 | 0.07 | 0.40 | -0.39 | 0.04 | 0.55 |
| EX $\text{premium}_{post}$ | 5166 | -0.15 | 0.53 | -0.76 | -0.12 | 0.42 |
| Haircut | 10235 | 68.64 | 38.01 | 15.77 | 100.00 | 100.00 |
| $\text{Haircut}_{pre}$ | 5069 | 42.32 | 32.60 | 8.12 | 30.90 | 100.00 |
| $\text{Haircut}_{post}$ | 5166 | 94.48 | 21.74 | 100.00 | 100.00 | 100.00 |
| Conversion | 10235 | 33.24 | 40.37 | 0.00 | 0.00 | 88.00 |
| $\text{Conversion}_{pre}$ | 5069 | 61.22 | 34.79 | 0.00 | 73.00 | 97.00 |
| $\text{Conversion}_{post}$ | 5166 | 5.79 | 22.81 | 0.00 | 0.00 | 0.00 |
| IB spread | 10235 | 2.41 | 0.79 | 1.42 | 2.44 | 3.40 |
| EX spread | 10235 | 2.45 | 0.86 | 1.34 | 2.51 | 3.48 |
| Matched spread | 9940 | 0.55 | 0.68 | -0.15 | 0.47 | 1.38 |
| Matched $\text{spread}_{pre}$ | 2227 | 0.06 | 0.16 | -0.13 | 0.04 | 0.27 |
| Matched $\text{spread}_{post}$ | 7713 | 0.69 | 0.71 | -0.16 | 0.70 | 1.49 |
| Matched $\text{spread}_{AA+}$ | 7570 | 0.54 | 0.67 | -0.14 | 0.46 | 1.37 |
| Matched $\text{spread}_{AA}$ | 2370 | 0.56 | 0.71 | -0.16 | 0.48 | 1.43 |
| $\Delta P^{high-low}$ | 10235 | 0.44 | 1.44 | -0.21 | 0.00 | 1.83 |
| Maturity | 10235 | 5.10 | 1.61 | 2.97 | 5.26 | 6.72 |
| Turnover | 10235 | 0.08 | 0.08 | 0.02 | 0.05 | 0.17 |
| Market price | 10235 | 104.97 | 5.76 | 100.36 | 105.36 | 110.72 |
| Volatility | 10235 | 0.02 | 0.02 | 0.00 | 0.01 | 0.04 |
| $\text{CDB}_{spot}$ | 10235 | 0.04 | 0.01 | 0.04 | 0.04 | 0.05 |
| Term spread | 10235 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 |
| GC001−SHIBOR | 10235 | 0.02 | 0.04 | 0.00 | 0.01 | 0.06 |
| $\text{Ret}_{stock}$ | 10235 | 0.00 | 0.02 | -0.01 | 0.00 | 0.02 |

Panel B: Exchange premia by rating (%)

| | N | Mean | STD | P10 | Median | P90 |
|---|---|---|---|---|---|---|
| AAA | 477 | 0.10 | 0.37 | -0.37 | 0.03 | 0.59 |
| AA+ | 3077 | 0.01 | 0.48 | -0.55 | 0.01 | 0.55 |
| AA | 5162 | -0.09 | 0.50 | -0.71 | -0.05 | 0.47 |
| AA− | 1519 | -0.02 | 0.45 | -0.49 | -0.01 | 0.47 |

Panel C: Haircuts by rating (%)

| | N | Mean | STD | P10 | Median | P90 |
|---|---|---|---|---|---|---|
| AAA | 477 | 11.26 | 10.03 | 5.48 | 6.81 | 26.28 |
| AA+ | 3077 | 62.32 | 40.58 | 7.44 | 100.00 | 100.00 |
| AA | 5162 | 68.49 | 35.46 | 29.81 | 100.00 | 100.00 |
| AA− | 1519 | 100.00 | 0.00 | 100.00 | 100.00 | 100.00 |

Table 3: Determinants of conversion rates and exchange premia

This table reports the regression results of dual-listed enterprise bonds' exchange market conversion rates (Columns 1 and 2) and exchange premia (Columns 3 and 4) on rating dummies and control variables. Age is the number of years for the issuer's first bond issuance; Nbond is the number of bonds issued by the issuer; OTR is a dummy variable for on-the-run bond of the issuer. The sample period is 6/9/2014 to 12/8/2014. Heteroscedasticity-consistent standard errors clustered by week are reported in parentheses. The symbols *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively. The standard error for AA− in Column (1) is undefined because the conversion rates of AA− bonds are always zero.

| | Conversion rates | | Exchange premia | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Haircut | | | -0.22*** | -0.27*** |
| | | | (0.03) | (0.05) |
| $\text{Dummy}_{AAA}$ | 89.40*** | -40.76 | | |
| | (1.35) | (25.23) | | |
| $\text{Dummy}_{AA+}$ | 79.40*** | -49.10* | | -0.00 |
| | (1.06) | (25.54) | | (0.05) |
| $\text{Dummy}_{AA}$ | 66.92*** | -60.20** | | -0.04 |
| | (0.72) | (25.29) | | (0.05) |
| $\text{Dummy}_{AA-}$ | 0.00 | -124.94*** | | 0.04 |
| | (−) | (24.76) | | (0.08) |
| Market price | | 0.95*** | | 0.02*** |
| | | (0.20) | | (0.00) |
| Volatility | | -20.36 | | -0.10 |
| | | (23.80) | | (0.89) |
| MCB | | -3.29** | | 0.10** |
| | | (1.39) | | (0.04) |
| Age | | 0.19 | | -0.02* |
| | | (0.36) | | (0.01) |
| Nbond | | -0.34*** | | 0.01** |
| | | (0.11) | | (0.00) |
| OTR | | -1.72** | | 0.03 |
| | | (0.83) | | (0.02) |
| Maturity | | 1.66*** | | -0.03*** |
| | | (0.32) | | (0.01) |
| Turnover | | -1.97 | | 0.34*** |
| | | (4.22) | | (0.11) |
| Size | | 4.11*** | | 0.01 |
| | | (0.73) | | (0.02) |
| Leverage | | -16.24*** | | -0.09 |
| | | (3.56) | | (0.07) |
| Issuance | | 1.40* | | 0.01 |
| | | (0.74) | | (0.01) |
| $\text{CDB}_{spot}$ | | 291.43*** | | 7.08 |
| | | (96.20) | | (4.36) |
| Term spread | | 539.71* | | -22.55* |
| | | (273.02) | | (12.39) |
| GC001−SHIBOR | | -7.47 | | -0.22 |
| | | (5.80) | | (0.19) |
| $\text{Ret}_{stock}$ | | -5.23 | | -2.52* |
| | | (33.92) | | (1.27) |
| R-square | 0.90 | 0.91 | 0.03 | 0.11 |
| N | 5069 | 5069 | 5069 | 5069 |

Table 4: Market reactions to the policy shock and other events

This table reports the average market reactions to the policy shock and other events. The average one-day post-announcement changes in credit spreads are reported in Panel A. Average haircuts of an anonymous major financial institution on the interbank market six/one months prior to and after the policy shock are reported in Panel B. The policy shock was on 12/8/2014, the release of Doc. 43 was on 10/2/2014, and the five announcements were made on 5/29/2014, 6/27/2014, 8/1/2014, 9/5/2014, and 11/3/2014, respectively. Due to the lack of trades on 9/30/2014 before the National Holiday (10/1/2014–10/7/2014), trades in the two-day window before the holiday are used to calculate the pre–Doc. 43 credit spreads. The post-pre credit spread difference between the interbank and the exchange markets for treatment and control groups is presented in the last two columns and estimated in a regression on $post_t \times \mathbb{1}_{IB}$ that includes the $post_t$ dummy, the interbank market indicator $\mathbb{1}_{IB}$, and $rating_j \times post_t$ fixed effects. Heteroscedasticity-robust standard errors are reported in parentheses. The symbols *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: Market reactions by market and rating (bps)

| | EX | | | | IB | | | | IB−EX | |
|---|---|---|---|---|---|---|---|---|---|---|
| | AAA | AA+ | AA | AA− | AAA | AA+ | AA | AA− | AA+ & AA | AAA & AA− |
| Policy Shock | -14.69 | 61.61*** | 37.64*** | 60.52*** | -24.33 | -7.97 | -9.12 | 23.87 | -55.31*** | -31.23 |
| | (17.40) | (12.10) | (13.47) | (18.99) | (32.26) | (13.39) | (8.20) | (21.49) | (11.96) | (24.37) |
| Doc. 43 | -17.97* | 5.58 | 6.73 | 1.46 | 17.86 | 11.23 | 7.66 | -11.29 | 4.24 | 8.49 |
| | (10.51) | (9.07) | (12.25) | (11.75) | (19.33) | (12.35) | (9.46) | (23.93) | (10.99) | (17.98) |
| Five Blacklists | -0.41 | 3.27 | 4.55 | 8.21 | -4.42 | 8.23 | 4.86 | -19.15 | 1.75 | -11.19 |
| | (7.35) | (4.57) | (5.05) | (8.67) | (11.58) | (6.51) | (3.60) | (23.75) | (4.89) | (12.16) |

Panel B: Haircuts on the interbank market (%)

| Sample period | AAA | AA+ | AA | AA− |
|---|---|---|---|---|
| 06/09/14–12/08/14 | 8.38 | 12.93 | 32.03 | 35.66 |
| | (0.56) | (0.96) | (1.53) | (7.01) |
| 12/09/14–06/08/15 | 13.76 | 14.38 | 31.23 | 37.20 |
| | (0.44) | (1.25) | (1.28) | (8.89) |
| 11/09/14–12/08/14 | 7.41 | 11.44 | 28.85 | 33.64 |
| | (0.85) | (1.87) | (3.12) | (14.11) |
| 12/09/14–01/08/15 | 17.24 | 16.53 | 32.14 | 37.18 |
| | (1.10) | (2.24) | (2.88) | (22.37) |

Table 5: IV estimation

This table reports the results of IV regressions using the simultaneous trading sample. Panels A and B present the results for the first and second stage regressions. Columns (1) and (2) present the results using full sample, without and with control variables, respectively. Column (3) presents the results using a subsample of AA+, AA, and AA− bonds. Column (4) presents the results using a subsample of AA+, AA, and AAA bonds. Column (5) presents the results using a subsample of AA+, AAA, and AA− bonds. Column (6) presents the results using a subsample of AA, AAA, and AA− bonds. The sample period is 6/9/2014 to 6/8/2015. Heteroscedasticity-consistent standard errors clustered by week are reported in parentheses. The symbols *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: First stage

| Dependent: Haircut | Full | | Exclude AAA | Exclude AA− | Exclude AA | Exclude AA+ |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Shock | 68.00*** | 68.20*** | 68.27*** | 67.83*** | 74.82*** | 63.67*** |
| | (0.64) | (0.65) | (0.67) | (0.64) | (0.88) | (0.79) |
| Controls | – | ✓ | ✓ | ✓ | ✓ | ✓ |
| Bond FE | – | ✓ | ✓ | ✓ | ✓ | ✓ |
| Rating FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Week FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| $R^2$ | 0.85 | 0.95 | 0.95 | 0.95 | 0.97 | 0.96 |
| N | 10235 | 10070 | 9615 | 8550 | 4993 | 7039 |

Panel B: Second stage

| Dependent: EX Premia | Full | | Exclude AAA | Exclude AA− | Exclude AA | Exclude AA+ |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\widehat{Haircut}$ | -0.39*** | -0.39*** | -0.40*** | -0.33*** | -0.38*** | -0.40*** |
| | (0.05) | (0.05) | (0.05) | (0.10) | (0.05) | (0.05) |
| Maturity | | 2.75*** | 2.84*** | 3.06*** | 3.30*** | 1.85* |
| | | (0.80) | (0.82) | (0.86) | (1.02) | (0.93) |
| Turnover | | 0.12 | 0.10 | 0.13 | 0.23 | 0.09 |
| | | (0.09) | (0.09) | (0.10) | (0.14) | (0.10) |
| Market price | | -0.00 | -0.00 | -0.00 | -0.01 | -0.00 |
| | | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |
| Volatility | | 0.03 | -0.07 | 0.20 | -0.65 | 0.24 |
| | | (1.04) | (1.06) | (1.13) | (1.71) | (0.77) |
| $\text{CDB}_{spot}$ | | -28.15** | -30.47*** | -20.06* | -34.60** | -27.66* |
| | | (11.05) | (11.36) | (11.36) | (12.94) | (15.22) |
| Term spread | | 27.95* | 28.48* | 28.01 | 36.52** | 23.77 |
| | | (15.85) | (15.51) | (17.08) | (17.47) | (18.22) |
| GC001−SHIBOR | | -0.15 | -0.15 | -0.07 | -0.10 | -0.27** |
| | | (0.15) | (0.15) | (0.14) | (0.19) | (0.13) |
| $\text{Ret}_{stock}$ | | 0.46 | 0.43 | 0.48 | 0.41 | 0.42 |
| | | (0.43) | (0.43) | (0.49) | (0.42) | (0.47) |
| Bond FE | – | ✓ | ✓ | ✓ | ✓ | ✓ |
| Rating FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Week FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| $R^2$ | 0.12 | 0.48 | 0.47 | 0.49 | 0.41 | 0.53 |
| N | 10235 | 10070 | 9615 | 8550 | 4993 | 7039 |

Table 6: IV estimation: Additional results

This table reports additional results for the IV regressions. Panels A and B present the results for the first and second stage regressions. Column (1, MCB) presents the results using the MCBs only. Column (2, Maturity$^{long}$) presents the results using a subsample of bonds for which the time-to-maturity as of the day of trade is above median. Column (3, Excl. Mth 1) presents the results using the subsample without the first post-event month. Column (4, 2SWLS) presents the results using two-stage weighted least squares, where the weight is equal to the inverse of the number of observations for each bond. Column (5, Continuous) presents the results using ($1-\text{haircut}^{pre}$) as the shock size for AA+ and AA bonds, where haircut$^{pre}$ is the average haircut for bond $i$ rating $j$ before the policy shock. Heteroscedasticity-consistent standard errors clustered by week are reported in parentheses. The symbols *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: First stage

| Dependent: | MCB | Maturity$^{long}$ | Excl. Mth 1 | 2SWLS | Continuous |
|---|---|---|---|---|---|
| Haircut | (1) | (2) | (3) | (4) | (5) |
| Shock | 68.34*** | 69.65*** | 68.26*** | 67.49*** | 99.65*** |
| | (0.75) | (0.95) | (0.70) | (0.76) | (0.50) |
| Controls | ✓ | ✓ | ✓ | ✓ | ✓ |
| Bond FE | ✓ | ✓ | ✓ | ✓ | ✓ |
| Rating FE | ✓ | ✓ | ✓ | ✓ | ✓ |
| Week FE | ✓ | ✓ | ✓ | ✓ | ✓ |
| $R^2$ | 0.95 | 0.97 | 0.96 | 0.97 | 0.99 |
| N | 8513 | 4995 | 9132 | 10070 | 10070 |

Panel B: Second stage

| Dependent: | MCB | Maturity$^{long}$ | Excl. Mth 1 | 2SWLS | Continuous |
|---|---|---|---|---|---|
| EX Premia | (1) | (2) | (3) | (4) | (5) |
| $\widehat{Haircut}$ | -0.34*** | -0.46*** | -0.43*** | -0.41*** | -0.34*** |
| | (0.05) | (0.06) | (0.04) | (0.06) | (0.05) |
| Controls | ✓ | ✓ | ✓ | ✓ | ✓ |
| Bond FE | ✓ | ✓ | ✓ | ✓ | ✓ |
| Rating FE | ✓ | ✓ | ✓ | ✓ | ✓ |
| Week FE | ✓ | ✓ | ✓ | ✓ | ✓ |
| $R^2$ | 0.47 | 0.58 | 0.51 | 0.48 | 0.48 |
| N | 8513 | 4995 | 9132 | 10070 | 10070 |

Table 7: IV estimation: Impacts on liquidity

This table reports the second-stage results of IV regressions using the difference in price range between the exchange and interbank markets as the dependent variable. The price range in percentage is defined as the daily high minus the daily low divided by the average of the two. Columns (1) and (2) present the results using full sample, without and with control variables, respectively. Column (3) presents the results using a subsample of AA+, AA, and AA− bonds. Column (4) presents the results using a subsample of AA+, AA, and AAA bonds. Column (5) presents the results using a subsample of AA+, AAA, and AA− bonds. Column (6) presents the results using a subsample of AA, AAA, and AA− bonds. The sample period is 6/9/2014 to 6/8/2015. Heteroscedasticity-consistent standard errors clustered by week are reported in parentheses. The symbols *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: First stage

| Dependent: Haircut | Full | | Exclude AAA | Exclude AA− | Exclude AA | Exclude AA+ |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Shock | 68.00*** | 68.23*** | 68.28*** | 67.97*** | 74.87*** | 63.68*** |
| | (0.64) | (0.66) | (0.68) | (0.67) | (0.88) | (0.79) |
| Controls | – | ✓ | ✓ | ✓ | ✓ | ✓ |
| Bond FE | – | ✓ | ✓ | ✓ | ✓ | ✓ |
| Rating FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Week FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| $R^2$ | 0.85 | 0.95 | 0.95 | 0.95 | 0.97 | 0.96 |
| N | 10235 | 10070 | 9615 | 8550 | 4993 | 7039 |

Panel B: Second stage

| Dependent: $\Delta P^{high-low}$ | Full | | Exclude AAA | Exclude AA− | Exclude AA | Exclude AA+ |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\widehat{Haircut}$ | 0.48*** | 0.41*** | 0.43** | 0.35* | 0.41** | 0.42*** |
| | (0.14) | (0.14) | (0.16) | (0.20) | (0.17) | (0.15) |
| Maturity | | -10.59*** | -10.31*** | -11.65*** | -10.39** | -10.02*** |
| | | (3.59) | (3.64) | (3.98) | (4.47) | (3.70) |
| Turnover | | -2.50*** | -2.50*** | -2.32*** | -3.05*** | -2.41*** |
| | | (0.28) | (0.29) | (0.31) | (0.46) | (0.34) |
| Market price | | -0.01 | -0.01 | -0.01 | -0.01 | -0.00 |
| | | (0.00) | (0.00) | (0.00) | (0.01) | (0.01) |
| $CDB_{spot}$ | | 58.98 | 56.03 | 43.49 | 68.74 | 81.36* |
| | | (45.94) | (46.35) | (60.70) | (48.97) | (48.18) |
| Term spread | | 19.09 | 25.52 | 25.91 | -50.67 | 40.13 |
| | | (38.51) | (39.13) | (46.01) | (46.45) | (41.31) |
| GC001−SHIBOR | | -0.63 | -0.51 | -0.61 | -1.70 | 0.13 |
| | | (0.79) | (0.80) | (0.87) | (1.22) | (0.53) |
| $Ret_{stock}$ | | -0.58 | -0.69 | -0.71 | -1.82 | 0.72 |
| | | (1.22) | (1.25) | (1.35) | (2.39) | (0.74) |
| Bond FE | – | ✓ | ✓ | ✓ | ✓ | ✓ |
| Rating FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Week FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| $R^2$ | 0.08 | 0.26 | 0.25 | 0.27 | 0.25 | 0.27 |
| N | 10235 | 10070 | 9615 | 8550 | 4993 | 7039 |

Table 8: IV estimation using matched AAA bonds as benchmark

This table reports the results of IV regressions using the matched AAA bonds as a benchmark. The dependent variable is the credit spread between the matched AAA bonds and that of AA+/AA dual-listed enterprise bonds, where the matching criteria include credit spread and haircut before 12/8/2014. Panels A and B present the results for the first and second stages. The sample period is 6/9/2014 to 6/8/2015. Heteroscedasticity-consistent standard errors clustered by week are reported in parentheses. The symbols *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: First stage

| Dependent: | Full | | AA+ | AA |
|---|---|---|---|---|
| Haircut | (1) | (2) | (3) | (4) |
| Shock | 86.17*** | 84.85*** | 86.82*** | 77.67*** |
| | (0.90) | (1.23) | (0.87) | (1.35) |
| Controls | – | ✓ | ✓ | ✓ |
| Bond FE | – | ✓ | ✓ | ✓ |
| Rating FE | ✓ | ✓ | ✓ | ✓ |
| $R^2$ | 0.98 | 0.99 | 0.99 | 0.98 |
| N | 9940 | 9897 | 7548 | 2349 |

Panel B: Second stage

| Dependent: | Full | | AA+ | AA |
|---|---|---|---|---|
| $Spread^{matched-AAA}$ | (1) | (2) | (3) | (4) |
| $\widehat{Haircut}$ | -0.74*** | -0.85*** | -0.84*** | -0.84*** |
| | (0.02) | (0.04) | (0.04) | (0.10) |
| Maturity | | 0.03 | 0.07 | -0.09 |
| | | (0.11) | (0.10) | (0.20) |
| Turnover | | 2.22* | 1.23 | 5.94* |
| | | (1.29) | (1.06) | (2.98) |
| Market price | | -0.00 | -0.00 | 0.01 |
| | | (0.00) | (0.00) | (0.01) |
| Volatility | | 0.12 | -1.03 | 2.19* |
| | | (0.99) | (1.34) | (1.29) |
| $CDB_{spot}$ | | -10.28** | -10.32** | -7.96 |
| | | (4.62) | (4.15) | (9.08) |
| Term spread | | -0.91 | -3.54 | 5.72 |
| | | (5.55) | (4.74) | (10.30) |
| GC001−SHIBOR | | -0.17 | -0.12 | -0.43 |
| | | (0.30) | (0.25) | (0.54) |
| $Ret_{stock}$ | | 0.77 | 1.00 | 0.11 |
| | | (0.64) | (0.63) | (0.88) |
| Bond FE | – | ✓ | ✓ | ✓ |
| Rating FE | ✓ | ✓ | ✓ | ✓ |
| $R^2$ | 0.15 | 0.55 | 0.56 | 0.54 |
| N | 9940 | 9897 | 7548 | 2349 |

# Appendix

## Data Construction

### A.1 Bond rating classification

**Multiple bond ratings.** There are five major rating agencies offering rating services to bond issuers in China.[32] To determine the unique bond rating, we follow the market convention of "the lowest rating principle." That is, if there are multiple ratings available for the same bond on a given day, we use the lowest one as the bond rating.

**Bond rating reclassification.** We classify our sample into four rating groups for each bond-day observation: AAA, AA+, AA, and AA− (including below-AA− rating). When a bond is included on one of the five black lists, its bond rating is adjusted to AA− and this rule applies to all its bond-day observations afterwards.

### A.2 Construction of exchange premium

The exchange premium is the credit spread between the interbank yield and the exchange yield for the same bond, based on the prices of either "simultaneous" or "same-day" transactions from the two markets.

The pairing procedure for "simultaneous trading" is as follows (the case of "same-day trading" is straightforward):

1. For days with interbank market trading, we match trading day $t$'s interbank market credit spread with the closest exchange market daily credit spread within the window [$t$-2, $t$]. Specifically, if this bond has non-zero trading on day $t$ on the exchange market, the exchange premium is the difference between day $t$ interbank market credit spread and day $t$ exchange market credit spread. If this bond does not have any trading on day $t$ on the exchange market but has non-zero trading on trading day $t$-1 ($t$-2), the exchange premium is the difference between day $t$ interbank market credit spread and day $t$-1 ($t$-2) exchange market credit spread.

2. For days with exchange market trading, we match day $t$'s exchange market credit spread with the closest interbank market daily credit spread within the window [$t$-2, $t$]. Because we have already paired the same-day two-market trades in step 1, exchange market day $t$ observation is dropped if the bond has non-zero interbank market trading on day $t$. Otherwise, the exchange premium is the difference between trading day $t$-1 ($t$-2) interbank market credit spread and trading day $t$ exchange market credit spread.

[32] These five rating agencies are Chengxin (Chengxin Securities Rating and Chengxin International Rating), Lianhe (China United Rating and China Lianhe Rating) and Dagong Global Credit Rating; for a comprehensive review of the rating agencies, see Amstad and He (2020).

3. If a paired trade spans the event day 2014/12/8, i.e., the trading day on one market is before the event day while the trading day on the other market is after, such paired observation is dropped. A total of 35 observations are dropped, including 1 AAA, 11 AA+, 20 AA, and 3 AA− observations.

## A.3 Matching procedures of AA+ and AA enterprise bonds with AAA enterprise bonds

We match exchange market listed AA+ and AA-rated enterprise bonds with AAA-rated enterprise bonds as a benchmark in two dimensions: haircut and matching CDB credit spread. The matching is conducted at the bond-day level in the six-month window before the event date, i.e., from 6/9/2014 to 12/8/2014. For any AA+/AA bond that was ever traded in the six-month window after the event date (12/9/2014 to 6/8/2015), the average credit spread of all non-zero trading AAA bonds that belong to the set of pre-event matched AAA bonds w.r.t. the AA+/AA bond is used as the benchmark. The following steps describe the detailed pre-event matching procedure and how we benchmark AA+/AA bonds with matched AAA bonds.

1. For a daily observation of an AA+ or AA-rated bond with non-zero exchange market trading in the [-6, 0] month pre-event window, the five non-zero trading AAA-rated bonds that have the smallest absolute differences in haircut w.r.t. the AA+/AA bond on the day of trade are kept as candidate benchmark bonds.

2. To ensure that an AA+ or AA bond's haircut is close enough to those of the candidate AAA bonds, an AA+ or AA bond's bond-day observation is dropped if the fifth smallest absolute haircut difference between an AA+ or an AA bond and the candidate AAA bond is larger than the median value of all absolute haircut differences. The candidate AAA bond pool for the AA+ or AA bond $i$ on day $t$ is denoted by $\text{AAA}_{i,t}^{haircut}$.

3. For a daily observation of an AA+ or AA rated bond with non-zero exchange market trading in the [-6, 0] month pre-event window, the five non-zero trading AAA-rated bonds that have the smallest absolute differences in matching CDB credit spread w.r.t. the AA+/AA bond on the day of trade are kept as candidate benchmark bonds.

4. To ensure that an AA+ or AA bond's matching CDB credit spread is close enough to those of the candidate AAA bonds, an AA+ or AA bond's bond-day observation is dropped if the fifth smallest absolute credit spread difference between an AA+ or AA bond and the candidate AAA bond is larger than the median value of all absolute credit spread differences. The candidate AAA bond pool for the AA+ or AA bond $i$ on day $t$ is denoted as $\text{AAA}_{i,t}^{yieldspread}$.

5. AAA bonds that belong to both $\text{AAA}_{i,t}^{haircut}$ and $\text{AAA}_{i,t}^{yieldspread}$ are denoted as a matched set of AAA bonds for AA+ or AA bond $i$ on day $t$, $\text{AAA}_{i,t}^{matched}$.

6. For any AA+ or AA bond $i$ day $t$ observation in the six-month pre-event window, the average credit spread of AAA bonds belonging to $\text{AAA}_{i,t}^{matched}$ is taken as the benchmark.

7. For any AA+ or AA bond $i$, the union of all its matched bond sets $\text{AAA}_{i,t}^{matched}$ across its non-zero trading days $T_i$ is denoted by $\text{AAA}_i^{matched} = \bigcup_{t \in T_i} \text{AAA}_{i,t}^{matched}$.

8. For any AA+ or AA bond $i$ day $\tau$ observation in the six-month post-event window, the average credit spread of AAA bonds with non-zero trading on day $\tau$ belonging to $\text{AAA}_i^{matched}$ is taken as the benchmark.

Figure A1: China's interbank and exchange bond markets

This figure plots China's two bond markets from 2008 to 2019. Panels A and B plot spot and repo transaction RMB volume, respectively, of all bonds on the interbank and exchange markets. Panels C and D plots the number of trades for spot and repo transactions, respectively, in these two markets. While the interbank market has the dominant market share for both spot and repo transactions based on dollar volume, the opposite is true based on the number of trades. Data on interbank-market transactions are from China Foreign Exchange Trade System (CFETS) and data on exchange-market transactions are from the Statistics Annuals of Shanghai exchange and Shenzhen exchange.

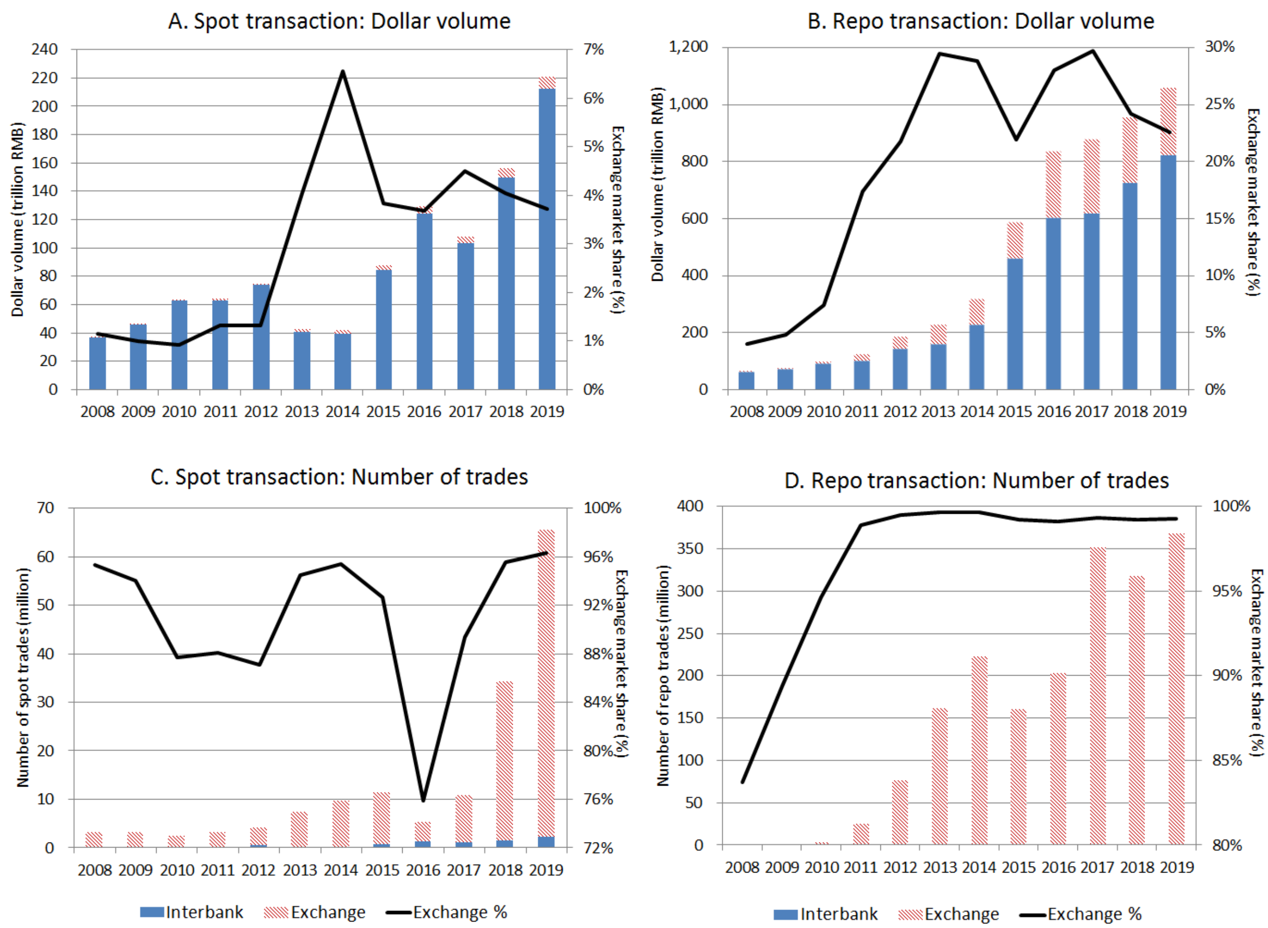
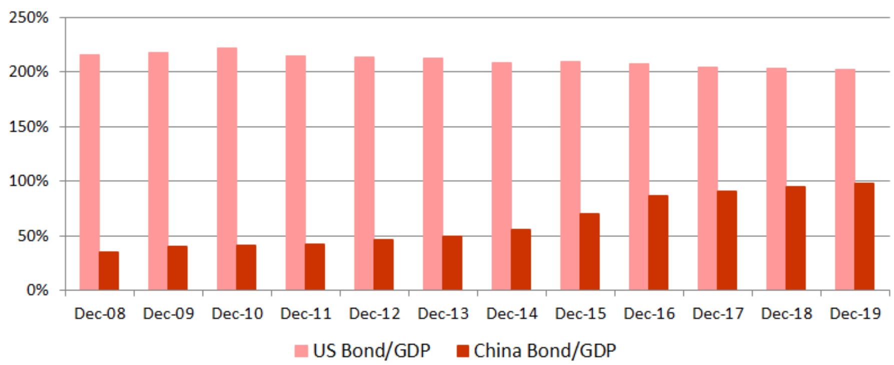


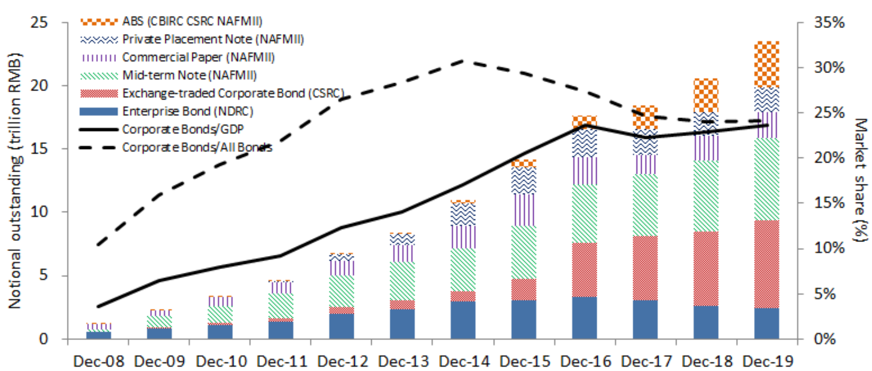
Figure A2: China's bond market

This figure plots statistics of China's bond market from 2008 to 2019. Panel A plots the bonds outstanding as a percentage of GDP in China and the US, Panel B plots China's corporate bonds outstanding by category (with corresponding regulators in parentheses), and Panel C plots PBoC aggregate social financing outstanding by category. For more details, see Amstad and He (2020).

Panel A: Bonds outstanding as % of GDP




Panel B: China's corporate bonds outstanding by category




Panel C: China's aggregate social financing outstanding by category

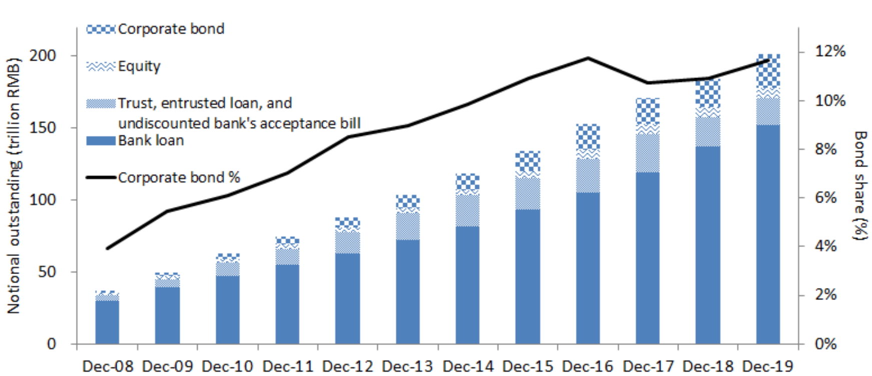


Figure A3: Exchange premia dynamics

This figure presents the average exchange premia by bond ratings and subperiods. The three bond-rating groups include the treated group (AA+ and AA), the AAA group, and the AA− group. The sample of simultaneous trading is a [−12, 12]-week window around the event day 12/8/2014. The sample is divided into 6 subperiods with 28 calendar days each.

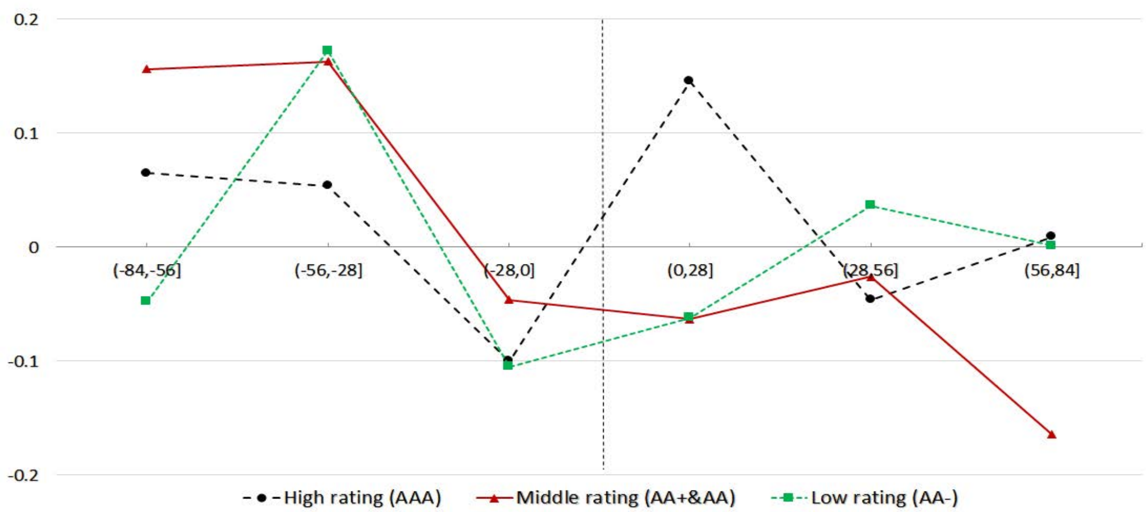


Table A1: China's bond market liquidity

This table reports various measures of China's bond market liquidity. ZDays is the time series average of the fraction of bonds that do not trade on a given day. $\text{ZDays}_{w/trade}$ is the time series average of the fraction of bonds that do not trade on a given day, excluding bonds that do not have any single trade over the sample period. Turnover is the average daily turnover across all bond-day observations where a zero is recorded on days without trade. Amihud is the average Amihud (2002) measure across all bonds, where a bond's Amihud measure is estimated using its all non-zero daily trading observations and multiplied by $10^6$. Panel A presents the comparison of liquidity between China's two bond markets and U.S. bond market. Panel B presents the exchange market liquidity measures for all exchange-traded bonds, enterprise bonds, and exchange-traded corporate bonds. Panel C presents the interbank market liquidity measures for all interbank-traded bonds, enterprise bonds, mid-term notes, and commercial papers. In Panel A, the sample period is 1/1/2012 to 12/31/2017 for China's two markets and the sample period is 1/1/2010 to 12/31/2014 for the U.S. market, where the U.S. market liquidity measures are from Anderson and Stulz (2017). In Panels B and C, the sample period is 6/9/2014 to 6/8/2015.

Panel A: China and U.S. comparison

| | China: Interbank | China: Exchange | U.S. |
|---|---|---|---|
| ZDays | 0.88856 | 0.81326 | 0.78820 |
| $\text{ZDays}_{w/trade}$ | 0.88768 | 0.79798 | 0.70940 |
| Turnover | 0.01212 | 0.00099 | 0.00150 |
| Amihud | 0.00016 | 2.54233 | 0.48810 |

Panel B: China's exchange bond market liquidity

| | All | Enterprise bond | Exchange-traded corporate bond |
|---|---|---|---|
| ZDays | 0.80693 | 0.83215 | 0.75485 |
| $\text{ZDays}_{w/trade}$ | 0.77092 | 0.80758 | 0.68604 |
| Turnover | 0.00109 | 0.00050 | 0.00231 |
| Amihud | 2.93788 | 3.79992 | 1.06712 |

Panel C: China's interbank bond market liquidity

| | All | Enterprise bond | Mid-term note | Commercial paper |
|---|---|---|---|---|
| ZDays | 0.90284 | 0.92185 | 0.92419 | 0.83746 |
| $\text{ZDays}_{w/trade}$ | 0.89786 | 0.91462 | 0.92160 | 0.83451 |
| Turnover | 0.00984 | 0.00801 | 0.00757 | 0.01647 |
| Amihud | 0.00021 | 0.00040 | 0.00023 | 0.00005 |

Table A2: The five black lists of repo disqualified enterprise bonds

This table presents the security codes of enterprise bonds in the five black lists announced by CSDC. The five lists were released on 5/29/2014, 6/27/2014, 8/1/2014, 9/5/2014, and 11/3/2014. MCBs are indicated with $\star$. Bonds in the simultaneous sample are indicated with #.

| **May 29, 2014** | **Aug 1, 2014** | | **Sep 5, 2014** |
|---|---|---|---|
| 122535.SH # | 122509.SH $\star$ # | 124364.SH $\star$ # | 111039.SZ |
| 122683.SH # | 122539.SH $\star$ # | 124373.SH $\star$ # | 111047.SZ $\star$ # |
| 122989.SH $\star$ # | 122541.SH # | 124457.SH $\star$ # | 124132.SH $\star$ # |
| 124102.SH # | 122562.SH $\star$ # | 124459.SH $\star$ | |
| **Jun 27, 2014** | 122568.SH $\star$ # | 124495.SH # | **Nov 3, 2014** |
| 122522.SH $\star$ # | 122582.SH $\star$ # | 124541.SH $\star$ | 111064.SZ $\star$ # |
| 122542.SH $\star$ # | 122601.SH $\star$ # | 124562.SH $\star$ # | 122590.SH $\star$ # |
| 122556.SH $\star$ # | 122662.SH $\star$ # | 124572.SH $\star$ # | 122687.SH $\star$ # |
| 122753.SH $\star$ # | 122694.SH $\star$ # | 124688.SH $\star$ # | 122811.SH |
| 122769.SH $\star$ # | 122721.SH $\star$ # | 124706.SH $\star$ # | 124001.SH $\star$ # |
| 122812.SH $\star$ # | 122754.SH $\star$ # | 124716.SH $\star$ # | 124039.SH $\star$ |
| 122843.SH $\star$ # | 122759.SH | 124734.SH $\star$ # | 124231.SH $\star$ # |
| 122857.SH $\star$ # | 122807.SH | 124766.SH $\star$ # | 124267.SH $\star$ |
| 122883.SH $\star$ # | 122841.SH $\star$ | | 124378.SH $\star$ # |
| 122931.SH $\star$ | 122918.SH $\star$ # | | 124478.SH $\star$ # |
| 122936.SH $\star$ # | 122945.SH $\star$ # | | 124509.SH $\star$ # |
| 122937.SH $\star$ # | 124010.SH $\star$ # | | 124521.SH $\star$ # |
| 124018.SH $\star$ # | 124025.SH $\star$ # | | 124587.SH $\star$ |
| 124019.SH $\star$ # | 124038.SH # | | 124611.SH $\star$ # |
| 124076.SH $\star$ # | 124061.SH $\star$ # | | 124632.SH $\star$ # |
| 124100.SH $\star$ # | 124079.SH $\star$ # | | 124730.SH $\star$ |
| 124127.SH $\star$ # | 124092.SH # | | 124802.SH $\star$ # |
| 124131.SH $\star$ # | 124104.SH $\star$ # | | 124812.SH $\star$ |
| 124262.SH $\star$ # | 124130.SH # | | 124852.SH $\star$ # |
| 124272.SH $\star$ # | 124175.SH $\star$ # | | 124864.SH $\star$ |
| 124316.SH $\star$ # | 124178.SH $\star$ # | | |
| 124334.SH $\star$ # | 124202.SH $\star$ | | |
| 124351.SH $\star$ # | 124218.SH # | | |
| 124396.SH $\star$ # | 124223.SH # | | |
| 124469.SH $\star$ # | 124256.SH # | | |
| 124512.SH $\star$ # | 124260.SH $\star$ # | | |
| 124564.SH $\star$ | 124274.SH # | | |
| 124627.SH $\star$ | 124309.SH # | | |
| 124656.SH $\star$ # | 124324.SH $\star$ # | | |
| 124699.SH $\star$ | 124329.SH $\star$ | | |
| 124749.SH $\star$ # | 124354.SH $\star$ | | |
| 124754.SH $\star$ # | 124360.SH $\star$ # | | |

Table A3: Definition of variables

| Variables | Definition |
|---|---|
| Dependent variables | |
| EX premium | Exchange premium in terms of percentage is the interbank market credit spread minus the simultaneous exchange market credit spread |
| EX $\text{premium}_{pre}$ | Exchange premium of the subsample before the policy shock from 6/9/2014 to 12/8/2014 |
| EX $\text{premium}_{post}$ | Exchange premium of the subsample after the policy shock from 12/9/2014 to 6/8/2015 |
| Matched spread | Credit spread in terms of percentage is the exchange market AA+/AA-rated bond credit spread minus the matched AAA-rated bond credit spread |
| Explanatory variables | |
| Haircut | The percentage of the levered investors' own money needed for the margin account to borrow using the underlying bond as collateral |
| $\text{Haircut}_{pre}$ | Haircut of the subsample before the policy shock from 6/9/2014 to 12/8/2014 |
| $\text{Haircut}_{post}$ | Haircut of the subsample after the policy shock from 12/9/2014 to 6/8/2015 |
| Conversion | The rate (%) between the value of exchange market standard bond that can be converted from one unit of pledgeable bonds |
| $\text{Conversion}_{pre}$ | Conversion rate of the subsample before the policy shock from 6/9/2014 to 12/8/2014 |
| $\text{Conversion}_{post}$ | Conversion rate of the subsample after the policy shock from 12/9/2014 to 6/8/2015 |
| Bond-day level variables | |
| IB spread | The interbank market credit spread defined as bond trading price implied YTM minus the matching China Development Bank bond yield |
| EX spread | The exchange market credit spread defined as bond trading price implied YTM minus the matching China Development Bank bond yield |
| $\Delta P^{high-low}$ | The difference in daily price range between the exchange market and interbank market, where the price range in percentage is defined as the daily high minus the low clean price divided by the average of the two |
| Maturity | The number of years to maturity as of the day of trade |
| Turnover | The total number of shares traded in both the interbank and the exchange markets over the number of shares outstanding |
| Market price | The average invoice trading price of the most recent five non-zero trading days of the exchange market |
| Volatility | The highest close price minus the lowest close price divied by the average of the two over the past five non-zero trading days of the exchange market |
| Day level variables | |
| $\text{CDB}_{spot}$ | 10-year China Development Bank spot yield as of the day of trade |
| Term spread | 10-year Treasury yield minus 1-year Treasury yield as of the day of trade |
| GC001−SHIBOR | Spread of 1-day Shanghai exchange repo rate over 1-day Shanghai Interbank Offering Rate as of the day of trade |
| $\text{Ret}_{stock}$ | Daily return of Shanghai Composite Index as of the day of trade |

# Internet Appendix

"Pledgeability and Asset Prices: Evidence from the Chinese Corporate Bond Markets"

Hui Chen, Zhuo Chen, Zhiguo He, Jinyu Liu, Rengming Xie

## IA1 Spot and Repo Transactions of NBFIs

In this section, we provide empirical evidence that the three types of NBFIs, including mutual funds, insurance companies, and securities firms, actively held enterprise bonds and traded on both the interbank and exchange markets during the sample period around the 2014 policy shock.

Figure IA2 Panel A plots the shares of enterprise bonds held by the NBFIs over deposited enterprise bonds on each market. Over the one-year window from 6/30/2014 to 6/30/2015, enterprise bonds held by those NBFIs account for more than 50% of bonds deposited on the interbank market and more than 70% on the exchange market. Figure IA2 Panel B plots the shares of enterprise bond spot transaction by NBFIs over the four quarters around the policy shock. NBFIs' spot transactions account for 30% to 50% of all enterprise bond trades on the interbank market and around 80% on the exchange market. Overall, mutual funds, insurance companies, and securities firms are important traders of enterprise bonds in both markets, not just before the policy shock, but also after the policy shock.

In Figure IA3, we plot the monthly repo and reverse repo transaction shares by participant type over the period of June 2014 to May 2015. NBFIs also actively participate in repo transactions on the interbank market: they conduct about 20% of repo and 7% of reverse-repo transactions. We do not have detailed repo transaction data by participant type for the exchange market. But according to a research report issued by the Shanghai Stock Exchange,[1] those three types of NBFIs account for 58.9% of repo transactions in 2014; on the reverse-repo

[1] http://bond.sse.com.cn/market/tradingm/strepo/

market, retail investors are the single largest lenders (44.5%), followed by general legal entities (17.4%), and trusts (10.4%). Therefore, NBFIs are important net borrowers, i.e., leverage users, in both interbank and exchange repo markets.

# IA2 Additional Results

In this section, we present additional empirical results. Table IA3 reports the results for OLS regressions, Table IA5 reports the results using the sample of matched AAA bonds as a benchmark with rating-market level controls, Table IA7/Table IA8 report the results using the same-day sample without/with rating-market level controls, respectively, and Table IA9 reports the results using different methodologies to clean outliers.

For robustness, we also include an alternative version of Figure 3 and Figure A3 in the paper based on the sampling frequency of 14 days, which are shown in Figure IA4 and Figure IA5. We can see that the dynamics of the diff-in-diff estimates are qualitatively similar under the two sampling frequencies. The dynamics of the exchange premia are noisier under the 14-day sampling frequency. However, they both show the general decline in the exchange premia for the treatment group of AA+ and AA bonds following the policy shock. In contrast, the exchange premia for AAA and AA− bonds did not become lower. The reason that the results based on the 14-day sampling frequency appear noisier is due to low number of daily observations in the simultaneous trading sample, which requires the same bond to be traded in both markets over a three-day window. For example, the treatment group has between 15 and 40 observations on a daily basis, while the daily observations for AAA and AA− bonds are mostly below 10. Even at the 14-day frequency, the average number of observations for the AAA group in a 14-day window is only 18.

**Higher frequency evidence.** Despite the data limitation mentioned above, we try to examine evidence of the effect of the policy shock at higher frequency by plotting the difference in the daily averages of the interbank credit spreads and exchange credit spreads across the three rating groups (see Panel A of Figure IA6). This approach has the obvious drawback in not controlling for potential differences in fundamentals for the bonds traded on the two markets. Nonetheless, it shows a consistent pattern with our main results: for the treatment group, the average credit spreads rose on the exchange market relative to those on the interbank market following the policy shock; the opposite is true for AAA bonds, while for AA− bonds the difference in average credit spreads across the two markets remained roughly the same.

Our second approach is to match each bond-day observation on the interbank (exchange) market with that on the exchange (interbank) market along three dimensions: bond rating, haircut, and issuer size. We then plot the average difference in the credit spreads of those matched bond-day observations within three-day subperiods. This approach helps increase the number of observations somewhat. The average number of observations over a 3-day window for AAA and AA- group is about 50 around the time of the policy shock. Panel B of Figure IA6 exhibits similar patterns as those in Panel A for treated bonds and the two control group bonds. Again, we see that the average interbank-exchange spreads for the treatment group declined following the policy shock, while those for AAA and AA− bonds either did not change significantly or increased after the policy shock.

## IA3 The Impact of Cross-Market Arbitrage on $\hat{\lambda}$

After the policy shock pushes up $h_{ijt}^{EX} = 1$, pledgeability premia tend to go negative. We start with the case in which $\lambda\left(h_{ijt}^{IB} - h_{ijt}^{EX}\right) + \epsilon_{ijt}^{EX} - \epsilon_{ijt}^{IB} < 0$; the logic is the same if it is positive. Then, Eq. (13) becomes

$$\underbrace{p_{ijt}^{EX} - p_{ijt}^{IB}}_{\text{exchange premia}} = \max\left[\underbrace{\lambda\left(h_{ijt}^{IB} - h_{ijt}^{EX}\right)}_{\text{Eq. (4)}}, -C\right] \geq \underbrace{\lambda\left(h_{ijt}^{IB} - h_{ijt}^{EX}\right)}_{\text{diff. in pledgeability premia}} . \tag{15}$$

As a result, our estimation essentially introduces an error term $\upsilon_{ijt}$ to restore the equality in (15) of the main body:

$$-C = p_{ijt}^{EX} - p_{ijt}^{IB} = \lambda\left(h_{ijt}^{IB} - h_{ijt}^{EX}\right) + \upsilon_{ijt}.$$

To see why this leads to a negative bias for $\hat{\lambda}$, first note that when the policy shock pushed up the exchange market haircuts $h_{ijt}^{EX}$ which drove a negative exchange premium for treated AA/AA+ bonds (Panel B in Figure 2), Eq. (13) became a (weak) inequality (at least for some bonds), and hence $\upsilon_{ijt}$ turned positive. Second, treated bonds exhibit a positive exchange premium before the shock (Panel B in Figure 2), implying a reverse (weak) inequality in (13) and $\upsilon_{ijt} < 0$ before the policy shock. This is because when the exchange premium is positive, then $p^{EX}_{ijt} - p^{IB}_{ijt} = \min\left[\lambda\left(h^{IB}_{ijt} - h^{EX}_{ijt}\right), C\right] \leq \lambda\left(h^{IB}_{ijt} - h^{EX}_{ijt}\right)$. Combining these two pieces, the policy shock introduces a negative correlation between $\upsilon_{ijt}$ and $h^{IB}_{ijt} - h^{EX}_{ijt}$, hence a negative bias of estimated $\hat{\lambda}$.

# IA4 Time-varying $\lambda$

Suppose that the Lagrange multiplier $\lambda_t$ rises after the policy shock, and consider the following simplified framework. For bond $j$, the exchange premium $p^{EXIB}_j \equiv p^{EX}_j - p^{IB}_j$, we have:

$$p^{EXIB}_{j,pre} = \lambda_{pre}\left(1 - h^{EX}_{j,pre}\right) - \lambda_{pre}\left(1 - h^{IB}_j\right)$$
$$p^{EXIB}_{j,post} = \lambda_{post}\left(1 - h^{EX}_{j,post}\right) - \lambda_{post}\left(1 - h^{IB}_j\right)$$

where *pre* or *post* indicates before and after the shock. Then $\Delta p^{EXIB}_j \equiv p^{EXIB}_{j,post} - p^{EXIB}_{j,pre}$ can be expressed as:

$$\begin{aligned}\Delta p^{EXIB}_j =& \lambda_{post}\left(1 - h^{EX}_{j,post}\right) - \lambda_{post}\left(1 - h^{IB}_j\right) \\ & - \lambda_{pre}\left(1 - h^{EX}_{j,pre}\right) + \lambda_{pre}\left(1 - h^{IB}_j\right) \\ =& - \lambda_{post}\left(h^{EX}_{j,post} - h^{EX}_{j,pre}\right) + \left(\lambda_{post} - \lambda_{pre}\right)\left(h^{IB}_j - h^{EX}_{j,pre}\right)\end{aligned}$$

Here, the change in exchange premium not only captures the first term, but also the second term where the policy shock on Lagrange multiplier $\lambda_{post} - \lambda_{pre}$ interacts with the pre-policy haircut difference between the two markets. In our triple-DiD specification, we are essentially looking at

$$\begin{aligned}\Delta p^{EXIB}_{treat} - \Delta p^{EXIB}_{ctrl} =& \underbrace{-\lambda_{post}\left(h^{EX}_{treat,post} - h^{EX}_{treat,pre}\right)}_{\text{negative}} \\ & + \underbrace{\left(\lambda_{post} - \lambda_{pre}\right)}_{\text{positive}}\underbrace{\left(h^{IB}_{treat} - h^{EX}_{treat,pre} - \left(h^{IB}_{ctrl} - h^{EX}_{ctrl,pre}\right)\right)}_{\text{positive?}}.\end{aligned}$$

This implies that the bias depends on the sign of

$$h^{IB}_{treat} - h^{EX}_{treat,pre} - \left(h^{IB}_{ctrl} - h^{EX}_{ctrl,pre}\right). \tag{16}$$

In our data, before the shock, AAA haircuts (in the units of percentage points) in the interbank and exchange markets are about $(8, 10)$, AA+ about $(13, 23)$, AA about $(32, 34)$ and AA− about $(36, 100)$. So, the first term $h^{IB}_{treat} - h^{EX}_{treat,pre}$ is almost zero at $-6$ while the second term $h^{IB}_{ctrl} - h^{EX}_{ctrl,pre}$ is negative (about $-33$). As a result, the extra term is positive in our sample, which leads to a negative bias for the estimation of $\lambda_{post}$. Or, in terms $\lambda_{pre}$, we have

$$\Delta p^{EXIB}_j = -\lambda_{pre}\left(h^{EX}_{j,post} - h^{EX}_{j,pre}\right) + \left(\lambda_{post} - \lambda_{pre}\right)\left(h^{IB}_j - h^{EX}_{j,post}\right).$$

As a result, $\Delta p^{EXIB}_{treat} - \Delta p^{EXIB}_{ctrl}$ equals

$$\underbrace{-\lambda_{pre}(h^{EX}_{treat,post} - h^{EX}_{treat,pre})}_{\text{negative}} + \underbrace{(\lambda_{post} - \lambda_{pre})}_{\text{positive}}\underbrace{\left(h^{IB}_{treat} - h^{EX}_{treat,post} - \left(h^{IB}_{ctrl} - h^{EX}_{ctrl,post}\right)\right)}_{\text{negative?}}$$

In our data, after the shock, AAA haircuts in two markets are about $(14, 9)$, AA+ are about $(14, 100)$, AA are about $(31, 100)$ and AA$-$ are about $(37, 100)$. Therefore, the extra term is negative around $-50$, which leads to an overestimate of $\lambda_{pre}$.

We now move on to investigate potential effect on the matched-AAA estimate. A similar logic as above implies that

$$\Delta p_{AA-AAA,post} \equiv p^{EX}_{AA,post} - p^{EX}_{AAA,post} = \lambda_{post}\left(h^{EX}_{AAA,post} - h^{EX}_{AA,post}\right),$$
$$\Delta p_{AA-AAA,pre} \equiv p^{EX}_{AA,pre} - p^{EX}_{AAA,pre} = \lambda_{pre}\left(h^{EX}_{AAA,pre} - h^{EX}_{AA,pre}\right),$$

and one can derive that $\Delta p_{AA-AAA,post} - \Delta p_{AA-AAA,pre}$ equals

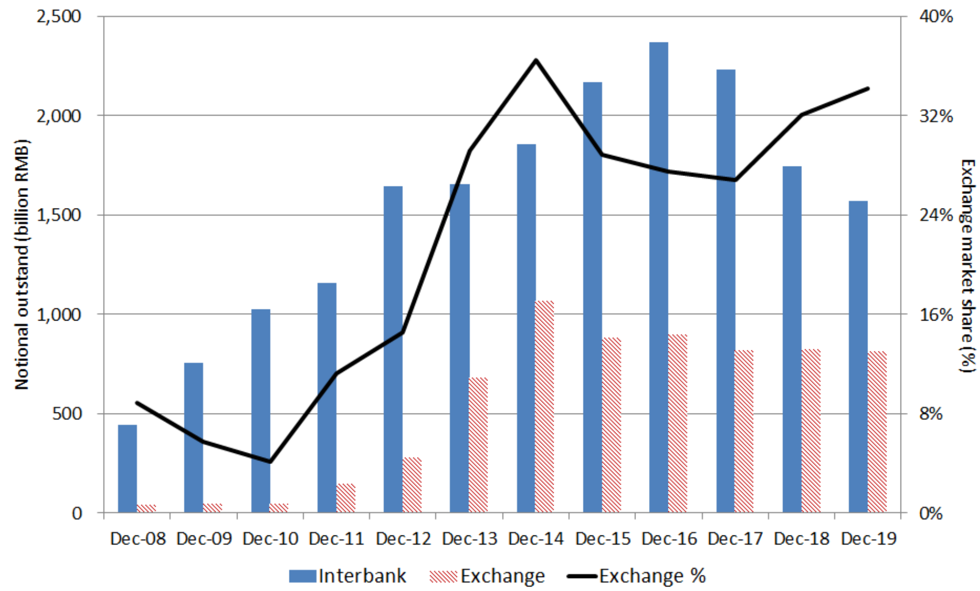
$$\begin{aligned} &\lambda_{post}\left(h^{EX}_{AAA,post} - h^{EX}_{AA,post}\right) - \lambda_{pre}\left(h^{EX}_{AAA,pre} - h^{EX}_{AA,pre}\right) \\ =& -\lambda_{post}\left(h^{EX}_{AA,post} - h^{EX}_{AA,pre}\right) + \left(\lambda_{post} - \lambda_{pre}\right)\left(h^{EX}_{AAA,pre} - h^{EX}_{AA,pre}\right), \end{aligned}$$

where we have used that $h^{EX}_{AAA,post} = h^{EX}_{AAA,pre}$. Because $h^{EX}_{AAA,pre} < h^{EX}_{AA,pre}$, the second term is negative, which implies that matched-AAA procedure produces an overestimate of $\lambda_{post}$.

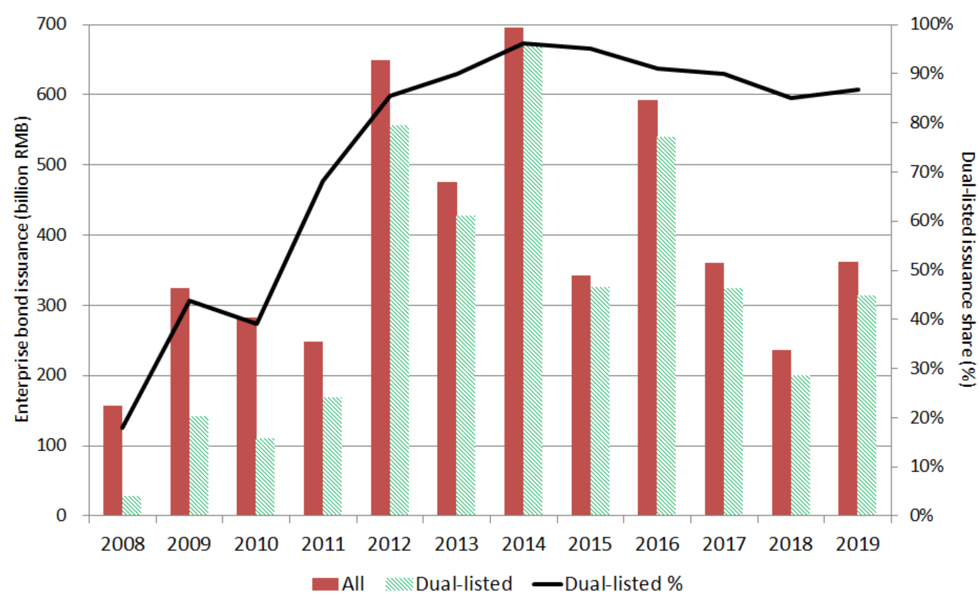
Figure IA1: Dual-listed enterprise bonds

This figure plots the notional outstanding and the issuance of dual-listed enterprise bonds in China from 2008 to 2019. Panel A plots enterprise bond outstanding in the interbank and exchange markets. Panel B plots the issuance amount for all enterprise bonds and dual-listed enterprise bonds.

Panel A: Dual-listed enterprise bond outstanding by depository market (billion RMB)



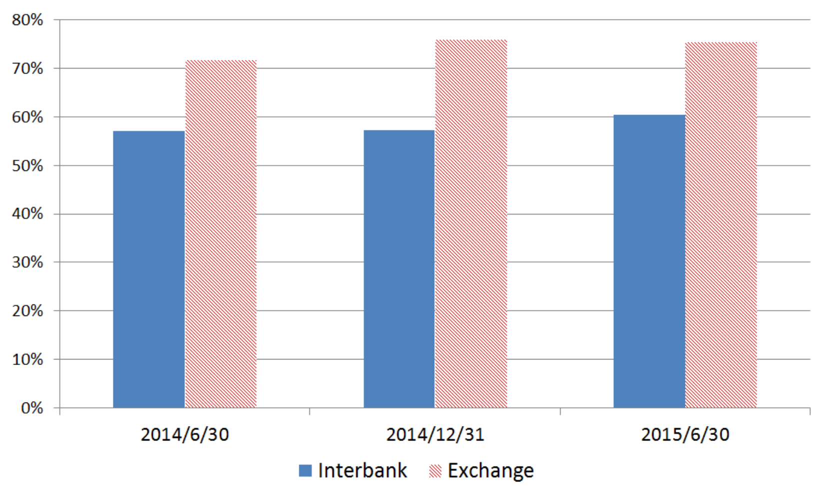

Panel B: Enterprise bond issuance (billion RMB)



## Figure IA2: NBFIs' shares of holding and spot transactions on the two markets

This figure plots NBFIs' shares of holdings and spot transactions of enterprise bonds on the interbank and exchange markets. Three groups of NBFIs include mutual funds, insurance companies, and securities firms. Panel A plots the aggregate holding shares of enterprise bonds by NBFIs over the deposited enterprise bond outstanding on each market as of 2014/6/30, 2014/12/31, and 2016/6/30. Panel B plots NBFIs' spot transaction shares of enterprise bonds on the two markets in the four quarters from 2014Q3 to 2015Q2. Data on NBFIs' holding and spot transaction shares of enterprise bonds on the exchange market are from Shanghai and Shenzhen exchanges. Data on NBFIs' holding share of enterprise bonds on the interbank market are from the China Central Depository & Clearing Co. Ltd (CCDC). Data on NBFIs' spot transaction share of enterprise bond on the interbank market are estimated: (1) through WIND, the CFETS provides three snapshots on 2018/5/18, 2018/7/4, and 2018/8/13 of the three groups of investors' spot transaction shares for enterprise bonds and all bonds; (2) Almanac of China's Finance and Banking provides quarterly spot transaction shares of NBFIs for all bonds on the interbank market; (3) NBFIs' spot transaction shares of the enterprise bonds on the interbank market from 2014Q3 to 2015Q2 are estimated assuming that the ratio between their spot transaction share of all bonds and enterprise bonds is the same as of the average of the three snapshots.

### Panel A: The share of NBFIs' holdings of enterprise bonds




### Panel B: The share of NBFIs' spot transactions of enterprise bonds

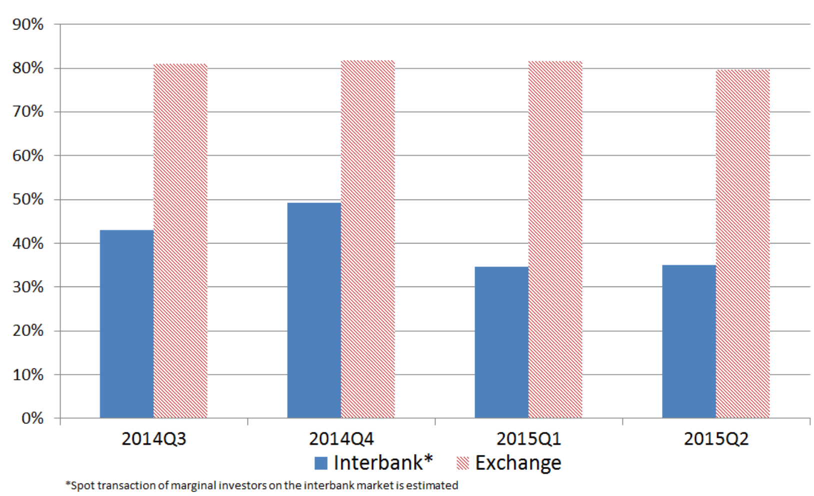
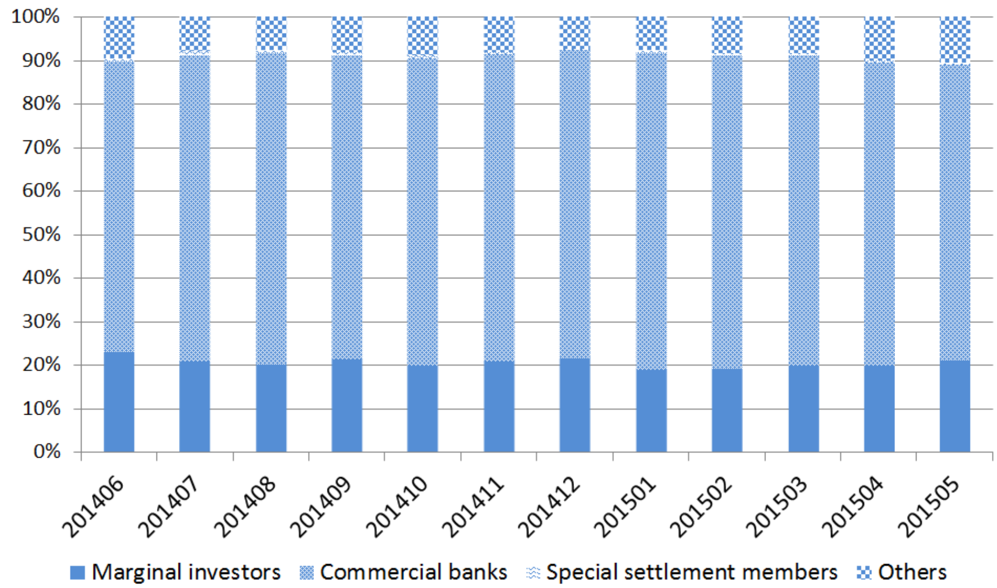


Figure IA3: Repo and reverse-repo transaction shares on the interbank market

This figure plots repo and reverse-repo transaction shares by participant type on the interbank market. Three groups of marginal investors include mutual funds, insurance companies, and securities firms. Special settlement members include policy banks, Ministry of Finance, and PBoC. Panel A plots the monthly repo transaction shares by borrower type. Panel B plots the monthly reverse-repo transaction shares by lender type. Data are from the CCDC and downloaded through WIND. The sample period is from 2014:6 to 2015:5.

Panel A: Repo transaction shares by participant type on the interbank market




Panel B: Reverse-repo transaction shares by participant type on the interbank market

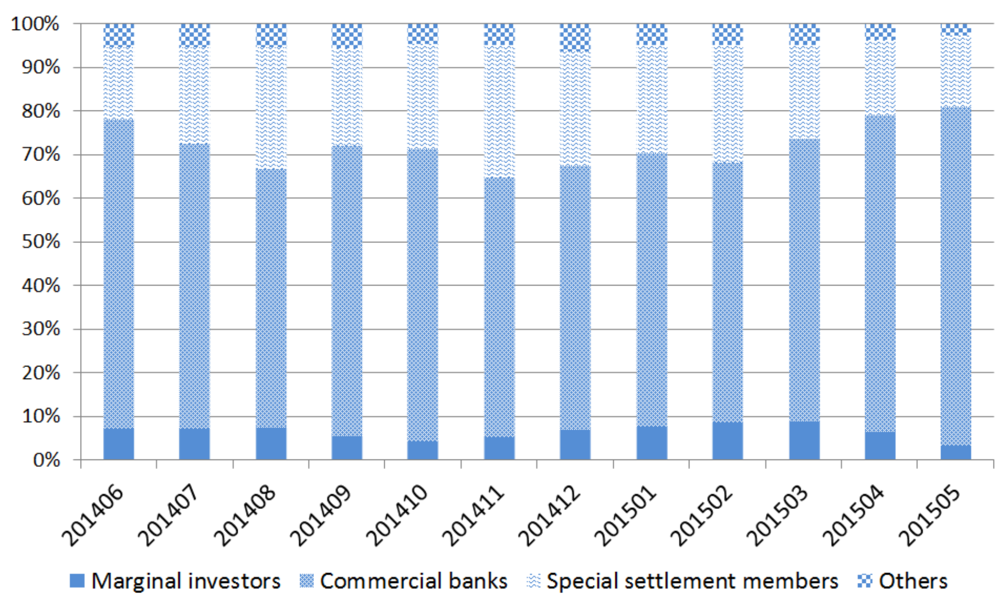


Figure IA4: Diff-in-diff estimation of exchange premia: 14-day subperiod

This figure plots the estimated coefficients $\hat{d}_k$ along with their confidence intervals calculated from heteroscedasticity-robust standard errors in the diff-in-diff specification of Eq. (6). The point estimate immediately before the event date is normalized to zero (hence a zero standard error). The dotted line indicates the event on 12/8/2014. The sample is from 2014/6/9 to 2015/6/8, which is divided into fourteen 14-day subperiods. Panel A is for the control group combining both AAA and AA− bonds, and panel B (C) is for the control group with only AA− (AAA) bonds.

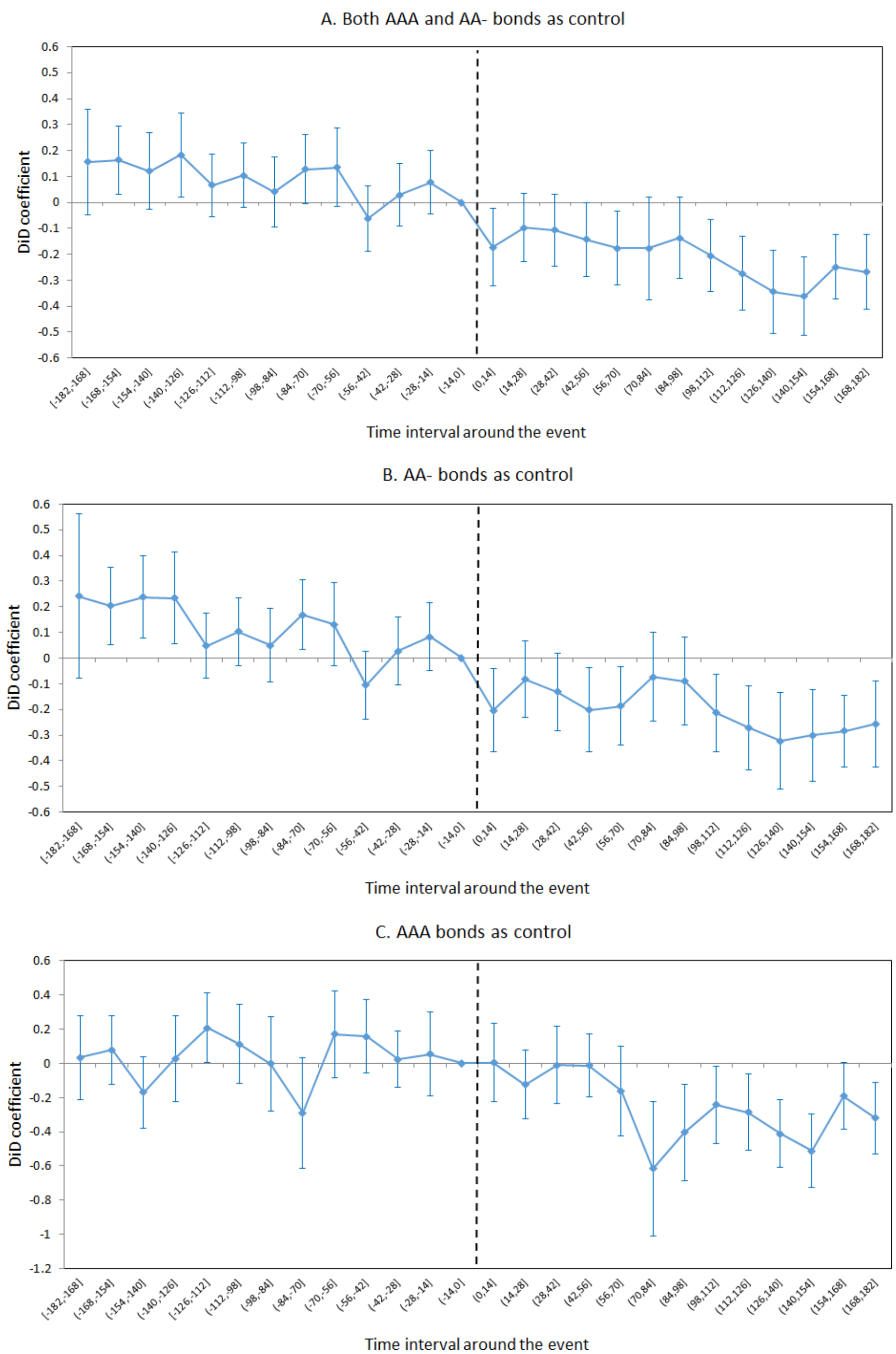


Figure IA5: Exchange premia dynamics: 14-day subperiod

This figure presents the average exchange premia by bond ratings and subperiods. The three bond-rating groups include the treated group (AA+ and AA), the AAA group, and the AA− group. The sample of simultaneous trading is a [−12, 12]-week window around the event day 12/8/2014. The sample is divided into 12 subperiods with 14 calendar days each.

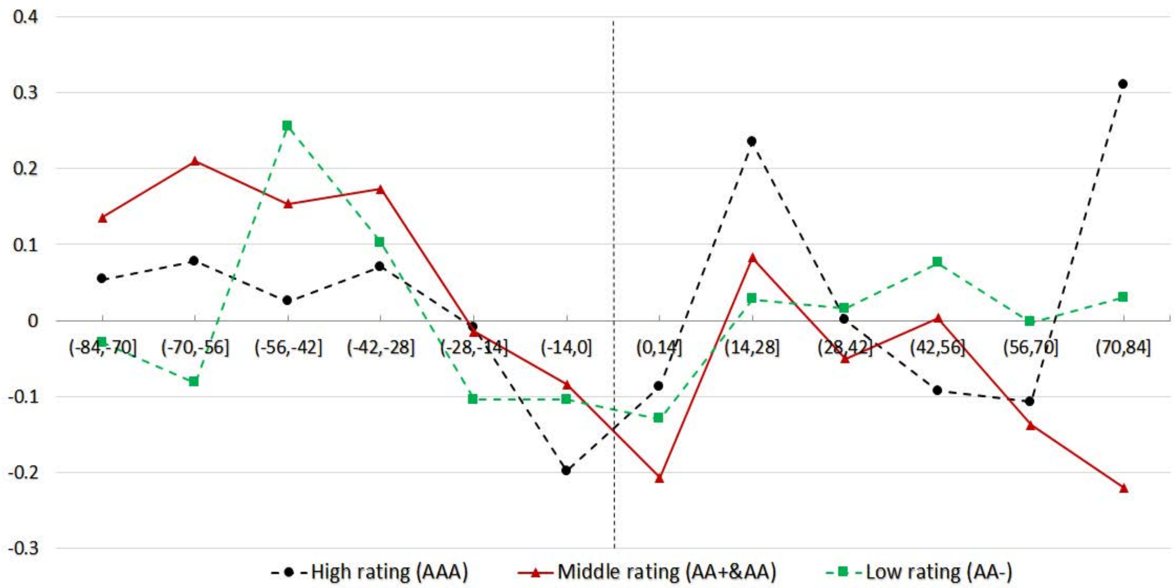
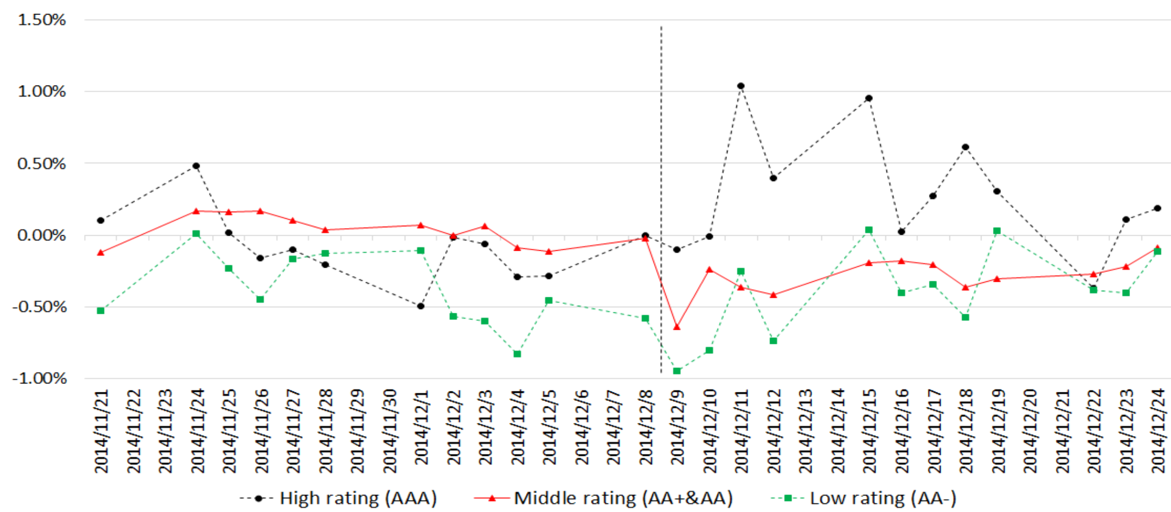


Figure IA6: The difference between the interbank and the exchange credit spreads

This figure plots the average difference between the interbank credit spread and the exchange credit spread. Panel A plots the average daily interbank credit spread minus the average exchange credit spread, where the average credit spreads are taken over all non-zero trading days for each market, respectively. Panel B plots the average interbank-exchange spread of matched enterprise bonds within three-day windows. For a non-zero trading bond-day observation on the interbank (exchange) market, we match those exchange (interbank) market observations on the same day with the same bond rating, similar haircut, and similar issuer size. Bonds are divided into 20 groups according to haircut and issuer size, respectively. A bond with interbank (exchange) market trading is matched with another bond with exchange (interbank) market trading if both bonds have the same rating and belong to the same haircut/issuer size group. The average is taken over all those (both directions) matched pairs within three-day subperiods. The dotted line indicates the event on 12/8/2014. The sample is one month ((−12, 12]-trading days) around the event.

Panel A: Average interbank credit spread minus average exchange credit spread




Panel B: Average interbank-exchange spread of matched enterprise bonds

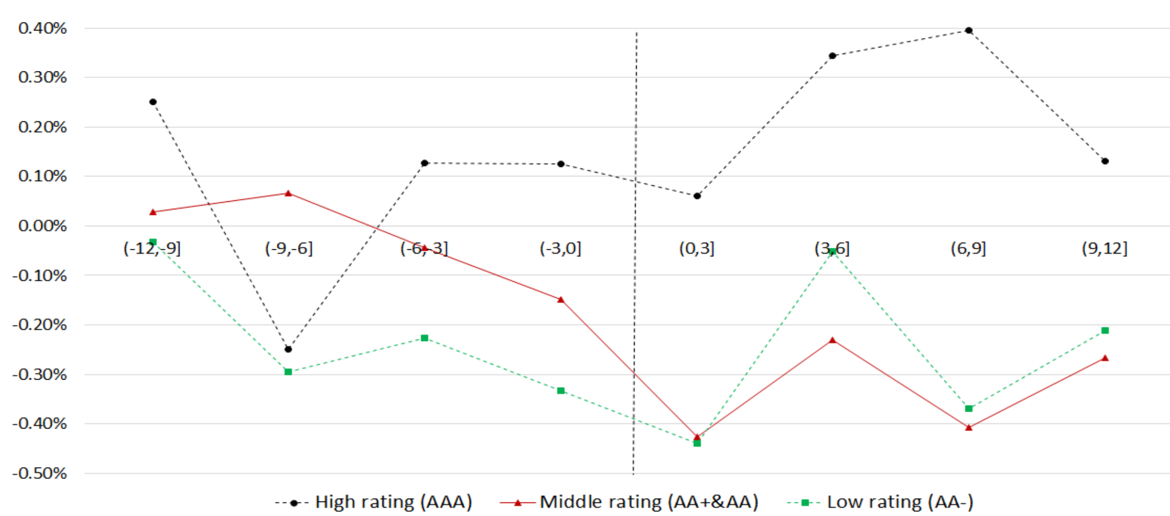
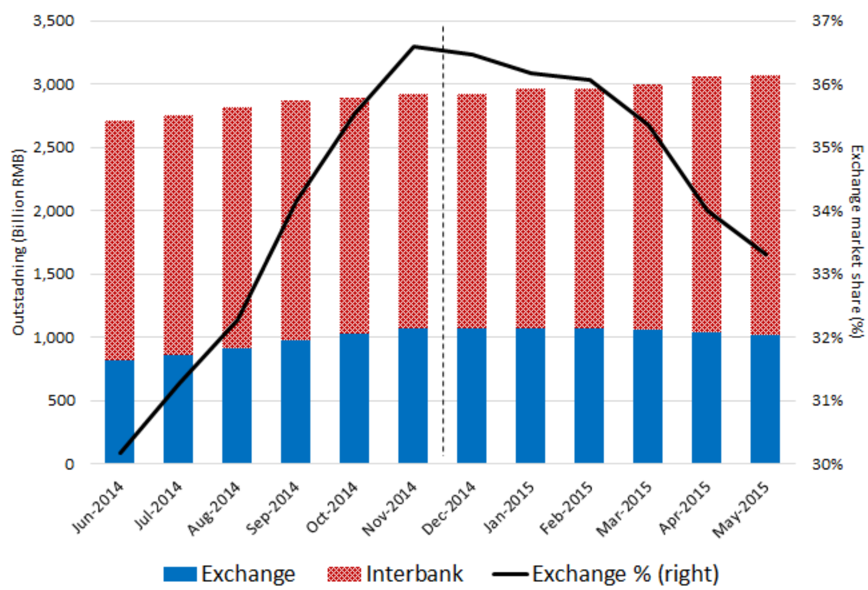


Figure IA7: Impact on bonds in custody

This figure plots the impact of the CSDC event on bonds in custody. Panel A plots the monthly RMB value of dual-listed enterprise bonds in custody on the two markets. Panel B plots the monthly RMB value of Treasury bonds in custody on the two markets. The share of bonds in custody in the exchange market is plotted in solid line. The dotted line indicates the CSDC event on 12/8/2014. The the aggregate RMB value of bonds outstanding is from WIND and the end-of-month bonds in custody on the exchange is from CSDC monthly statistics. The sample period is 6/9/2014 to 6/8/2015.

Panel A: Enterprise bonds in custody by market




Panel B: Treasury bonds in custody by market

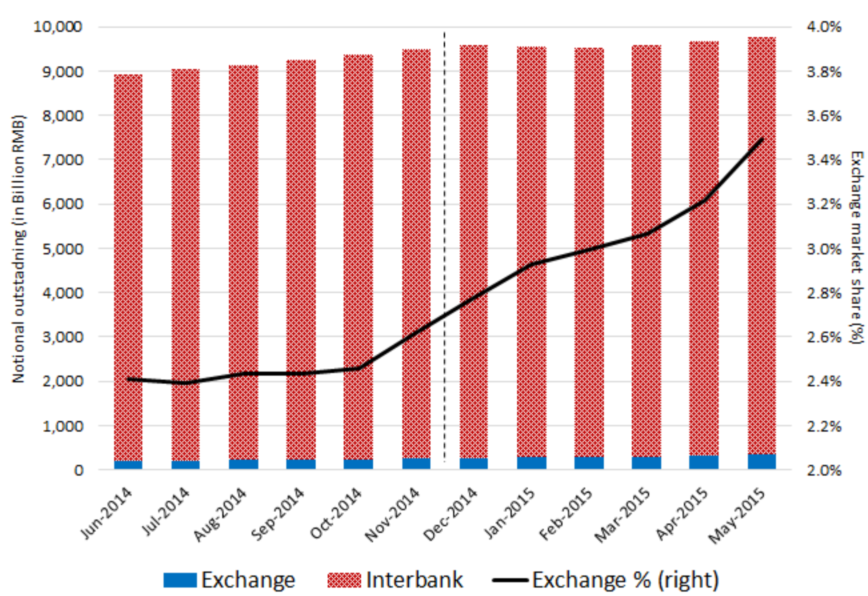
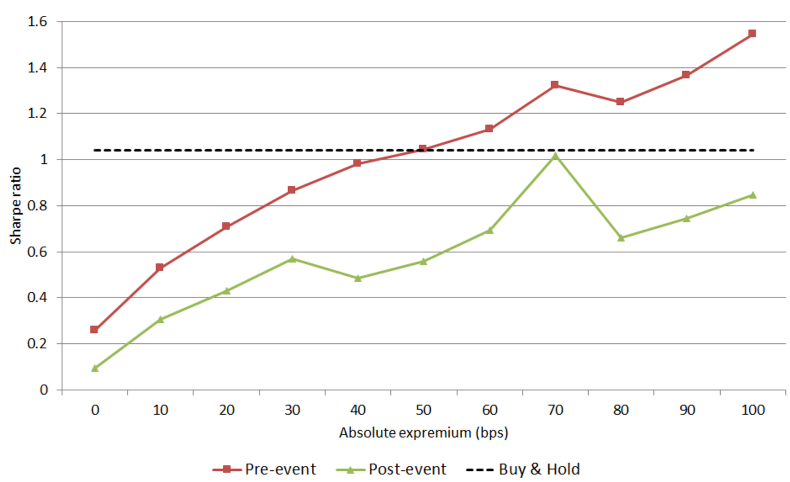


Figure IA8: Sharpe ratio and average holding days of cross-market arbitrage trades

This figure plots the Sharpe ratio (Panel A) and average holding days (Panel B) of cross-market arbitrage trades conditional on the magnitude of exchange premium. When the exchange premium is positively above the 10-bp cutoffs, an arbitrage trade is to "buy on the interbank and sell on the exchange"; when the exchange premium is negatively below the 10-bp cutoffs, an arbitrage trade is to "buy on the exchange and sell on the interbank". The waiting time for change of depository is five working days. The volume-weighted average prices on the interbank market and the volume-weighted average bid/ask prices on the exchange are used. According to industry practice, a minimum daily interbank market trading volume of RMB 10 million and a minimum daily exchange market trading volume of RMB 0.5 million are required. The pace of selling/buying on the exchange is capped at 20% of its daily volume. The transaction cost is 0.0001% for the exchange market and 0.005% for the interbank market. The accrued interest is included in calculating returns of arbitrage positions. The "buy & hold" strategy is based on the ChinaBond Enterprise Bond Total Index (WIND ticker: CBA02001.CS). The risk-free rate is the return of ChinaBond China Development Bank Bond Total Index (WIND ticker: CBA02501.CS). The average holding days is calculated across all arbitrage positions that are initiated during the sample period of 6/9/2014 to 6/8/2015.

Panel A: Sharpe ratio for cross-market arbitrage conditional on exchange premium




Panel B: Average holding days for cross-market arbitrage positions

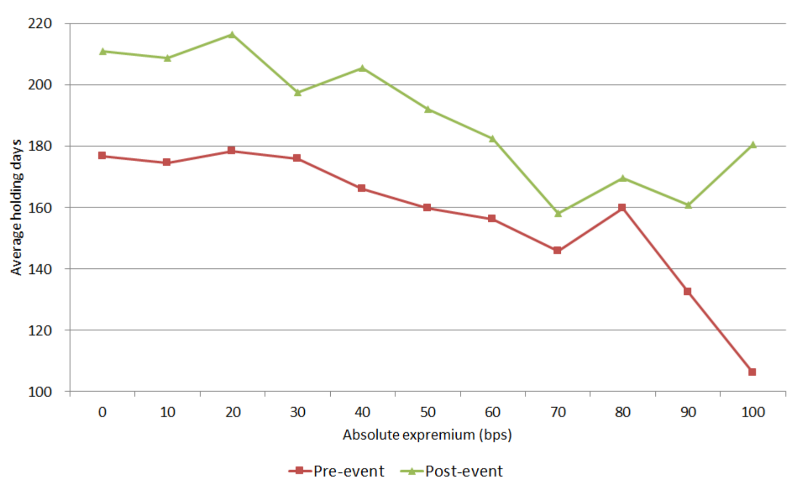


Table IA1: Summary statistics: Same-day trading sample

This table reports the summary statistics of the same-day trading sample from 6/9/2014 to 6/8/2015. The table presents number of observations, the mean, the standard deviation, the 10th percentile, the median, and the 90th percentile. Panel A presents the summary statistics of key variables. Panel B presents the summary statistics of exchange premia by rating. Panel C presents the summary statistics of haircuts by rating.

Panel A: All variables

| | N | Mean | STD | P10 | Median | P90 |
|---|---|---|---|---|---|---|
| EX premium | 3514 | -0.07 | 0.48 | -0.66 | -0.03 | 0.49 |
| EX $\text{premium}_{pre}$ | 1719 | 0.06 | 0.40 | -0.39 | 0.03 | 0.56 |
| EX $\text{premium}_{post}$ | 1795 | -0.18 | 0.51 | -0.79 | -0.13 | 0.40 |
| Haircut | 3514 | 70.15 | 37.84 | 15.88 | 100.00 | 100.00 |
| $\text{Haircut}_{pre}$ | 1719 | 43.80 | 33.89 | 8.10 | 30.87 | 100.00 |
| $\text{Haircut}_{post}$ | 1795 | 95.38 | 20.04 | 100.00 | 100.00 | 100.00 |
| Conversion | 3514 | 31.60 | 40.15 | 0.00 | 0.00 | 87.00 |
| $\text{Conversion}_{pre}$ | 1719 | 59.54 | 36.13 | 0.00 | 73.00 | 97.00 |
| $\text{Conversion}_{post}$ | 1795 | 4.84 | 21.03 | 0.00 | 0.00 | 0.00 |
| IB spread | 3514 | 2.47 | 0.79 | 1.47 | 2.48 | 3.46 |
| EX spread | 3514 | 2.53 | 0.85 | 1.39 | 2.60 | 3.51 |
| Maturity | 3514 | 5.11 | 1.56 | 3.07 | 5.21 | 6.73 |
| Turnover | 3514 | 0.08 | 0.08 | 0.02 | 0.06 | 0.19 |
| Market price | 3514 | 104.89 | 5.77 | 100.22 | 105.27 | 110.63 |
| Volatility | 3514 | 0.02 | 0.02 | 0.00 | 0.01 | 0.04 |
| $\text{CDB}_{spot}$ | 3514 | 0.04 | 0.01 | 0.04 | 0.04 | 0.05 |
| Term spread | 3514 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 |
| GC001−SHIBOR | 3514 | 0.02 | 0.04 | 0.00 | 0.01 | 0.05 |
| $\text{Ret}_{stock}$ | 3514 | 0.00 | 0.02 | -0.01 | 0.00 | 0.02 |

Panel B: Exchange premia by rating

| | N | Mean | STD | P10 | Median | P90 |
|---|---|---|---|---|---|---|
| AAA | 139 | 0.08 | 0.36 | -0.42 | 0.03 | 0.57 |
| AA+ | 1025 | -0.02 | 0.48 | -0.61 | -0.01 | 0.51 |
| AA | 1784 | -0.12 | 0.48 | -0.72 | -0.09 | 0.45 |
| AA− | 566 | -0.01 | 0.48 | -0.49 | 0.00 | 0.52 |

Panel C: Haircuts by rating

| | N | Mean | STD | P10 | Median | P90 |
|---|---|---|---|---|---|---|
| AAA | 139 | 11.43 | 11.03 | 5.46 | 6.75 | 26.01 |
| AA+ | 1025 | 64.16 | 40.71 | 7.44 | 100.00 | 100.00 |
| AA | 1784 | 68.69 | 35.86 | 28.03 | 100.00 | 100.00 |
| AA− | 566 | 100.00 | 0.00 | 100.00 | 100.00 | 100.00 |

Table IA2: Market reactions to the five black-list announcements

This table reports the average market reactions by rating and market of the five black-list announcements. The five announcements were made on 5/29/2014, 6/27/2014, 8/1/2014, 9/5/2014, and 11/3/2014. The average one-day post-announcement changes in credit spreads are reported in basis point. No IB transaction was on 5/30/2014 for AA− bonds so the change in IB credit spread cannot be calculated. Standard errors are reported in parentheses with "(−)" indicating not enough observation for the standard error estimation. The symbols *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

| | EX market | | | | IB market | | | |
|---|---|---|---|---|---|---|---|---|
| | AAA | AA+ | AA | AA− | AAA | AA+ | AA | AA− |
| $\Delta\text{Spread}^{5/29}$ | -8.31 | 0.46 | 0.86 | 3.23 | 33.26 | -3.84 | 9.97 | |
| | (17.87) | (9.35) | (8.45) | (−) | (26.19) | (12.95) | (9.02) | |
| $\Delta\text{Spread}^{6/27}$ | 1.24 | 4.54 | 14.71 | 2.92 | -16.75 | -3.91 | -1.19 | -8.34 |
| | (19.52) | (10.65) | (11.38) | (71.77) | (21.42) | (11.55) | (8.02) | (−) |
| $\Delta\text{Spread}^{8/1}$ | -17.73 | -0.30 | -3.79 | 1.85 | -40.20 | -1.33 | 2.31 | 33.58 |
| | (18.14) | (9.79) | (13.93) | (23.04) | (26.01) | (16.35) | (8.16) | (−) |
| $\Delta\text{Spread}^{9/5}$ | 6.41 | 1.56 | 3.45 | 6.10 | -51.78** | 8.44 | 1.08 | -20.24 |
| | (11.47) | (11.45) | (15.22) | (12.69) | (24.22) | (19.59) | (7.29) | (48.63) |
| $\Delta\text{Spread}^{11/3}$ | 8.63 | 7.71 | 8.43 | 13.17 | 21.05 | 40.66*** | 16.76** | -7.53 |
| | (14.45) | (9.78) | (10.44) | (12.03) | (29.52) | (14.50) | (7.90) | (34.75) |

Table IA3: OLS estimation

This table reports the results of OLS regressions using the simultaneous trading sample. Columns (1) and (2) present the results using full sample, without and with control variables, respectively. Column (3) presents the results using a subsample of AA+, AA, and AA− bonds. Column (4) presents the results using a subsample of AA+, AA, and AAA bonds. Column (5) presents the results using a subsample of AA+, AAA, and AA− bonds. Column (6) presents the results using a subsample of AA, AAA, and AA− bonds. The sample period is 6/9/2014 to 6/8/2015. Heteroscedasticity-consistent standard errors clustered by week are reported in parentheses. The symbols *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

| Dependent: Haircut | Full | | Exclude AAA | Exclude AA− | Exclude AA | Exclude AA+ |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Haircut | -0.34*** | -0.37*** | -0.38*** | -0.34*** | -0.41*** | -0.34*** |
| | (0.03) | (0.04) | (0.05) | (0.06) | (0.05) | (0.05) |
| Maturity | | 2.76*** | 2.85*** | 3.06*** | 3.29*** | 1.85* |
| | | (0.81) | (0.82) | (0.86) | (1.02) | (0.94) |
| Turnover | | 0.12 | 0.10 | 0.13 | 0.23 | 0.09 |
| | | (0.09) | (0.09) | (0.10) | (0.14) | (0.09) |
| Market price | | -0.00 | -0.00 | -0.00 | -0.01 | -0.00 |
| | | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |
| Volatility | | 0.02 | -0.08 | 0.20 | -0.64 | 0.23 |
| | | (1.04) | (1.06) | (1.12) | (1.71) | (0.78) |
| $CDB_{spot}$ | | -28.14** | -30.40*** | -20.01* | -34.58*** | -27.49* |
| | | (11.05) | (11.35) | (11.29) | (12.90) | (15.15) |
| Term spread | | 28.11* | 28.67* | 27.93 | 36.14** | 23.85 |
| | | (15.82) | (15.47) | (16.98) | (17.38) | (18.18) |
| GC001−SHIBOR | | -0.15 | -0.15 | -0.07 | -0.10 | -0.27** |
| | | (0.15) | (0.15) | (0.14) | (0.19) | (0.13) |
| $Ret_{stock}$ | | 0.46 | 0.43 | 0.48 | 0.40 | 0.42 |
| | | (0.43) | (0.43) | (0.49) | (0.42) | (0.47) |
| Bond FE | – | ✓ | ✓ | ✓ | ✓ | ✓ |
| Rating FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Week FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| $R^2$ | 0.12 | 0.48 | 0.47 | 0.49 | 0.41 | 0.53 |
| N | 10235 | 10070 | 9615 | 8550 | 4993 | 7039 |

## Table IA4: IV estimation: Robustness with alternative controls

This table reports the results of IV regressions using the simultaneous trading sample with alternative control variables. $\text{Turnover}^{ex}/\text{Turnover}^{ib}$ is the bond-day-market level turnover. $\text{Turnover}^{ex}_{rating}/\text{Turnover}^{ib}_{rating}$ is the rating-day-market level turnover. Panels A and B present the results for the first and second stage regressions. Columns (1) and (2) present the results using full sample, without and with control variables, respectively. Column (3) presents the results using a subsample of AA+, AA, and AA− bonds. Column (4) presents the results using a subsample of AA+, AA, and AAA bonds. Column (5) presents the results using a subsample of AA+, AAA, and AA− bonds. Column (6) presents the results using a subsample of AA, AAA, and AA− bonds. The sample period is 6/9/2014 to 6/8/2015. Heteroscedasticity-consistent standard errors clustered by week are reported in parentheses. The symbols *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: First stage

| Dependent: Haircut | Full | | Exclude AAA | Exclude AA− | Exclude AA | Exclude AA+ |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Shock | 68.00*** | 68.21*** | 68.27*** | 67.77*** | 74.77*** | 63.54*** |
| | (0.64) | (0.69) | (0.73) | (0.64) | (0.90) | (0.80) |
| Controls | – | ✓ | ✓ | ✓ | ✓ | ✓ |
| Bond FE | – | ✓ | ✓ | ✓ | ✓ | ✓ |
| Rating FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Week FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| $R^2$ | 0.85 | 0.95 | 0.95 | 0.95 | 0.97 | 0.96 |
| N | 10235 | 10070 | 9615 | 8550 | 4993 | 7039 |

Panel B: Second stage

| Dependent: EX Premia | Full | | Exclude AAA | Exclude AA− | Exclude AA | Exclude AA+ |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\widehat{Haircut}$ | -0.39*** | -0.39*** | -0.40*** | -0.33*** | -0.39*** | -0.40*** |
| | (0.05) | (0.05) | (0.05) | (0.10) | (0.05) | (0.05) |
| Maturity | | 2.69*** | 2.78*** | 2.99*** | 3.08*** | 1.84* |
| | | (0.84) | (0.86) | (0.89) | (1.09) | (0.95) |
| $\text{Turnover}^{ex}$ | | 1.07** | 1.01** | 1.04** | 1.53* | 1.01* |
| | | (0.44) | (0.43) | (0.50) | (0.89) | (0.53) |
| $\text{Turnover}^{ib}$ | | 0.10 | 0.09 | 0.11 | 0.19 | 0.07 |
| | | (0.09) | (0.09) | (0.10) | (0.15) | (0.10) |
| Market price | | -0.00 | -0.00 | -0.00 | -0.01 | -0.00 |
| | | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |
| Volatility | | 0.04 | -0.06 | 0.21 | -0.65 | 0.25 |
| | | (1.04) | (1.06) | (1.13) | (1.71) | (0.77) |
| $\text{Turnover}^{ex}_{rating}$ | | 7.41 | 8.89 | -18.80 | 23.83 | 8.02 |
| | | (14.34) | (14.73) | (21.04) | (19.23) | (13.36) |
| $\text{Turnover}^{ib}_{rating}$ | | 1.24 | 1.09 | 1.66 | 4.27 | -0.21 |
| | | (1.97) | (2.01) | (2.32) | (2.68) | (1.91) |
| $\text{CDB}_{spot}$ | | -27.55** | -29.85** | -19.64* | -31.48** | -27.60* |
| | | (11.26) | (11.57) | (11.26) | (14.65) | (15.19) |
| Term spread | | 27.98* | 28.56* | 27.84 | 38.28** | 24.21 |
| | | (15.99) | (15.68) | (17.21) | (17.52) | (18.49) |
| GC001−SHIBOR | | -0.14 | -0.14 | -0.07 | -0.07 | -0.26** |
| | | (0.14) | (0.15) | (0.14) | (0.20) | (0.13) |
| $\text{Ret}_{stock}$ | | 0.45 | 0.41 | 0.47 | 0.33 | 0.41 |
| | | (0.43) | (0.43) | (0.50) | (0.43) | (0.47) |
| Bond FE | – | ✓ | ✓ | ✓ | ✓ | ✓ |
| Rating FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Week FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| $R^2$ | 0.12 | 0.48 | 0.47 | 0.49 | 0.41 | 0.53 |
| N | 10235 | 10070 | 9615 | 8550 | 4993 | 7039 |

## Table IA5: IV estimation using matched AAA bonds as a benchmark: Robustness with alternative controls

This table reports the results of IV regressions using the matched AAA bonds as a benchmark using alternative control variables. The dependent variable is the spreads between the matched AAA bonds and that of AA+/AA dual-listed enterprise bonds, where the matching criteria include credit spread and haircut before 12/8/2014. Control variables indicated with "bmk" refer to the average value of matched AAA bonds. $\text{Turnover}^{ex}_{rating}$/$\text{Turnover}^{ib}_{rating}$ is the rating-day-market level turnover. Panels A and B present the results for the first and second stage. The sample period is 6/9/2014 to 6/8/2015. Heteroscedasticity-consistent standard errors clustered by week are reported in parentheses. The symbols *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: First stage

| Dependent: | Full | | AA+ | AA |
|---|---|---|---|---|
| Haircut | (1) | (2) | (3) | (4) |
| Shock | 86.17*** | 84.41*** | 86.50*** | 77.56*** |
| | (0.90) | (1.29) | (0.85) | (1.28) |
| Controls | – | ✓ | ✓ | ✓ |
| Bond FE | – | ✓ | ✓ | ✓ |
| Rating FE | ✓ | ✓ | ✓ | ✓ |
| $R^2$ | 0.98 | 0.99 | 0.99 | 0.99 |
| N | 9940 | 9897 | 7548 | 2349 |

Panel B: Second stage

| Dependent: | Full | | AA+ | AA |
|---|---|---|---|---|
| $\text{Spread}^{matched-AAA}$ | (1) | (2) | (3) | (4) |
| $\widehat{Haircut}$ | -0.74*** | -0.82*** | -0.82*** | -0.79*** |
| | (0.02) | (0.04) | (0.04) | (0.09) |
| Maturity | | -0.02 | 0.04 | -0.14 |
| | | (0.11) | (0.11) | (0.17) |
| Turnover | | 2.23* | 1.22 | 5.99** |
| | | (1.24) | (1.05) | (2.67) |
| Market price | | -0.00 | -0.00 | 0.01 |
| | | (0.00) | (0.00) | (0.01) |
| Volatility | | 0.12 | -0.96 | 1.96 |
| | | (0.95) | (1.33) | (1.29) |
| $\text{Maturity}_{bmk}$ | | 0.03*** | 0.02** | 0.07*** |
| | | (0.01) | (0.01) | (0.02) |
| $\text{Turnover}_{bmk}$ | | -4.30** | -2.20 | -11.51*** |
| | | (1.97) | (1.56) | (2.64) |
| $\text{Market price}_{bmk}$ | | 0.00*** | 0.00*** | 0.00** |
| | | (0.00) | (0.00) | (0.00) |
| $\text{Volatility}_{bmk}$ | | -3.32*** | -3.33*** | -4.37* |
| | | (1.24) | (1.08) | (2.29) |
| $\text{Turnover}^{ex}_{rating}$ | | 31.53 | 52.98 | -156.53 |
| | | (54.75) | (55.23) | (106.52) |
| $\text{Turnover}^{ib}_{rating}$ | | -0.85 | -0.73 | -4.27 |
| | | (4.92) | (5.08) | (7.08) |
| $\text{CDB}_{spot}$ | | -8.55* | -9.24** | -5.44 |
| | | (4.84) | (4.51) | (7.85) |
| Term spread | | 1.59 | -0.99 | 11.01 |
| | | (6.24) | (5.16) | (11.83) |
| GC001−SHIBOR | | -0.10 | -0.04 | -0.26 |
| | | (0.27) | (0.23) | (0.51) |
| $\text{Ret}_{stock}$ | | 0.80 | 0.98 | 0.18 |
| | | (0.64) | (0.62) | (0.82) |
| Bond FE | – | ✓ | ✓ | ✓ |
| Rating FE | ✓ | ✓ | ✓ | ✓ |
| $R^2$ | 0.15 | 0.56 | 0.57 | 0.57 |
| N | 9940 | 9897 | 7548 | 2349 |

Table IA6: IV estimation: Impacts on turnover

This table reports the second-stage results of IV regressions using log difference of turnovers in the two markets as the dependent variable. Columns (1) and (2) present the results using full sample, without and with control variables, respectively. Column (3) presents the results using a subsample of AA+, AA, and AA− bonds. Column (4) presents the results using a subsample of AA+, AA, and AAA bonds. Column (5) presents the results using a subsample of AA+, AAA, and AA− bonds. Column (6) presents the results using a subsample of AA, AAA, and AA− bonds. The sample period is 6/9/2014 to 6/8/2015. Heteroscedasticity-consistent standard errors clustered by week are reported in parentheses. The symbols *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: First stage

| Dependent: Haircut | Full | | Exclude AAA | Exclude AA− | Exclude AA | Exclude AA+ |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Shock | 68.00*** | 68.20*** | 68.27*** | 67.84*** | 74.83*** | 63.67*** |
| | (0.64) | (0.65) | (0.67) | (0.64) | (0.87) | (0.79) |
| Controls | – | ✓ | ✓ | ✓ | ✓ | ✓ |
| Bond FE | – | ✓ | ✓ | ✓ | ✓ | ✓ |
| Rating FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Week FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| $R^2$ | 0.85 | 0.95 | 0.95 | 0.95 | 0.97 | 0.96 |
| N | 10235 | 10070 | 9615 | 8550 | 4993 | 7039 |

Panel B: Second stage

| Dependent: $\log(\text{Turnover}^{ex}/\text{Turnover}^{ib})$ | Full | | Exclude AAA | Exclude AA− | Exclude AA | Exclude AA+ |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\widehat{Haircut}$ | -1.36*** | -0.78** | -0.99*** | 0.13 | -0.69** | -0.70* |
| | (0.30) | (0.32) | (0.35) | (0.73) | (0.29) | (0.39) |
| Maturity | | 6.85 | 6.43 | 5.81 | 13.22* | 3.27 |
| | | (5.68) | (5.67) | (6.04) | (7.77) | (6.18) |
| Market price | | 0.01 | 0.01 | 0.00 | 0.03** | 0.01 |
| | | (0.01) | (0.01) | (0.01) | (0.01) | (0.02) |
| Volatility | | -13.38*** | -13.02*** | -11.76*** | -8.65** | -19.44*** |
| | | (3.02) | (3.20) | (3.19) | (4.17) | (3.25) |
| $\text{CDB}_{spot}$ | | -145.08** | -144.23* | -203.76*** | -177.85* | -74.69 |
| | | (70.10) | (73.79) | (74.88) | (92.88) | (64.79) |
| Term spread | | 109.01 | 117.94 | 141.36* | 215.45* | -16.05 |
| | | (77.13) | (78.44) | (82.25) | (108.05) | (86.06) |
| GC001−SHIBOR | | -2.54*** | -2.58*** | -2.22** | -4.02*** | -1.58** |
| | | (0.60) | (0.62) | (0.91) | (0.71) | (0.74) |
| $\text{Ret}_{stock}$ | | 2.52 | 3.24 | 2.09 | 2.46 | 2.07 |
| | | (2.51) | (2.48) | (2.61) | (3.01) | (2.86) |
| Bond FE | – | ✓ | ✓ | ✓ | ✓ | ✓ |
| Rating FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Week FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| $R^2$ | 0.06 | 0.38 | 0.38 | 0.39 | 0.37 | 0.39 |
| N | 10235 | 10070 | 9615 | 8550 | 4993 | 7039 |

Table IA7: IV estimation: Same-day sample

This table reports the results of IV regressions using the same-day trading sample. Panels A and B present the results for the first and second stage regressions. Columns (1) and (2) present the results using full sample, without and with control variables, respectively. Column (3) presents the results using a subsample of AA+, AA, and AA− bonds. Column (4) presents the results using a subsample of AA+, AA, and AAA bonds. Column (5) presents the results using a subsample of AA+, AAA, and AA− bonds. Column (6) presents the results using a subsample of AA, AAA, and AA− bonds. The sample period is 6/9/2014 to 6/8/2015. Heteroscedasticity-consistent standard errors clustered by week are reported in parentheses. The symbols *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: First stage

| Dependent: Haircut | Full | | Exclude AAA | Exclude AA− | Exclude AA | Exclude AA+ |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Shock | 66.95*** | 69.16*** | 69.21*** | 69.07*** | 75.51*** | 64.69*** |
| | (0.92) | (1.08) | (1.13) | (0.88) | (1.52) | (1.24) |
| Controls | – | ✓ | ✓ | ✓ | ✓ | ✓ |
| Bond FE | – | ✓ | ✓ | ✓ | ✓ | ✓ |
| Rating FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Week FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| $R^2$ | 0.84 | 0.96 | 0.95 | 0.95 | 0.97 | 0.97 |
| N | 3514 | 3257 | 3137 | 2688 | 1613 | 2314 |

Panel B: Second stage

| Dependent: EX Premia | Full | | Exclude AAA | Exclude AA− | Exclude AA | Exclude AA+ |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\widehat{Haircut}$ | -0.40*** | -0.39*** | -0.41*** | -0.21 | -0.39*** | -0.37*** |
| | (0.06) | (0.07) | (0.08) | (0.15) | (0.08) | (0.08) |
| Maturity | | 3.03** | 3.09** | 3.96*** | 4.06* | 1.21 |
| | | (1.26) | (1.26) | (1.33) | (2.13) | (1.47) |
| Turnover | | 0.03 | 0.01 | 0.05 | 0.14 | -0.02 |
| | | (0.12) | (0.11) | (0.14) | (0.19) | (0.11) |
| Market price | | -0.01 | -0.01 | -0.00 | -0.01* | -0.00 |
| | | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |
| Volatility | | -1.52 | -1.73 | -1.36 | -2.56 | -0.73 |
| | | (1.61) | (1.63) | (1.74) | (2.34) | (1.32) |
| $CDB_{spot}$ | | -34.86** | -38.97** | -11.31 | -52.75* | -37.98** |
| | | (14.44) | (14.88) | (15.07) | (30.30) | (14.37) |
| Term spread | | 46.10** | 44.06** | 47.36** | 82.84** | 22.39 |
| | | (19.51) | (19.41) | (18.87) | (32.79) | (18.94) |
| GC001−SHIBOR | | -0.32 | -0.32 | -0.50** | -0.14 | -0.28 |
| | | (0.28) | (0.29) | (0.25) | (0.30) | (0.41) |
| $Ret_{stock}$ | | 0.11 | -0.03 | -0.26 | 0.24 | 0.37 |
| | | (0.57) | (0.56) | (0.61) | (0.93) | (0.77) |
| Bond FE | – | ✓ | ✓ | ✓ | ✓ | ✓ |
| Rating FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Week FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| $R^2$ | 0.15 | 0.53 | 0.53 | 0.54 | 0.48 | 0.59 |
| N | 3514 | 3257 | 3137 | 2688 | 1613 | 2314 |

## Table IA8: IV estimation using same-day sample: Robustness with alternative controls

This table reports the results of IV regressions using the same-day trading sample with alternative control variables. $\text{Turnover}^{ex}/\text{Turnover}^{ib}$ is the bond-day-market level turnover. $\text{Turnover}^{ex}_{rating}/\text{Turnover}^{ib}_{rating}$ is the rating-day-market level turnover. Panels A and B present the results for the first and second stage regressions. Columns (1) and (2) present the results using full sample, without and with control variables, respectively. Column (3) presents the results using a subsample of AA+, AA, and AA− bonds. Column (4) presents the results using a subsample of AA+, AA, and AAA bonds. Column (5) presents the results using a subsample of AA+, AAA, and AA− bonds. Column (6) presents the results using a subsample of AA, AAA, and AA− bonds. The sample period is 6/9/2014 to 6/8/2015. Heteroscedasticity-consistent standard errors clustered by week are reported in parentheses. The symbols *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: First stage

| Dependent: Haircut | Full | | Exclude AAA | Exclude AA− | Exclude AA | Exclude AA+ |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Shock | 66.95*** | 69.08*** | 69.09*** | 69.41*** | 75.44*** | 64.37*** |
| | (0.92) | (1.18) | (1.26) | (0.83) | (1.53) | (1.27) |
| Controls | – | ✓ | ✓ | ✓ | ✓ | ✓ |
| Bond FE | – | ✓ | ✓ | ✓ | ✓ | ✓ |
| Rating FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Week FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| $R^2$ | 0.84 | 0.96 | 0.95 | 0.95 | 0.97 | 0.97 |
| N | 3514 | 3257 | 3137 | 2688 | 1613 | 2314 |

Panel B: Second stage

| Dependent: EX Premia | Full | | Exclude AAA | Exclude AA− | Exclude AA | Exclude AA+ |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $\widehat{Haircut}$ | -0.40*** | -0.38*** | -0.40*** | -0.25* | -0.39*** | -0.37*** |
| | (0.06) | (0.08) | (0.08) | (0.15) | (0.08) | (0.08) |
| Maturity | | 3.13** | 3.19** | 4.22*** | 3.90* | 1.30 |
| | | (1.25) | (1.25) | (1.38) | (2.13) | (1.47) |
| $\text{Turnover}^{ex}$ | | 1.27* | 1.26* | 1.51* | 1.72 | 0.91 |
| | | (0.71) | (0.72) | (0.82) | (1.49) | (0.74) |
| $\text{Turnover}^{ib}$ | | 0.02 | -0.00 | 0.04 | 0.12 | -0.03 |
| | | (0.12) | (0.12) | (0.14) | (0.20) | (0.12) |
| Market price | | -0.01 | -0.01 | -0.00 | -0.01* | -0.00 |
| | | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |
| Volatility | | -1.54 | -1.75 | -1.40 | -2.54 | -0.75 |
| | | (1.61) | (1.63) | (1.75) | (2.34) | (1.32) |
| $\text{Turnover}^{ex}_{rating}$ | | -1.86 | 2.26 | -94.14* | 29.30 | 0.63 |
| | | (15.69) | (15.38) | (48.17) | (24.69) | (16.01) |
| $\text{Turnover}^{ib}_{rating}$ | | -3.53 | -3.33 | -7.13 | 0.48 | -3.89 |
| | | (3.49) | (3.53) | (4.51) | (4.43) | (3.33) |
| $\text{CDB}_{spot}$ | | -36.84** | -40.77** | -11.00 | -51.44 | -40.12*** |
| | | (14.80) | (15.37) | (13.80) | (31.35) | (14.57) |
| Term spread | | 45.85** | 44.13** | 43.25** | 84.90** | 23.24 |
| | | (18.97) | (18.96) | (16.90) | (32.15) | (18.82) |
| GC001−SHIBOR | | -0.32 | -0.31 | -0.60** | -0.08 | -0.28 |
| | | (0.29) | (0.30) | (0.25) | (0.30) | (0.42) |
| $\text{Ret}_{stock}$ | | 0.12 | -0.02 | -0.25 | 0.18 | 0.38 |
| | | (0.57) | (0.56) | (0.63) | (0.92) | (0.77) |
| Bond FE | – | ✓ | ✓ | ✓ | ✓ | ✓ |
| Rating FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Week FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| $R^2$ | 0.15 | 0.53 | 0.53 | 0.54 | 0.48 | 0.59 |
| N | 3514 | 3257 | 3137 | 2688 | 1613 | 2314 |

Table IA9: IV estimation: different cleaning methodologies for outliers

This table reports the results of IV regressions with different cleaning methodologies for yield/exchange premium outliers. Panels A and B present the results for the first and second stage regressions using full sample with control variables. Column (1) presents the results when interbank and exchange yields are winsorized at 0.5% and 99.5%. Columns (2)/(3) present the results when interbank and exchange yields are truncated at 0.5%/1% and 99.5%/99%, respectively. Columns (4)/(5) presents the results when exchange premia are winsorized at 0.5%/1% and 99.5%/99%. Columns (6)/(7) present the results when exchange premia are truncated at 0.5%/1% and 99.5%/99%. The sample period is 6/9/2014 to 6/8/2015. Heteroscedasticity-consistent standard errors clustered by week are reported in parentheses. The symbols *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: First stage

| Dependent: | At yield level | | | At exchange premium level | | | |
|---|---|---|---|---|---|---|---|
| Haircut | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| Shock | 68.20*** | 68.19*** | 68.10*** | 68.20*** | 68.20*** | 68.21*** | 68.23*** |
| | (0.65) | (0.67) | (0.67) | (0.65) | (0.65) | (0.66) | (0.65) |
| Controls | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Bond FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Rating FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Week FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| $R^2$ | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 | 0.95 |
| N | 10070 | 9902 | 9756 | 10070 | 10070 | 9965 | 9858 |

Panel B: Second stage

| Dependent: | At yield level | | | At exchange premium level | | | |
|---|---|---|---|---|---|---|---|
| Haircut | (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| $\widehat{Haircut}$ | -0.38*** | -0.37*** | -0.38*** | -0.40*** | -0.39*** | -0.40*** | -0.36*** |
| | (0.05) | (0.05) | (0.04) | (0.04) | (0.04) | (0.05) | (0.05) |
| Maturity | 2.75*** | 2.76*** | 2.76*** | 2.76*** | 2.64*** | 2.46*** | 2.19*** |
| | (0.80) | (0.78) | (0.78) | (0.78) | (0.76) | (0.76) | (0.72) |
| Turnover | 0.11 | 0.09 | 0.08 | 0.11 | 0.11 | 0.09 | 0.12 |
| | (0.08) | (0.08) | (0.08) | (0.08) | (0.08) | (0.08) | (0.08) |
| Market price | -0.00 | -0.00 | -0.00 | -0.00 | -0.00 | -0.00 | -0.00 |
| | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) | (0.00) |
| Volatility | 0.08 | 0.69 | 0.55 | 0.18 | 0.16 | 0.42 | 0.41 |
| | (1.02) | (0.85) | (0.83) | (0.78) | (0.71) | (0.57) | (0.52) |
| $CDB_{spot}$ | -28.07** | -26.43** | -25.78** | -26.46** | -24.74** | -21.79** | -18.70** |
| | (11.11) | (10.74) | (10.68) | (10.28) | (9.82) | (9.62) | (9.00) |
| Term spread | 27.10* | 23.20 | 22.14 | 26.08* | 25.19* | 22.07 | 22.04* |
| | (15.80) | (14.86) | (15.00) | (15.04) | (14.50) | (14.20) | (12.50) |
| GC001−SHIBOR | -0.14 | -0.14 | -0.15 | -0.12 | -0.12 | -0.13 | -0.09 |
| | (0.14) | (0.12) | (0.13) | (0.14) | (0.13) | (0.13) | (0.11) |
| $Ret_{stock}$ | 0.48 | 0.46 | 0.51 | 0.45 | 0.44 | 0.36 | 0.35 |
| | (0.43) | (0.38) | (0.38) | (0.40) | (0.40) | (0.40) | (0.35) |
| Bond FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Rating FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Week FE | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| $R^2$ | 0.48 | 0.48 | 0.49 | 0.49 | 0.49 | 0.49 | 0.48 |
| N | 10070 | 9902 | 9756 | 10070 | 10070 | 9965 | 9858 |