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 that feature 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 an increase in the haircut from 0 to 100% would result in an increase in bond yields in the range of 39 to 85 bps. These estimates help us infer the magnitude of the shadow cost of capital in China.

Keywords: Pledgeability, haircut, repo, interbank and exchange markets, enterprise bonds, shadow cost of capital

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1 Introduction

It has long been recognized that asset prices depend not only on the fundamental cash flows but also liquidity factors that are broadly related to the frictions prevalent in modern financial markets (see e.g., Duffie, 2010). Among these liquidity considerations, the most attention has arguably been given to asset pledgeability—the ability of an asset to serve as collateral and help reduce financing costs—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).

Our paper aims to offer an empirical estimate for the value of asset pledgeability. Our study focuses on bonds, which, besides spot transactions, are often involved in repurchase agreements, or repos. Repos are essentially collateralized loans, with the assets in transaction (typically fixed income securities) serving as the collateral.[1] 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.

In a world where collateral helps reduce the costs of borrowing for a financially constrained investor (relative to default-adjusted uncollateralized borrowing), pledgeable bonds carry a convenience yield. We refer to this type of convenience yield as the *pledgeability premium*, which is jointly determined by the frequency of the liquidity shocks, the degree of pledgeability (the haircut), and the shadow cost of capital (the gap in financing costs between collateralized and default-adjusted uncollateralized borrowing). The pledgeability premium should be reflected in the equilibrium pricing of the bonds. This logic has been used to explain repo specialness (Duffie, 1996), Treasury convenience yields (Longstaff, 2004; Fleckenstein, Longstaff, and Lustig, 2014; Lewis, Longstaff, and Petrasek, 2021; Jiang, Krishnamurthy, and Lustig, 2021), and "basis" across assets with different margins (Gârleanu and Pedersen, 2011). Haircut-implied funding costs have also been used by Chen, Cui, He, and Milbradt (2018) to endogenize the holding costs of illiquid assets, which in turn helps account for the liquidity premium in corporate bonds.

Though the theoretical mechanisms through which pledgeability boosts asset values are relatively clear, it is challenging to measure the effect empirically. Asset pledgeability is endogenous and, in general, will depend 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.

The Chinese bond markets have experienced tremendous growth during the past decade

[1] A key difference between repos and collateralized loans is that the repo collateral is exempt from an automatic stay in the event of bankruptcy. See, e.g. Adrian, Begalle, Copeland, and Martin (2013).

and are now ranked second in the world only behind the U.S. bond market. A distinct feature of the Chinese bond markets is the co-existence of two bond markets, the OTC-based interbank market and the centralized exchange market. The interbank bond market is a wholesale market serving only institutional investors including banks and non-bank financial institutions; on the other hand, the exchange bond market, as a part of the Shanghai and Shenzhen Stock Exchanges, is populated by non-bank financial institutions as well as wealthy retail investors. What is relevant to our study is that non-bank financial institutions, including mutual funds, securities firms, and insurance companies, are active institutional investors on both markets, though the restrictions on market access and trading frictions cause the two markets to be segmented to a certain degree (for more details, see Section 2.2).

Furthermore, the two markets differ significantly in their rules for repos. Repos in the interbank market essentially follow the standard tri-party repo model in the US. The key transaction terms (collateral, haircuts, repo rates) are negotiated bilaterally; they depend not only on bond characteristics, but also on the identity (credit quality) of the counter-parties. On the exchange market, the exchange acts as the Central Counter-Party (CCP) for all repo buyers and sellers; the exchange unilaterally determines the list of eligible collateral bonds as well as their respective haircuts, which are almost exclusively based on bond ratings. As a result, the pledgeability of the same bond can vary depending on the market for different investors. For instance, smaller institutional participants with limited government support could find it difficult to borrow on the interbank market even when using AAA bonds as collateral, while borrowing against these bonds will be relatively easy on the exchange. In contrast, a large state-owned commercial bank can borrow against AA− bonds on the interbank market, even though these bonds are not eligible for repo on the exchange. Together, the differences in rating-dependent 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 these dual-listed bonds. Specifically, we define the "exchange premium" as the yield on the interbank market minus that on the exchange market for the same bond with simultaneous transaction prices on the two markets. As we show in Section 4.1, since any unobservable fundamentals affect the pricing of the same bonds on the two markets identically, the exchange premium isolates the effects of the remaining non-fundamental factors, including the differences in pledgeability and potentially other liquidity factors in the two markets.

To further isolate the pledgeability premium, we exploit a policy shock that significantly changed the pledgeability for a set of bonds on the exchange. In the after-hours on December 8, 2014, the exchange suddenly announced that enterprise bonds with ratings below AAA were no longer accepted as repo collateral. This policy, with more detailed background provided in Section 2.3, was aimed at the exchange market only; effectively it only changed the pledgeability of bonds rated AA+ and AA on the exchange (AA− bonds were already ineligible for repo before the event). Thus, even if the exchange premium is partly due to differences in liquidity factors on the two markets, so long as the pricing impact of such factors varies in the same way over time for the treated bonds (AA+ and AA) and the bonds in the control group (AAA and AA−), we are able to identify the pricing impact of changes in the exchange market pledgeability on the exchange premia via a difference-in-differences (Diff-in-Diff) study.

We show that AAA and AA− bonds had similar trends in their exchange premia with the treatment group (AA+ and AA) before the December 2014 shock. However, in the first two weeks after the shock, the exchange premia of both AAA and AA− ratings rose, while that of the treatment group fell. This suggests that this rating-dependent pledgeability shock adversely affected the prices of bonds with middle ratings only. Notice that our control group consists of both higher- (AAA) and lower-rated (AA−) bonds, which helps us rule out many alternative fundamental-based explanations: typically, these mechanisms generate asset pricing reactions that are monotonic in asset qualities (here, credit ratings).

It is also important to note that, this policy on December 8, 2014 only applied to those enterprise bonds that had not been used as collateral yet. In other words, there was no deleveraging pressure for investors who had taken leveraged position in the AA+ and AA rated bonds, as regulators would like to minimize the potential negative market impact of this policy. However, the spot market prices of these affected bonds should go down as this policy eliminated their pledgeability. This unique institutional feature makes our policy shock particularly suitable to study the value of pledgeability: free from any temporary fire-sale pressure, any asset pricing change in response to the policy announcement should only reflect the change of their pledgeability.

A main contribution of our paper is to provide an estimate of the effect of changes in pledgeability on asset prices. 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, implying a roughly 2.1% drop in price for a typical enterprise bond in our sample.

While the exchange premia–based estimates help address the issue of the policy shock's endogeneity related to unobservable bond fundamentals, they are likely downward-biased for several reasons. One leading concern is that despite the limits to cross-market arbitrages in the short-run, the policy shock on the exchange market will be transmitted to the interbank as long as some institutional investors engage in arbitrage activities. As a result, the yields on the interbank market rise to offset the declines in exchange premia, and consequently the price impact of the changes in pledgeability on the exchange is underestimated. Moreover, it is likely that the policy shock would trigger a flight-to-quality effect that raises in the price of AAA bonds relative to other bonds. When this effect is stronger on the interbank market, it will cause the exchange premia of AAA bonds to drop at the same time. As a result, using AAA-rated bonds as the control group can also lead to an underestimate of the pledgeability premium.

We address this concern by providing an alternative IV estimate that likely overstates the price impact of changes in pledgeability. Thus, the two sets of IV estimates together plausibly bound the magnitude of the pledgeability premium. Specifically, instead of using the prices of the same bonds on the interbank market as a benchmark, we compare the price changes of the treated bonds against those of the matched policy shock–free 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 was not affected by the policy shock. It is plausible that these matched AAA bonds have better unobservable fundamentals relative to the treated bonds, which would cause this alternative IV estimate to be upward biased. For instance, a potential flight-to-quality effect in response to the policy shock can boost the prices of AAA bonds and thus inflate the relative price changes between the treated bonds and the matched AAA bonds, leading to an overestimate of the pledgeability premium. A similar logic applies to the case where the regulator has private information that AA+/AA -rated bonds are worse than the market believes. The resulting IV (over)estimate suggests that raising the haircut from 0 to 100% leads to a 85 bps increase of yield (compared to 39 bps based on the exchange premium), or a roughly 4.5% drop in price for a typical enterprise bond in our sample. These estimates are in the same range as the effect documented in Ashcraft, Gârleanu, and Pedersen (2011) (see more details in the literature review).

We provide a formal theoretical framework in Section 4.1 to guide our empirical study outlined above. The pledgeability premium derives from the convenience yield for a group of financially constrained investors who are marginal on both markets; in our context, these investors represent non-bank investors such as securities firms in China. Heuristically, the pledgeability premium is determined by the following formula, which is modified from Gârleanu and Pedersen (2011),

$$\text{Pledgeability premium} = \text{Freq. of liq. shocks} \times \text{shadow cost of capital} \times (1 - \text{haircut}).$$

The pledgeability premium is higher when the marginal investor is more frequently in a liquidity-constrained state, and it is higher when the investor faces a high shadow cost of capital in the constrained state. The shadow cost of capital is the gap between the interest-rate spread of collateralized and uncollateralized financing—that is, a form of 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 investors on 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 being liquidity constrained, then the pledgeability premium estimates of 39 to 85 bps correspond to a shadow cost of capital between 1.1% to 2.4%.

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. This model provides the closest theoretical framework to our empirical study.[2]

There is no doubt that margin constraints or haircuts are endogenously determined by aggregate conditions in financial markets as well as asset characteristics. Influential theoretical contributions include Fostel and Geanakoplos (2008) and Geanakoplos (2010), in which riskless lending arises endogenously due to heterogeneous beliefs.[3] 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. Rampini and Viswanathan (2019) provide a dynamic model in which endogenously determined firm and intermediary net worth jointly affect firms' financing cost and real economic activities.

Our paper contributes to the literature that connects pledgeability to asset prices. The related empirical studies include Gorton and Metrick (2012), Copeland, Martin, and Walker (2014), and Krishnamurthy, Nagel, and Orlov (2014), among others, with the focus on the failure of the law of one price and its connections to margin constraints and liquidity.[4]

[2]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 equilibrium asset pricing models with financial constraints Basak and Cuoco (1998), Gromb and Vayanos (2002), Danielsson, Zigrand, and Shin (2002), He and Krishnamurthy (2013), and Chabakauri (2015). For recent empirical evidence on intermediary asset pricing, see Adrian, Etula, and Muir (2014), He, Kelly, and Manela (2017), and He, Khorrami, and Song (2019). 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; Lagos and Rocheteau, 2009; He and Milbradt, 2014, 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).

[3]The extensions include Simsek (2013) and He and Xiong (2012), among others.

[4]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),

The pledgeability premium we estimate in the Chinese bond markets, which is about 39 to 85 bps, is higher but in the similar magnitude to those found in other major markets; this result is to our surprise as the Chinese financial market and its underlying structural parameters might significantly differ from U.S. or Europe. 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, perhaps the worst time in 2008 financial crises. Based on market reactions of bonds that were rejected by the program (which might carry some additional information other than pledgeability), the authors find that an increase in the haircut from 0 to 100% would result in an increase of 28 to 52 bps in bond yields.[5] 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).[6] The main difference between these papers and our paper is that the dual-listed nature of Chinese enterprise bonds, together with two control groups—one with bonds of higher quality and the other with lower—helps with identifying the causal effect of asset pledgeability on asset prices, by controlling for changes in (unobservable) asset fundamentals that are often correlated with changes in asset pledgeability. From this perspective, the estimate in Pelizzon, Riedel, Simon, and Marti (2019) should be upward biased, as included bonds tend to be bonds with higher qualities.

Finally, our paper also makes contribution to the burgeoning literature on the Chinese bond market. They include Fan and Zhang (2007), Ang, Bai, and Zhou (2019), Chen, He, and Liu (2020), Wang and Xu (2019), Geng and Pan (2019), and Ding, Xiong, and Zhang (2021), among others.[7]

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.

[5] We have scaled the estimated effect by Ashcraft, Gârleanu, and Pedersen (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.

[6] Pelizzon, Riedel, Simon, and Marti (2019) find that the average yield reaction to be 11-24 bps for lendable bonds and 30-50 bps for non-lendable bonds. We have scaled the lower and upper bounds of their estimates using the haircut schedule for assets eligible for use as collateral in Eurosystem market operations.

[7] Asset pledgeability also matters for the stock market in China; Bian, He, Shue, and Zhou (2018) 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 (2020) study the event of first bond default by a central SOE

2 Institutional Background

In this section, we provide 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 Overview of the Chinese Bond Markets

Over the past twenty years, especially the past decade, China has taken enormous strides to develop its bond markets as an integral step of financial reforms, along with the efforts to liberalize interest rates and internationalize its currency. Chinese bond market capitalization scaled by GDP rose from 35% in 2008 to almost 100% in 2019; in comparison, the US bond market has remained slightly above 200% of the US GDP during the same time period (see Appendix Figure A2).

Following the framework laid out in Amstad and He (2020), 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.[8] Our paper focuses on enterprise bonds, a type of corporate bonds issued by non-listed state-owned enterprises (SOEs). They account for 25% of total corporate bonds outstanding by 2014 when the policy took place.[9] For our analysis which exploits dual-listed enterprise bonds, it is important to understand the following features of the Chinese bond markets: (1) the co-existence of the exchange and interbank bond markets, and (2) the different ways that repo transactions are conducted on these two markets.

2.2 Dual-Listing of Enterprise Bonds

For historical reasons, there are two distinct and largely segmented markets in today's Chinese bond markets: the over-the-counter interbank market and the centralized exchange market.

in 2015 to estimate the value of implicit guarantees; and Huang, Huang, and Shao (2018) are after the same question by looking at financial bonds issued by commercial banks.

[8]Government bonds, which account for 55% of bond outstanding in 2019, are issued by formal government agencies. Financial bonds (18% of bond outstanding in 2019) are issued by financial institutions. Corporate bonds (25% of bond outstanding) are issued by non-financial firms. Appendix Figure A2 shows the notional outstanding and market shares of the different types of corporate bonds. In the aggregate social financing statistics released by the People's Bank of China (PBoC), corporate bonds correspond to "bonds," contributing 11.7% of financing to the real sector as shown in Panel C of Figure A2. There is also another widely used classification among practitioners in China, which groups financial bonds and corporate bonds together as the so-called "credit bonds."

[9]After 2014, the outstanding balance of enterprise bonds started to shrink, partially due to the policy shock in question as well as other long-term macroeconomic factors. By 2019, enterprise bonds account for 8% of the total corporate bonds outstanding.

Both markets overlap in several key bond products, mainly government bonds and enterprise bonds.

The issuance of enterprise bonds is regulated by the National Development and Reform Commission (NDRC), a powerful government agency which oversees SOE reforms in China. 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, which embraced this reform with great enthusiasm. Consequently about 78% of the enterprise bonds outstanding are dual-listed by the end of 2014. However, almost all enterprise bonds issuances were still initially placed in the interbank market at that time; in 2014, 562 out of 568 newly issued dual-listed enterprise bonds were first listed on the interbank market. Figure IA1 in the Internet Appendix provides more information regarding the notional outstanding in two respective depository markets and issuance of dual-listed enterprise bonds.

2.2.1 Co-Existence of Exchange and Interbank Markets

The interbank market is largely a "wholesale" market, similar to the interbank markets in developed economies like the US, with participants including non-bank financial institutions, corporate investors, and qualified (wealthy and experienced) retail investors.[10] In contrast, the exchange market (which resides within the Shanghai and Shenzhen stock exchanges) is more "retail" oriented, including smaller non-bank financial institutions, and high net-worth individual investors with ample investment experience. The exchange market has aggressively competed with the interbank market, which led to the dual-listing of enterprise bonds. For more details, see Section 2.2.

The interbank market 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 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 the depository and settlement services for the exchange market.

Consistent with the "wholesale vs. retail" distinction, the average trade size for spot transactions is 100 to 200 million RMB on the interbank market, compared to 0.3 to 1 million on the exchange. For repos, the average trade size is 200 to 500 million RMB on the interbank

[10] Although publicly listed commercial banks could participate in the exchange market after certain restrictions were removed by the Chinese banking regulators in 2010, they still face significant trading constraints even today, and as a result the presence of commercial banks in the exchange market is negligible. In particular, commercial banks are prohibited from repo transactions on the exchange market.

market and just 1 to 3 million on the exchange. This helps explain the fact that 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. As Panel A of Appendix Figure A1 shows, the interbank market accounts for more than 90% of the dollar volume of spot transactions for all bonds and over 70% for repo transactions. On the other hand, when it comes to the number of trades (Panel B), the exchange market accounts for 75% to 96% of all spot transactions and over 98% of repo transactions.

Appendix Figure A1 highlights that while the two bond markets serve different clienteles with different trading needs, they are both quite active. In short, the wholesale interbank market satisfies infrequent but large transaction needs, while the exchange accommodates frequent but small trades. This is in sharp contrast to the bond markets in the U.S., where the exchange attracts very limited trading in corporate bonds (see e.g., Biais and Green, 2019). 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 similar between the interbank market and 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 if we look at turnovers.

Limits to arbitrage Despite having identical fundamentals, the prices of a dual-listed bond on the two markets can differ significantly. Such differences can persist for a long time because there are major frictions that prevent "textbook" cross-market arbitrages. Among them, the most significant one 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, which takes five working days or more in 2014.[11] A transfer in the opposite direction is slightly faster and takes 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 explain why the prices of the same bond on the two markets may not converge quickly. 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.

[11] The depository and clearing agency in the interbank market is China Central Depository & Clearing Co. Ltd (CCDC) and Shanghai Clearing House, while in the exchange market it is China Security Depository & Clearing Co. Ltd (CSDC). Before the system upgrade in 2012, the process of transferring from interbank to exchange was even longer, taking about six to eight working days.

2.2.2 Repos on the Exchange and the Interbank Market

A repurchase agreement, or "repo," is the sale of a security coupled with a seller's commitment to purchase the same security back from the buyer at a pre-specified price on a pre-specified future date. It is effectively a form of collateralized borrowing with the security serving as collateral. As shown in Panel B of Figure A1, repos are quite active on both the exchange and interbank markets. In 2019, repo transactions account for 83% of the total volume of bond transactions in China (including both repo and spot trading).

Our research design crucially depends on the different mechanisms for repo transactions on these two markets, which we explain below.

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.[12] The trading protocol is nearly identical to the tri-party repos in the U.S., with the China Central Depository & Clearing Co., Ltd (CCDC) serving as the third-party agent who processes the post-trading settlement.[13] As explained in Section 2.2.1, 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 specification of collateral, the repo rate, and the method of delivery.

Repo terms, including types of collateral, haircuts, and repo rates, are set through private bargaining on the interbank market. The haircuts and repo rates primarily reflect the risks of the underlying securities and that of the counter-party. For example, the perceived default risk is almost zero for large state-owned Big Four banks.[14] 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 we lack access to trade-level repo data on the interbank market, we do have some information on average haircuts for enterprise bonds before and after the policy shock in question based

[12] Two types of repo transactions are available for interbank market participants: pledged repo, where bonds are used as a pledge of rights; and outright repo, where bonds are sold from a positive repo party to a reverse repo party. Pledged repo accounts for the majority (94.2% in our one-year sample period) of interbank repo transactions. Another informal "repo"-type transaction is agent-holding ("dai chi" in Chinese), which has decreased dramatically since April 2013 when the regulator put strict restrictions on agent-holding (for more details, see Mo and Subrahmanyam, 2019).

[13] Tri-party repo is a transaction for which post-trade processing—collateral selection, payment and settlement, custody and management during the life of the transaction—is outsourced by the borrowing and lending parties to a third-party agent, which is called the custodian bank. Bank of New York Mellon and JP Morgan are the two custodian banks in the U.S., while in Europe they are Clearstream Luxembourg, Euroclear, Bank of New York Mellon, JP Morgan, and SIS.

[14] The Big Four banks are Industrial and Commercial Bank of China, China Construction Bank, Bank of China, and Agricultural Bank of China.

on the interbank market transactions conducted by an anonymous major financial institution in China.

Repos on the exchange For repos on the exchange market, the exchange (specifically the CSDC) not only facilitates transactions—just like the CCDC for interbank repos—but also acts as the Central Counter-Party (CCP) for all repo buyers and sellers. Unlike the third-party agent in tri-party repos, 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 (Mancini, Ranaldo, and Wrampelmeyer, 2016).

In the exchange repo market, the CSDC unilaterally sets the collateral pool (i.e., the list of securities eligible as collateral) and haircuts on a daily basis. For each eligible bond security, the CSDC announces the conversion rate (CR), which is the borrowed amount quoted as a fraction of the face value of the security. For instance, suppose that Treasuries receive a conversion rate of 1, while that of an AAA corporate bond is 0.9. Then an investor posting one unit each of the two types of bonds as collateral, both with face value of 100 RMB, will be able to borrow $190 = 100 \times 1 + 100 \times 0.9$ RMB from the exchange. Suppose a bond has face value FV and market price P. We can translate its conversion rate into the haircut using the following formula:

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

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 whose function crucially relies on standardization.

While the exchange sets the haircuts, the equilibrium repo rate for any given maturity is determined by the market and is common across all repo sellers after the standardization of collateral. A central limit order book aggregates all bids and asks from repo sellers (borrowers) and buyers (lenders) in continuous double auctions. Even though repo buyers and sellers have limited information about each other and the actual composition of the collateral pool (the exchange does not publish such information), the counterparty risk component in the repo rates is negligible due to the exchange's implicit government backing. Consequently, the exchange repo rates mainly reflect the market supply and demand for short-term funding.[15]

That the exchange's CCP structure offers counterparty risk–free repo transactions with

[15] The maturities of these repo contracts are 1, 2, 3, 4, 7, 14, 28, 91, and 182 days. One-day repo transactions account for 85% to 90% of total exchange market transactions.

desirable transparent standardization is likely a major reason behind the popularity of the exchange repo market. As Figure A1 shows, in contrast to its small market share for spot transactions (Panel A), which is in the range of 1–6% after 2012, the exchange market's share of repo transactions has been over 20% during the same period (Panel B). This comparison highlights the significant role that the exchange repo market plays in China's short-term financing market.

2.3 The 2014 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.

The background of this policy shock is related to the local government debt problem in China (Chen, He, and Liu, 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 MCBs—a type of enterprise bonds—to either refinance the maturing bank loans or continue the ongoing long-term infrastructure projects.[16] As a result, the enterprise bond market became flooded with MCBs, with the share of MCB-type enterprise bonds rising from about 30% in 2010 to about 67% by the end of 2014. In fact, as shown in Panel A Table 1, for enterprise bonds that enter our final sample, 87% of them are MCBs.

Increasingly concerned about local government debt problems, the State Council of China released the tone-setting guideline No. 43 Document in October 2014, which explicitly banned the backing of MCBs by local governments. This guideline is widely expected by the market, and various layers of Chinese financial regulators had been coordinating to support Beijing on this agenda even before No. 43 Document.

At that time, MCBs were quite popular on the exchange market for their low perceived credit risk—even for bonds with low credit ratings, thanks to the implicit guarantee by local governments, and relatively high pledgeability—thanks to transparent haircuts published by the CSDC. Besides many other regulatory attempts, the CSDC had been taking some actions since May 2014 by black-listing some individual corporate bonds with inferior credit

[16]MCB, also known as Urban Construction Investment Bond or Chengtou Bond, is one of the perfect examples of the mixture between planning and market in today's Chinese economy. In a strict 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. For more details, see Chen, He, and Liu (2020).

ratings to disqualify their pledgeability as collateral. More specifically, the CSDC disqualified several enterprise bonds from repo eligibility, if the bond's *issuer* rating was either below-AA, or with an AA issuer rating but *a negative outlook*. A predominant share (84.4%) of these black-listed enterprise bonds are MCBs, and more importantly, the CSDC retains certain discretion in deciding the exact composition of the list.

However, these confined and small-scale regulatory moves triggered little market-wide responses from financial investors; Section 3.2 provides more detailed information on these black lists and their associated market reactions. To fully curb the overheated demand of MCBs, the CSDC decided to slash the conversion rates for enterprise bonds with ratings below AAA.

During the after-hours on December 8, 2014, the CSDC issued No. 149 Document "Notice on the Issues of Risk Management on Enterprise Bond Pledged-Repo Transactions" 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 No. 43 Document issued two months earlier by the State Council of China, which explicitly banned the backing of MCBs by local governments.

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.

There is another unique feature of this policy that is worth emphasizing. Perhaps 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 those enterprise bonds that had not been used as collateral yet. In other words, there was no deleveraging pressure for investors who had taken leveraged position in the AA+ and AA rated bonds. However, the spot market prices of these affected bonds, whether outstanding or newly issued, should go down as this policy eliminated their pledgeability.[17] This unique institutional feature makes our policy shock particularly suitable to study the value of pledgeability: free from any temporary fire-sale pressure, any asset pricing change in response to the policy announcement should only reflect the change of their pledgeability.

The sudden move by the CSDC surprised exchange market investors to a large extent; we

[17] At that time roughly 1/3 of outstanding bonds were used as collateral before the policy shock in the exchange market. Specifically, we use bond conversion rates to estimate the exchange market collateral composition by bond type. We then calculate the fraction as the enterprise-bond collateral value over the total enterprise bonds in the exchange market at the end of November 2014.

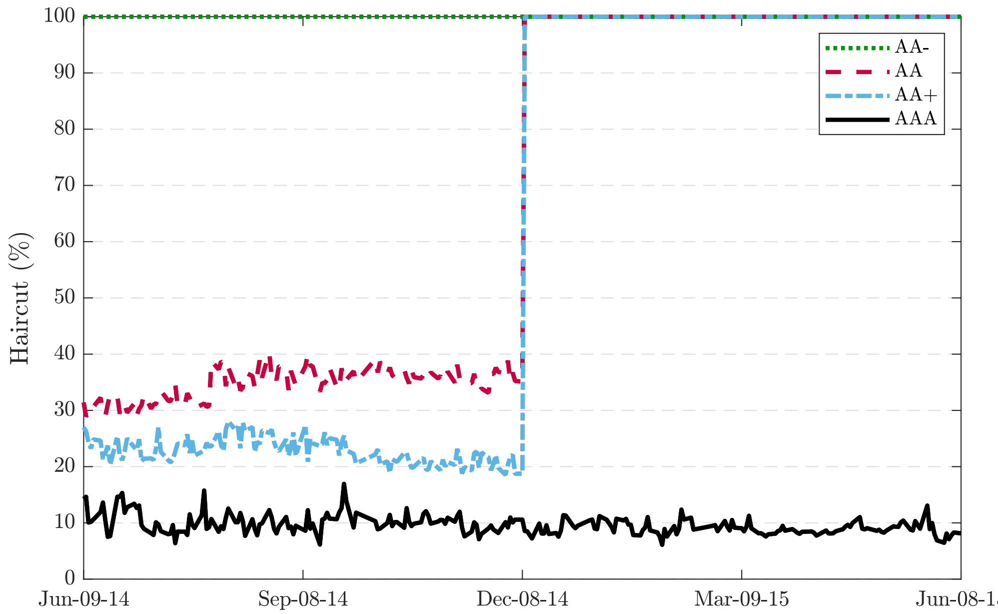

Figure 1: **Average repo haircut on the exchange market.** This figure plots the average daily haircut on the exchange market for dual-listed enterprise bonds in each of the four rating categories. The sample period is from 6/9/2014 to 6/8/2015.

will discuss the market reaction in Section 3.2.[18] 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. This is partly because it is well documented that the local government debt problem is rooted in the commercial banking system (Bai, Hsieh, and Song, 2016; Chen, He, and Liu, 2020), which heavily relies on the interbank market—not the exchange—for liquidity management; and recall that almost all enterprise bond issuances were initially placed in the interbank market (Section 2.2). 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 Document No. 43 released by the State Council in October 2014.

3 Exchange Premia and Preliminary Evidence

As described in the previous section, the policy shock on December 8, 2014 provides a unique setting to study the impact of shocks to pledgeability on bond pricing. In this section, we first

[18] According to estimates from Haitong Securities (one of the leading securities firms in China), about 75% of enterprise bonds deposited in the two exchanges lost their pledgeability. See http://www.p5w.net/stock/news/zqyw/201412/t20141209_868742.htm

describe our data, examine the market reactions to this policy shock, and then examine the empirical properties of the exchange premia, i.e., the price gap for the dual-listed enterprise bonds between the exchange and interbank markets.

3.1 Data

The major part of our empirical analysis focuses on the enterprise bonds that are dual-listed on both markets. We obtain enterprise bond characteristics and exchange-market trading data from WIND. Data on interbank market trading are from the CFETS, which is the trading platform of the interbank market. Our sample period ranges from June 9, 2014 to June 8, 2015, a twelve-month window around the event date (the policy shock is on December 8, 2014). This dual-listed enterprise bond sample covers 82.7% of the total trading volume of all the enterprise bonds during the same period (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 the formula in Eq. (1). We also calculate the enterprise bond yields based on the RMB volume-weighted average clean prices. These yields are winsorized at 0.5% and 99.5% on the exchange and interbank markets, respectively. Following industry practice, the credit spreads of the enterprise bonds are calculated relative to the matching China Development Bank bond (CDB) yields following the similar procedure of Ang, Bai, and Zhou (2019) and Liu, Lyu, and Yu (2017).[19]

Bond rating information is from WIND; following the industry standard, we take the lowest rating if a bond receives multiple ratings (Amstad and He (2020)). As mentioned in Section 2.3, a small list of AA+ and AA-rated bonds, due to their inferior *issuer* ratings, had been disqualified as collateral for repo transactions in the exchange market even before the December 8, 2014 policy shock. To the extent that we link ratings to pledgeability, we reclassify these AA+ and AA bonds to be with AA- ratings accordingly. On 05/19/2014, the CSDC issued No. 48 document that disqualified the repo eligibility of an enterprise bond if the bond's *issuer* rating was either below-AA, or with an AA issuer rating but *a negative outlook*, with some extent of discretion determined by the CSDC. In the appendix of this

[19] Bonds issued by the China Development Bank, the largest of the three policy banks in China, are fully backed by the central government, although they do not enjoy the tax-exempt status that Treasuries do. Thanks to this identical tax treatment as well as CDB bonds' superior liquidity, the CDB yield curves are commonly used as the benchmark by the bond market participants in China, especially institutional investors. Specifically, 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 the 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.

document, the CSDC included a list of 4 affected enterprise bonds. After that, on 06/27/2014, 08/01/2014, 09/05/2014, and 11/03/2014, the CSDC issued four additional lists of affected bonds that were disqualified for repo collateral due to low issuer rating. From all these five lists, a total of 109 enterprise bonds were disqualified as collateral for repo transactions, even though their bond ratings are 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 to one of the five lists. See Appendix A.1 for details.

We further exclude bonds that a) were issued after the policy event to rule out the possibility that issuers may engage in rating shopping (for AAA ratings); b) experienced rating changes after the event to reduce the contamination caused by (potentially endogenous) changes in post-event rating grouping; and c) that were matured before the event date. Three filters cut our sample in a rather minor way.[20] Finally, one obvious concern is that some issuers may try to improve their ratings before the event if information leakage of the policy shock exists. However, we do not observe any bond rating change in our sample during the [-1, 0] month window.

As the main empirical object, we construct the "exchange market premium" or simply the "exchange premium," which is defined shortly in Eq. (2) as the yield difference between two markets, based on synchronous trading of dual-listed bonds. 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 the 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).[21] The exchange premium for each pair is calculated as the yield on the interbank market minus the exchange market counterpart. In the robustness test, we also repeat our empirical exercises using a more strict same-day trading window and hence a smaller sample, which requires trades of the very same bond in two markets on the same day.[22]

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

[20]These three filters apply to 32, 41, and 4 bond-day observations from 15, 6, and 2 unique bonds.

[21]Since our observations are at bond-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 1771 and the simultaneous sample (978 unique bonds) covers 55.2% of all these dual-listed enterprise bonds. Among all bonds in the simultaneous sample, 851 of them are MCBs.

[22]See Appendix A.2 for details on the construction of these two trading samples. "Same-day" trading requires a bond-day observation to have transactions on both markets on the same day to be included in the sample. Since enterprise bond transactions are relatively sparse in both markets, this definition limits the sample size to about 3,500 bond-day observations, compared to about 10,000 bond-day observations in the simultaneous trading sample.

enterprise bonds and that of the matched AAA-rated ones but with similar haircuts and yields, based on their trading prices on the exchange market (see Section 4.3 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 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 Market Reactions to the Policy Shock

We first present the evidence that the December 8, 2014 policy shock is unexpected, by documenting the market reactions to the shock. We also compare them to the market reactions to a series of black-listing announcements before the policy shock.

Credit spread reactions on two markets What are the reactions from both markets? As a first pass, we examine the average credit spreads for all dual-listed enterprise bonds in the four rating categories around the event, across two bond markets. Note, due to illiquidity, these credit spreads are based on observed transaction prices which are not necessarily matched to be with the same bonds; we will analyze the matched sample shortly in our main empirical analysis in Section 3.

We find that on the exchange market, the average credit spreads for AA+ and AA bonds jumped up on the event date (by 62 and 38 bps, respectively; and both of them are significant at 1% significance level, as shown in Panel A of Table 3). This is in direct contrast to the market reactions on the interbank market where the average credit spreads for AA+ and AA bonds actually fell slightly on the event date (by 8 and 9 bps). For the AAA bonds, on the event date the average credit spreads fell in both the exchange and interbank markets (by 15 and 24 bps, respectively); while the credit spreads of the AA− bonds rose on both markets (by 61 and 24 bps). 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.

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 haircuts on the interbank market during the same period. Based on the sample of repo transactions conducted by an anonymous major financial institution in China, Panel B of Table 3 reports the average haircuts for enterprise bonds on the interbank market during the six-month window before and after December 8, 2014. We observe a tightening of liquidity in the interbank market, as the average haircuts rose by about 5 percentage points for AAA bonds (8.4% to 13.8%) and are relatively stable for the other rating categories. We will come back to this point in Section 4.2.2.[23]

Market reactions to black-lists before the policy In Section 3.1, we have mentioned that before the aggressive policy move on December 8, 2014, the CSDC had been employing a much more confined method of black-listing some individual bonds from repo eligibility, with certain discretion in deciding the exact black list. In total, from May to November in 2014, the CSDC issued five such black lists on five different days, with a total of 109 enterprise bonds. The full security codes of the five lists are reported in Table A2 with * to indicate MCBs, which are 92 in total.

We follow the similar procedure as above to calculate the market reactions from these black-list announcements.[24] Panel C of Table 3 shows the change of credit spreads of four rating groups, excluding these bonds affected directly by the announcements.[25] We find that none of these market reactions are significant.

The sharp comparison between the significant market reactions on our December 8, 2014 policy, and those subdued ones observed on previous black-listing announcements, is consistent with the unexpectedness of the policy shock in our study. Readers should not be surprised to see this sharp contrast. For Chinese regulators, it is their routine job to issue small-scale regulatory tightenings here and there, especially given the broad context of "reining in local government debt" as explained in Section 2.3. Besides, there is quite a distance from black-listing individual bonds with inferior issuer ratings (which seems more idiosyncratic), to a sweeping ban of pledgeability for AA+ and AA rated bonds (which is more systematic). In fact, the CSDC even black-listed an AAA-rated corporate bond with inferior issuer rating.[26]

[23] Since the repo terms are bilaterally negotiated, one would ideally like to control for the credit quality of this financial institution's counter-parties when comparing interbank market haircuts from two different periods. Unfortunately this is not feasible due to the lack of trade-level data; anecdotally, the credit quality of counter-parties of this financial institution remained stable over this period.

[24] We calculate the market reactions on the event day, i.e., the event window of [0, 1] for the policy shock as well as the five black-listing announcements. The results are similar if we take a wider event window [-1, 1] in consideration of potential information leakage.

[25] For those affected bonds, it is challenging to calculate the immediate IB market reactions due to lack of liquidity. Meanwhile, we can still calculate the EX market reactions for AA+ and AA affected bonds, which are -5 (insignificant) and 18 (significant at 10% lelve) bps. The increase in credit spreads for AA bonds is consistent with a lower pledgeability premium once black-listed.

[26] In the first announcement on 2014/5/29, the corporate bond with identifier 122257.SH (issued by Yueyang Forest & Paper, a publicly listed central SOE) had an AAA rating, but got black-listed due to AA issuer rating with a negative outlook.

3.3 Haircuts and Credit Ratings

In the exchange market, any bond's haircut that is published by the CSDC is tightly linked to its credit rating. As shown in Eq. (1), the haircut is equivalent to the conversion rate for a given bond price. The conversion rates on the exchange are set by the CSDC and exclusively depend on security-level characteristics. During our sample period, the CSDC published a formula for how the conversion rates were set, which involves the bond's credit rating, market price, and volatility.[27] However, the CSDC also made it clear that the formula was only suggestive; by inserting an opaque term called "discount coefficient," the CSDC effectively reserved the discretion in setting the conversion rate for each bond.

To check the extent that one can reverse-engineer the conversion rate formula prior to the policy shock, in the six-month period before the policy shock, we regress the conversion rates on four bond rating dummies (AAA, AA+, AA, AA−), market price, volatility, maturity, turnover, coupon, issue size, dummy of on-the-run, issuer characteristics such as number of bonds ever issued, firm age, size, and leverage, plus additional market variables such as CDB spot rate, term spread, one-day EX repo rate over SHIBOR spread, and stock market returns. The results for both the full sample and the simultaneous-trading sample are shown in Table 4. By far the most important determinant of the conversion rates is credit rating. For the full sample of dual-listed enterprise bonds, the rating dummies explain 93% of the total variation in conversion rates, while a kitchen sink regression only raises the R^2 to 94%; the results are quite similar in the simultaneous trading sample. The main reasons that the CSDC appears to rely primarily on credit ratings when setting the conversion rates include the transparency and third-party objectiveness of credit ratings, as well as the poor secondary market liquidity. 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.

3.4 Exchange Premia and the Policy Shock

We define the exchange premium measure, $EXpremium_{ijt}$, as the cross-market difference in credit spreads for bond i from rating category j on day t. Because the credit spreads for the same bond on the two markets are based on the same matching CDB yield, we have

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

[27] The exact definitions of "market price" and "volatility" are given by the relevant regulatory documents and differ slightly from what are commonly accepted in academia. We replicate these variables and the definitions are given in Table A3.

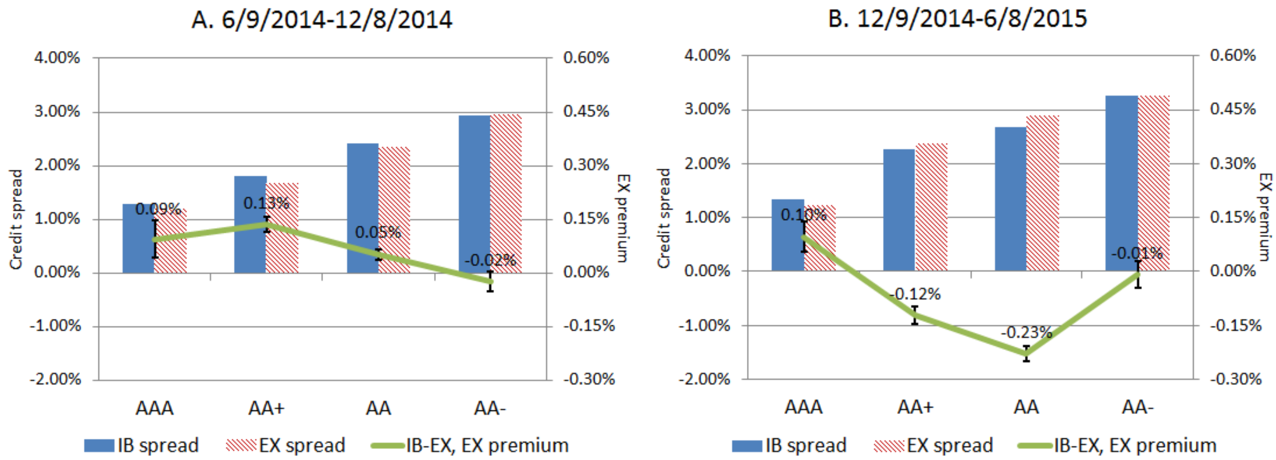

Figure 2: **Exchange premia before and after the event.** This figure plots the average credit spreads for each of the four rating categories on the interbank market and the exchange, along with the average exchange premium and 95% confidence intervals. Panels A and B show the results for the six months before and after the event date 12/8/2014, respectively.

where $j \in \{AAA, AA+, AA, AA\text{-}\}$. A positive premium means the price of a bond is higher on the exchange than on the interbank market. With common fundamentals, $EXpremium_{ijt}$ should primarily reflect the differences in pledgeability on the two markets, plus differences in other liquidity factors (e.g., trade size, frequency). We compute the exchange premia for all the dual-listed enterprise bonds that satisfy the simultaneous (or same-day) trading criterion defined in Section 3.1.

Exchange premia before the policy shock For bonds in the simultaneous trading sample, we first plot the average credit spreads (on the two markets) and the average exchange premia for the four rating categories in the 6-month window prior to the policy shock (Figure 2, Panel A). We observe that AAA, AA+, and AA bonds enjoy positive exchange premia (9 bps, 13 bps, and 5 bps respectively), while there is a negative exchange premium (or exchange discount) of -2 bps for AA$-$ bonds.

To understand the pattern of average exchange premia across ratings, we examine how pledgeability differs on the two markets for bonds with high and low ratings (assuming for now that the other components of exchange premia are common across ratings). On the exchange, the pledgeability of a bond is solely determined by its haircut. We have explained that the central counter-party system on the exchange features fungibility across various bond securities: the CSDC treats Treasuries and corporate bonds with different ratings the same way after adjusting for their conversion rates. In addition, the conversion rates set by the CCP are non-discriminatory to all investors on the exchange. Such standardization greatly improves the liquidity of repo transactions on the exchange.

On the interbank market, however, the haircut for a bond can vary significantly across counter-parties. Smaller institutional investors—especially local rural credit unions or small securities firms—often complain about the difficulty of using even AAA corporate bonds as collateral for repo transactions, whereas large state-owned commercial banks can get favorable haircuts on the same type of bonds.[28] Thus, despite the fact that the average haircut for AAA bonds based on the reported repo transactions on the interbank market (about 8%, see Panel B of Table 3) is lower than the quoted values on the exchange (about 10%, see Panel B of Table 3), the AAA bonds are actually more pledgeable on the exchange from the point of view of small institutions. Furthermore, due to tighter financial constraints, we expect these small institutions to value asset pledgeability more than the large commercial banks. These factors would tend to raise the valuation for AAA bonds on the exchange relative to the interbank market, contributing to a positive exchange premium. The similar logic applies to the AA+ bonds.

On the other end of the rating spectrum, while OTC-based bilateral bargaining on the interbank market would allow some reputable institutions to borrow against bonds with AA− ratings, the haircuts for these bonds were essentially at 100% on the exchange even before the policy shock. This makes AA− bonds more pledgeable on the interbank market for the large institutions, resulting in a negative exchange premium (-2 bps, which is marginally significant at 90% significance level).

Exchange premia after the policy shock We examine the impact of the policy shock on the exchange premia across ratings in the raw data. Suppose that the exchange premia are driven by the rating-dependent haircut rule imposed by the CSDC. Then because the policy shock alters the rating-haircut relationship, one should expect corresponding changes in rating-dependent exchange premia afterwards. This is indeed the case, as shown in Panel B of Figure 2. After the policy shock, exchange premia turned negative for bonds with both AA+ and AA ratings, consistent with these two type of bonds losing their pledgeability edge on the exchange. The control groups do not exhibit this behavior: 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).

[28]Large state-owned commercial banks are in a dominant position in the Chinese interbank market. According to the official statistics released by the interbank market's clearing and settlement agencies (China Central Depository & Clearing Corporation and Shanghai Clearing House), at the end of 2014, large state-owned commercial banks, "joint-stock" commercial banks, and city commercial banks held 57% of total bonds outstanding, while small banks like rural commercial banks, rural credit unions, and postal savings bank only held about 6%. For non-bank financial institutions, mutual funds held about 15%, insurance companies held about 7.5%, and securities firms held about 1%.

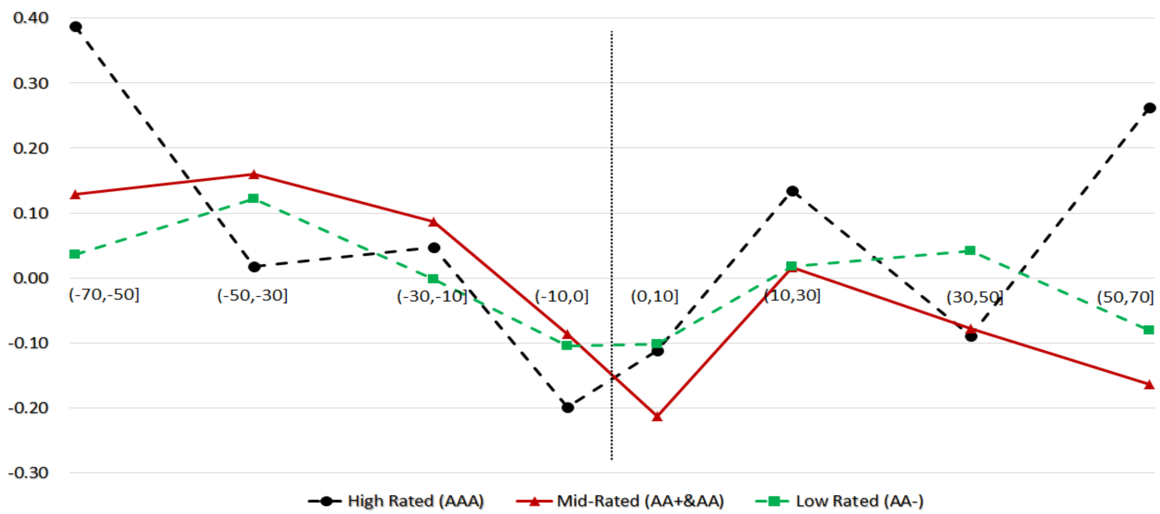

Figure 3: **Exchange premia dynamics.** This figure presents the average exchange premia by bond ratings and subperiods. The three bond-rating groups include the treated group (AA+ and AA), the AAA group, and the AA− group. The sample of simultaneous trading is a [−3, 3]-month window around the event day 12/8/2014. The sample is divided into 8 subperiods, with two subperiods of 10 trading days each before and after the event day, and the remaining 6 subperiods of 20 trading days each.

Time-series of exchange premia around the policy shock Figure 3 shows the time series of average exchange premia for three rating groups: AAA, AA+/AA (combined into one "mid-rated group"), and AA−. Before the event, the treatment "mid-rated group" share a similar trend with both the higher credit quality AAA group and the lower credit quality AA− group. During the window of policy shock, the exchange premia for treated AA+/AA bonds fell sharply, while that of AAA bonds rose and that of AA− bonds remained almost flat. After the shock, three groups returned to a similar trend again, as their exchange premia co-moved together to a large extent.

We highlight that our unique empirical setting uses higher- and/or lower-credit rating groups as controls to rule out many alternative mechanisms. In these alternative mechanisms, the policy event represents some aggregate fundamental shock, and the treatment and control groups could just differ in their sensitivities to the fundamental shock. However, the implied responses under those mechanisms tend to be monotonic in ratings, which is not what the data show.

We also observe that exchange premia of AAA bonds are more volatile than that of AA− bonds; this raises the question about which of these two rating categories serves better as a control group. Section 4.2.2 examines the sensitivity of our estimates to the choice of control group, and argues that AA− bonds are more suitable to serve as the unbiased control group than AAA bonds which likely suffer the standard flight-to-quality effect. Furthermore,

Figure 3 does not control for the potential changes in bond characteristics of the simultaneous-trading sample around the event, a concern that we address based on a formal regression-based Diff-in-Diff approach with various fixed effects in Section 4.

4 Empirical Analysis

We present our formal empirical analysis in this section. After highlighting the identification challenge in estimating the pledgeability effect on asset pricing, we lay out our empirical framework and research design to tackle this challenge.

4.1 Research Design

To identify the effects of changes in pledgeability on bond pricing, ideally we would like to compare how the price of the same bond behaves with and without an exogenous shock to the haircut. As is evident in Figure 1, the policy shock brought drastic changes to the haircuts of AA+ and AA bonds (the treatment group) while leaving those of AAA and AA− bonds (the control group) unaffected. But the bonds in the treatment group are not randomly selected. Besides the differences in the observable characteristics, it is possible that the exchange's new policy specifically targeted AA+ and AA bonds for reasons that are not controlled for. In particular, the policy makers might have private information about the rising risks of the treated enterprise bonds, which are signaled to the market through the policy action. If so, the policy shock would be correlated with unobserved changes in investors' beliefs about asset fundamentals and hence would violate the exclusion restriction. In this case, we may not be able to attribute the relative changes in credit spreads of the treated bonds to the changes in haircuts.

We tackle this challenge in two ways after laying out our theoretical framework. As the main empirical strategy, the first approach exploits dual-listed bonds, for which the cross-market credit spread of the same bond (i.e., the exchange premium) is arguably immune to any unobservable changes in asset fundamentals. As we explain later, the resulting IV estimates based on the exchange premia are likely to be downward biased due to cross-market arbitrage. Our second strategy is a more standard Diff-in-Diff estimation, where we use the non-treated AAA bonds with matching pre-event characteristics as controls. In contrast to the estimates based on exchange premia of dual-listed bonds, the second set of estimates are likely upward biased. Together, the two sets of estimates provide a range for the economic magnitude of the pledgeability effect.

4.1.1 Exchange premia based on dual-listed bonds

We explain our main identification strategy through the following economic framework. We assume that the marginal investors have access to both the exchange and interbank market. This assumption is supported by the fact that, in the Chinese corporate bond markets, mutual funds, insurance companies, and securities firms are active on both markets (see Section 2.2.1).[29]

A one-period corporate bond i with rating j is traded on both markets. However, market segmentation prevents investors from buying the bond on one market and selling it on the other (we will come back to this point later). The bond's payoff at time $t+1$ (maturity) is $\widetilde{Y}_{i,t+1}$. The market-specific haircut at time t is h^m_{ijt}, with $m \in \{EX, IB\}$. Let p^m_{ijt} be the price of the bond at time t in market m. The first-order condition for the investor's optimal portfolio decision yields the Euler equation:[30]

$$p^m_{ijt} = \mathbb{E}_t[\widetilde{M}_{t+1}\widetilde{Y}_{i,t+1}] + \underbrace{\lambda_t\,(1 - h^m_{ijt})}_{\text{pledgeability premium}}. \tag{3}$$

The first term on the right-hand side of (3) is standard: $\widetilde{M}_{t+1}$ is the pricing kernel for the marginal investor (as determined by the ratio of marginal utility of consumption between $t+1$ and t); the second term is the pledgeability premium due to borrowing constraint. Notice that λ_t is the Lagrange multiplier associated with the collateral constraint scaled by the marginal utility at time t, which represents the shadow value of relaxing the collateral constraint and hence is related to the financing condition at the aggregate level. It is related to the "specialness" in Duffie (1996) and can be microfounded by the wedge between the collateralized and uncollateralized borrowing (see, e.g. Gârleanu and Pedersen, 2011; Chen, Cui, He, and Milbradt, 2018). Since our empirical analysis focuses on a relatively short time period, we will assume λ is constant within the event window and drop the time subscript.

Since the same agent is marginal on both markets, it follows from Eq. (3) that the exchange premium in terms of price differential for the same bond on the two markets is:

$$p^{EX}_{ijt} - p^{IB}_{ijt} = \lambda\left(h^{IB}_{ijt} - h^{EX}_{ijt}\right), \tag{4}$$

where the asset fundamental component from Eq. (3), $\mathbb{E}_t[\widetilde{M}_{t+1}\widetilde{Y}_{i,t+1}]$, drops out. Eq. (4)

[29]In particular, we offer empirical evidence in Internet Appendix IA1 that these three groups of financial institutions were actively trading, and hence were marginal, in both markets around the 2014 policy shock.

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

shows that one can identify λ based on how the exchange premium changes in response to relative changes in haircuts across the two markets.

Besides the collateral constraints, there could be additional factors (such as market liquidity) that affect bond pricing. While the simple model above does not consider these factors, we summarize them in reduced form with a pair of residuals ϵ^m_{ijt}. The exchange premium then becomes:

$$p^{EX}_{ijt} - p^{IB}_{ijt} = \lambda \left(h^{IB}_{ijt} - h^{EX}_{ijt} \right) + \epsilon^{EX}_{ijt} - \epsilon^{IB}_{ijt}. \tag{5}$$

As discussed in Section 2.3, the 2014 policy shock significantly increased the haircuts for AA+ and AA enterprise bonds on the exchange. Since we do not directly observe the haircuts on the interbank market or the residual terms, two additional identification assumptions are needed for estimating λ from Eq. (5).

First, we assume that the interbank haircuts satisfy

$$h^{IB}_{ijt} = h^{IB}_{i} + h^{IB}_{j} + h^{IB}_{t}; \tag{6}$$

that is, any time-variation in haircuts on the interbank market is common across bonds with different ratings. Consistent with this assumption, Panel B of Table 3, which reports the interbank market haircuts of a major bank before and after the policy shock, shows that bonds in the four rating groups appear to have largely experienced a parallel shift in their haircuts. Although the data shows that the average haircuts for AAA bonds rose more on the interbank market, the difference is still quite small relative to the size of haircut changes for the treated bonds on the exchange market.

Second, we similarly assume that the pricing residuals, which capture non-pledgeability-related liquidity effects, satisfy

$$\epsilon^{m}_{ijt} = \epsilon^{m}_{i} + \epsilon^{m}_{j} + \epsilon^{m}_{t}. \tag{7}$$

The key point of this assumption is to rule out rating-time variations in the residuals. One mechanism that potentially violates this assumption is the “flight-to-quality” effect. For example, the polic shock might trigger a fire sale of AA+/AA bonds on the exchange market and push investors to buy AAA bonds. We address this concern in Section 4.2.2 by showing that the estimation results do not vary significantly based on different control groups (AAA vs. AA− rated bonds). In addition, as mentioned in Section 2.3, since the new policy still allows investors to continue to roll over all existing repos on the exchange, it does not directly force investors to delever, which also helps limit the extent of fire sales.

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

$$p_{ijt}^{EX} - p_{ijt}^{IB} = \underbrace{-\lambda \cdot h_{ijt}^{EX}}_{\text{identifies } \lambda} + \underbrace{\left(\lambda \cdot h_i^{IB} + \Delta\epsilon_i\right)}_{\alpha_i\text{: bond fixed effect}} + \underbrace{\left(\lambda \cdot h_j^{IB} + \Delta\epsilon_j\right)}_{\alpha_j\text{: rating fixed effect}} + \underbrace{\left(\lambda \cdot h_t^{IB} + \Delta\epsilon_t\right)}_{\alpha_t\text{: time fixed effect}}. \tag{8}$$

In other words, the shadow cost of capital, λ, can be identified from the responses of exchange premia to the rating-time dependent haircuts in the exchange market (the first term), as all other terms can be absorbed by bond, rating, or time fixed effects. This equation forms the basis of our 2SLS regression, which we explain next.

2SLS estimation procedure Recall that for each bond i with rating j, we construct its exchange premium $EXpremium_{ijt}$ on some trading day t. Let D_{jt} be the dummy variable for the treatment-group rating categories and the post-policy-shock period, i.e.,

$$D_{jt} = \begin{cases} 1, & j \in \{\text{AA+,AA}\} \quad \& \quad t > 12/08/2014 \\ 0, & \text{otherwise} \end{cases} \tag{9}$$

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 follows:

$$haircut_{ijt} = \rho_i + \kappa_j + \eta_t + \beta\, D_{jt} + X'_{it}\gamma + v_{ijt}. \tag{10}$$

The second stage of the 2SLS is:

$$EXpremium_{ijt} = \alpha_i + \alpha_j + \alpha_t + \delta\, \widehat{haircut}_{ijt} + X'_{it}\theta + \xi_{ijt}, \tag{11}$$

where $\widehat{haircut}_{ijt}$ are the first-stage fitted values for exchange market haircuts. As in Eq. (8), the regression includes bond fixed effects, rating fixed effects, and weekly time fixed effects. We use weekly time fixed effects because daily time fixed effects are too stringent given the low frequency of bond trading in our sample. For this reason, we add market-level controls including CDB spot rates, term spreads, the spread between one-day exchange repo rate and interbank lending rate, and stock market returns. We also include four bond-level time-varying controls including time-to-maturity, turnover, price, and volatility, as of the day of the simultaneous trade. Finally, we add rating fixed effects together with bond fixed effects because a bond's rating can change over time.

Effectively, the 2SLS identifies the pledgeability premium δ through a Diff-in-Diff approach. It compares the average change in exchange premium for the treated bonds after the policy shock against that for the bonds in the control group. This relative difference in the average change of exchange premium is then scaled by the average change in exchange haircut for the treated bonds to determine δ.

Cross-market arbitrage and its impact on $\hat{\delta}$ So far we have been assuming that market segmentation completely prevents investors from arbitraging away the exchange premium. We have discussed in detail in Section 2.2.1 the significant trading frictions—in particular the delays caused by transfer of custody across two markets. Nonetheless, when cross-market price difference drifts sufficiently far away from zero, market forces will tend to bring it towards zero over time. In fact, we verify that the observed exchange premium is plausibly within the arbitrage bounds empirically measured in the data.[31] This means that the exchange premium–based estimate of $\hat{\delta}$ in Eq. (11) will likely be biased downward. With the possible downward bias of the 2SLS estimator in mind, we consider the following alternative approach to estimate δ that is designed to deliver an upward-biased estimate.

4.1.2 Premia over matching AAA exchange-market bonds

Recall that the unexpected policy shock hit the exchange market by only disqualifying AA+ and AA enterprise bonds' pledgeability without affecting AAA bonds. We hence construct the pledgeability premium of AA+ and AA enterprise bonds over "similar" AAA enterprise bonds using the credit spreads of these treated and benchmark bonds on the exchange market only. This alternative exchange-market AAA benchmark improves our previous estimate in addressing the downward-bias problem, as there is no cross-market arbitrage involved between the treatment bonds and benchmark bonds.

The question is how to choose "similar" AAA exchange-trade enterprise bonds. For each treated exchange-traded enterprise bond—which we denote by "treated"—we match it with another exchange-traded AAA-rated bond with similar haircut and credit spreads. Under the framework established in Section 4.1.1, we have $h^{EX}_{\text{treated},t} - h^{EX}_{\text{matched-AAA},t} = 0$ for $t < 12/08/2014$, while after the policy shock we have $h^{EX}_{\text{treated},t} - h^{EX}_{\text{matched-AAA},t}$ increases. Hence

[31] Specifically, we calculate the returns of a cross-market arbitrage strategy in our sample. For the half-year period before the policy shock, consider buying AAA bonds on the interbank market whenever the exchange premium exceeds zero, holding the bonds for 5 working days, and then selling the holdings on the exchange. We use the volume-weighted average invoice prices on the interbank market as buying prices. The volume-weighted invoice bid prices on the exchange market are used as selling prices. According to industry practice, a minimum trade size of 10 million RMB is assumed on the interbank market. The pace of selling on the exchange is capped at 20% of its daily volume. The annualized Sharpe ratio of this strategy is 0.37 based on the IID assumption. Taking into account the correlation in returns across bonds will likely further reduces the Sharpe ratio.

one can write the matched-AAA premium as:

$$
\begin{aligned}
p^{EX}_{\text{treated},t} - p^{EX}_{\text{matched-AAA},t} = \quad & \underbrace{\lambda \left(h^{EX}_{\text{matched-AAA},t} - h^{EX}_{\text{treated},t} \right)}_{\text{identifies } \lambda} \\
& + \underbrace{\mathbb{E}_t \left[\widetilde{M}_{t+1} \left(\widetilde{Y}_{\text{treated},t+1} - \widetilde{Y}_{\text{matched-AAA},t+1} \right) \right]}_{\text{fundamental residual: 0 if matched well}} + \underbrace{\epsilon^{EX}_{\text{treated},t} - \epsilon^{EX}_{\text{matched-AAA},t}}_{\text{liquidity residual}}.
\end{aligned} \tag{12}
$$

In the above Eq. (12), the first line identifies λ, which is the focus of our study. In the second line, we have the first term, the "fundamental residual", that captures the fundamental difference between the matched-bond-pair; if the "matching" is perfect, then it should be exactly zero (more precisely, we only need the difference to stay at a constant). The second term "liquidity residual" in the second line captures the liquidity differential between the treated and control bonds, which might be dependent on the policy shock. Since "matching" is never ideal, both the second and third terms might be correlated with the policy shock.

But keep in mind that we are interested in an overestimate of the value of pledgeability. In other words, we are tolerant on potential mechanisms that produce a positive correlation between the terms in the second line in Eq. (12) and the policy shock.

All plausible economic mechanisms in our context that could contaminate our estimate seem to satisfy this condition. More specifically, recall that the policy shock in December 2014 represents a negative shock to pledgeability. We argue all of the following three leading endogeneity concerns generate a negative shock to the terms in the second line of Eq. (12), thereby delivering an overestimate of λ in this approach:

1. First, suppose that the policy maker has some private information that AA+/AA rated bonds are lower quality than the market believes, and hence releases the 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. Second, suppose that 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. Finally, suppose that the policy shock represents a liquidity-tightening event, and the resulting flight-to-liquidity effect raises the price 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.

The rest of the IV estimation procedure is the same as the 2SLS procedure laid out in Section 4.1.1, and we present the corresponding empirical results in Section 4.3.

4.2 Pledgeability and Asset Prices: Exchange Premia

This section conducts our formal empirical analyses on exchange premia, by presenting a Diff-in-Diff estimation and then the IV estimate of the pledgeability on asset prices.

4.2.1 Diff-in-Diff analysis

We have provided preliminary evidence in Figure 2 and Figure 3 that exchange premia across ratings react differently to the policy shock. Overall, they are consistent with the interpretation that the drop in pledgeability on the exchange adversely affects its bond prices. These results, however, have potentially severe limitations, as they do not control for the potential changes in the bond characteristics in our sample before and after the event. To have a higher chance of being included in the simultaneous trading sample (i.e., being traded on both markets within a three-day window), a bond needs to be traded relatively frequently on the two markets. Trading frequencies are endogenous and could change with market conditions, including the policy shock. For example, the trading of AAA enterprise bonds became more frequent relative to AA+/AA bonds after the event, which could have raised the average quality of the AAA bonds in the simultaneous trading sample.

To address the above concerns, we conduct a formal Diff-in-Diff analysis in the 12-month window around the policy shock, controlling for bond, rating, and weekly fixed effects, as well as additional market- and bond-level variables. The model specification is given in Eq. (13). For better illustration of the dynamics of the differences in exchange premia between treatment and control groups, we divide the 12-month window into 26 sub-periods (with 10 trading days or 2 weeks in each period); this ensures a sufficient number of observations in each sub-period. The dummy variable D_{jt}^k, $k \in \{1, \cdots, 26\}$, equals 1 for the treatment group bonds $j \in \{AA+, AA\}$ in the sub-period k and 0 otherwise. Following Freyaldenhoven, Hansen, and Shapiro (2019), we normalize the point estimate of the Diff-in-Diff coefficient immediately before the event date to zero. We plot the point estimate, d_k, of each sub-period and the associated 95% confidence interval calculated using standard errors clustered by week.

$$EXpremium_{ijt} = a_i + b_j + c_t + \sum_{k=1}^{26} d_k D_{jt}^k + X_{it}' e + u_{ijt} \tag{13}$$

As Figure 4 shows, the average exchange premia for the treated (AA+/AA) and control

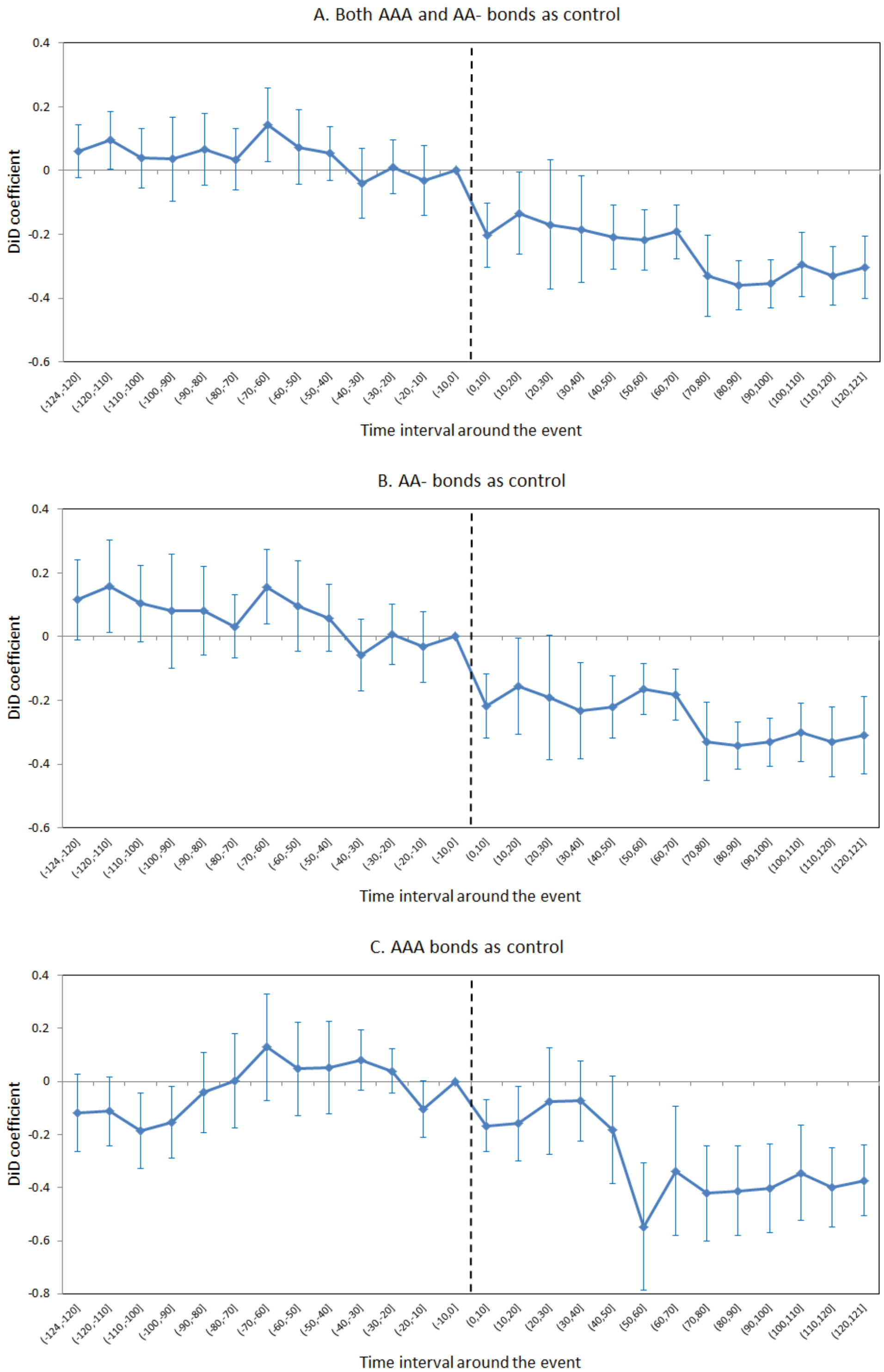

Figure 4: **Diff-in-Diff estimation of exchange premia.** This figure plots the estimated coefficients $\hat{d}_k$ along with their confidence intervals in the Diff-in-Diff specification of (13). The point estimate immediately before the event date is normalized to zero (hence a zero standard error). The dotted line indicates the event on 12/08/2014. The sample is from 2014/6/9 to 2015/6/8, which is divided into 26 10-day sub-periods. 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.

(AAA/AA−) bonds share a common trend before the policy shock. The Diff-in-Diff coefficients up to 100 days before the event are insignificantly different from the one immediately before the event. After the event, the exchange premia for the treated group became significantly lower relative to the control group. Consistent with the results in Figure 2, the gap ranges between -15 to -35 bps and remained significant 6 months after. We also repeat the same exercise for two different controls (AAA and AA−) separately, with qualitatively similar results reported in Figure 4.

4.2.2 IV estimation

Table 5 reports the IV estimation following the procedure outlined in Section 4.1, based on four different samples. The first (Columns 1 and 2) is the full simultaneous trading sample. The second (Column 3) is the subsample that excludes AAA bonds (i.e., using only AA− bonds as the control group), while the third (Column 4) is the subsample excluding AA− bonds (i.e., using only AAA bonds as the control group). By comparing the results based on different control groups, we can assess the sensitivity of the IV estimates to the assumption regarding the treated group and the two control groups share common variations in their exchange premia over time. Next, the fourth (Column 5) is the subsample excluding AA bonds (i.e., using only AA+ bonds as the treated group). The fifth (Column 6) is the subsample excluding AA+ bonds (i.e., using only AA bonds as the treated group). As the first stage results show, the AA+ groups have experienced a bigger haircut shock than the AA group, and it would be informative to compare their implied estimates on the pledgeability premium δ.

To simplify the interpretation of estimation magnitude, the exchange premium is quoted as percentage while explanatory variables are quoted as raw values, and the estimated coefficients in the first stage are reported as percentage. In all regressions we always include rating fixed effects and time fixed effects at the weekly level. 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). The control variables include bond-day level characteristics (time to maturity, turnover ratio, market price, and volatility) and various macro factors (term spread, CDB yield, 1-day exchange market repo rate over SHIBOR spread, and stock market return). For samples with other control groups or treatment groups, we only report the results with all control variables.[32] The standard errors in parentheses are based on standard errors clustered by week. For robustness, we also report the standard errors clustered by rating and week (in brackets).

The first stage, which regresses exchange market haircuts on the policy shock dummies

[32]The results without are similar and available upon request.

and other controls (see Eq. (10)), is quite strong. This result, is expected given the sharp dependence of bond-level haircuts on credit ratings (see Table 4) and the nature of the policy shock (which specifically targeted ratings). The magnitude of the coefficient on the policy shock dummy is consistent across all three samples. Without bond fixed effects and regular controls, the value of the estimated coefficients around 70% reflects the average rise in haircut for AA+ and AA bonds (see Figure 1). The magnitude of the coefficient are similar after bond level controls are included. The standard errors are indeed higher when clustering by rating and week than when clustering by week, consistent with persistent variations in haircuts within each rating.

In the second stage, we regress the exchange premia on the fitted haircuts, $\widehat{haircut}$, from the first-stage regression (see Eq. (11)), with the coefficient δ measuring the effect of changes in haircut on exchange premia. The coefficient estimate is highly statistically significant across different samples and specifications, although the economic magnitude varies depending on the control group (more on this point later). In the full sample, the estimated $\hat{\delta}$ of -0.39 (Column 2) implies that an increase in the haircut from 0 to 100% would raise the bond yields on the exchange by 39 bps.

Using different subsamples yields slightly different estimates for $\hat{\delta}$. When using only AA- bonds as controls (Column 3), the estimated $\hat{\delta}$ is essentially unchanged (-0.39 vs. -0.40). In contrast, when only the AAA bonds are used as the control group (Column 4), the magnitude of $\hat{\delta}$ becomes smaller (-0.32). This is the most conservative estimate among the four samples, implying that a rise in haircut from 0 to 100% would raise the bond yields on the exchange by 32 bps. The estimated $\hat{\delta}$ is again essentially the same as in the full sample for the AA+ only and AA only treated groups.

Flight-to-quality effect: Which control group is better? The reason that the estimated pledgeability premium is smaller (about 8 bps difference) with AAA bonds as the control is likely due to a "flight-to-quality" effect, as 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) while that of the other groups of bonds would rise. This would make AAA bonds a poor control group, biasing the estimate of δ downward.

What drove a stronger "flight-to-quality" effect in the interbank market in this episode? First of all, recall that the policy shock on December 2014 still allowed investors to continue to roll over existing repos on the exchange market and thus did not directly force investors to delever those affected AA and AA+ bonds, which directly limited the extent of fire sales on the exchange market. Second, the exchange market is more "retail" oriented while the interbank market is a "wholesale" market (recall Section 2.2.1 and Figure A1). When financial institutions scrambled for liquidity following the policy shock, they tend to turned to the interbank market as the primary source of funding to cover any large-scale liquidity shortage. In fact, this force might be the underlying force that pushed the haircut of AAA bonds up in the interbank market documented in Section 3.2 (Panel B Table 3). While we do not have detailed enterprise bond holdings data in the two markets, we are able to obtain data on the enterprise bond holdings from an anonymous institutional investor during that event. 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 market. In contrast, their AA+ and AA enterprise bond holdings declined by around 10% on the interbank market and by up to 40% on the exchange. These statistics are consistent with our interpretation of the "flight-to-quality" effect above in the interbank market.

Other robustness tests One factor that could potentially affect our estimate is that post-event market liquidity could change differentially across ratings and markets. As a robustness test, we add controls that measure the liquidity of the two markets separately, including the rating-level turnover by market as of the day of trade. The economic and statistical magnitudes for the estimates of pledgeability premia are almost the same (Table A4 in the Appendix). Notice that controlling for rating-level turnover (or similarly bid-ask spreads) may lead to underestimation of the pledgeability premium due to over-controlling. The reason is that the policy shock is likely to have heterogeneous effects on liquidity for different ratings and markets, which cannot be separated from the effects on exchange premia.

As another robustness test, we report the results of OLS regressions of exchange premium on the haircut in Internet Appendix Table IA3. The OLS estimate of $\hat{\delta}$ has slightly smaller magnitude of -0.37 compared to the IV estimate. The upward bias in the OLS estimate is likely due to omitted variables.[33]

Lastly, we also repeat the analysis for a half-year event window (three months before and after the policy shock; see Table IA4 in the Internet Appendix) and using the same-day trading sample (Table IA5 and Table IA6 in the Internet Appendix). The findings are

[33] To see this, consider the unobservable credit quality of some dual-listed enterprise bonds. Lower-quality bonds usually have worse liquidity in the spot market; but because interbank-only investors such as commercial banks face restrictions by regulation or internal compliance to invest in those bonds, such a quality-liquidity link tends to be stronger in the interbank market. As a result, bonds with low (unobservable) credit quality tend to have relatively lower interbank prices and hence relatively higher exchange premia. On the other hand, these low quality bonds also have higher haircuts, leading to a positive correlation between haircuts and exchange premia and hence an upward bias for the OLS estimate.

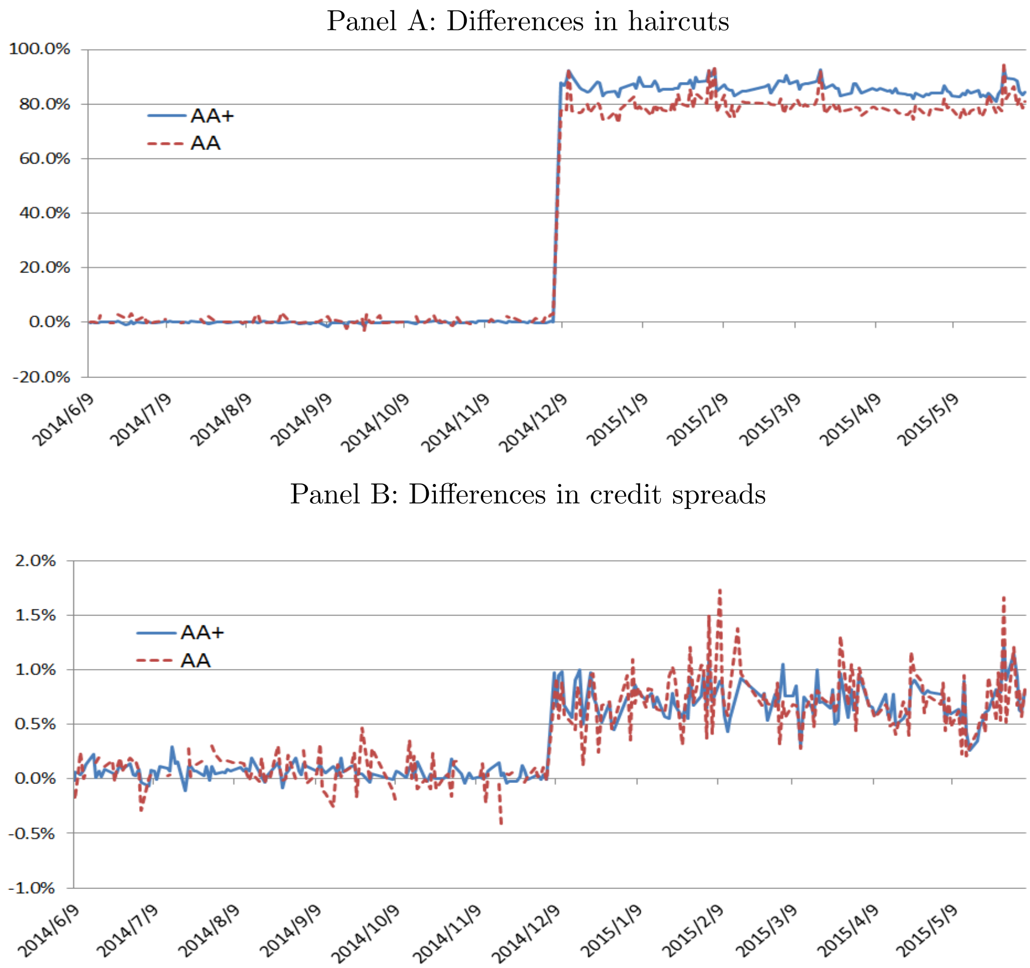

Figure 5: **Differences in haircuts and exchange credit spreads between the AA+/AA and matched AAA bonds.** This figure plots differences of AA+/AA dual-listed enterprise bonds' haircut and exchange market credit spread with respect to matched AAA bonds. Panels A and B plot the differences in haircut 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.

quantitatively similar.

4.3 Pledgeability and Asset Prices: Matching AAA Bonds

As mentioned toward the end of Section 4.1.1, our IV estimate based on exchange premium is likely biased downward due to arbitrage, and one can address this concern by considering matched exchange-trade AAA enterprise bonds (with similar haircuts and credit spreads) as the control group. As we have explained in Section 4.1.2, this approach produces an overestimate of the pledgeability premium.

We match each bond-day observation of AA+ and AA enterprise 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 5 shows the differences in haircuts and credit spreads of the bonds in the treatment group and those of the matched AAA bonds. Before the event date, the average haircuts are 13.7% and 13.5% for treatment and control bonds, respectively; the 10th percentile haircuts are 5.4% and 5.5%; and the 90th percentile haircuts are 30.0% and 27.7%. The average credit spreads are 1.30% and 1.25% for treatment and control bonds; the 10th percentile credit spreads are 0.76% and 0.71%; and the 90th percentile credit spreads are 1.82% and 1.75%.

We follow the same two-stage IV estimation as before, but replacing the exchange premium by the difference between a treatment bond's exchange market credit spread and the average credit spread of all matched exchange-market AAA bonds on the same day of trade. Table 6 reports the results.[34] 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 are consistent with our conjecture (Panel B of Table 6): a 100% increase in the haircut of AA+/AA bonds transfers to a 85 bps decrease in the pledgeability premium, the effect of which is larger than the estimate of 39 bps when the interbank credit spread of the simultaneous trading sample is used as the benchmark (Column 2 of Table 5). The magnitude is similar with rating-day level liquidity controls (Internet Appendix Table IA7). 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 3.29% price change for an average dual-listed enterprise bond as we will discuss with more detail in the next section.

4.4 Economic Effects

We end this section by examining the economic significance of the pledgeability premium coefficient δ estimated from the exchange premia and premia over matching AAA bonds.

First, we can re-express the impact of changes in the haircut on bond yield in dollar terms. Consider a bond with face value of 100 RMB. The average enterprise bond in our

[34] 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+ and AA bonds (and their premium 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.

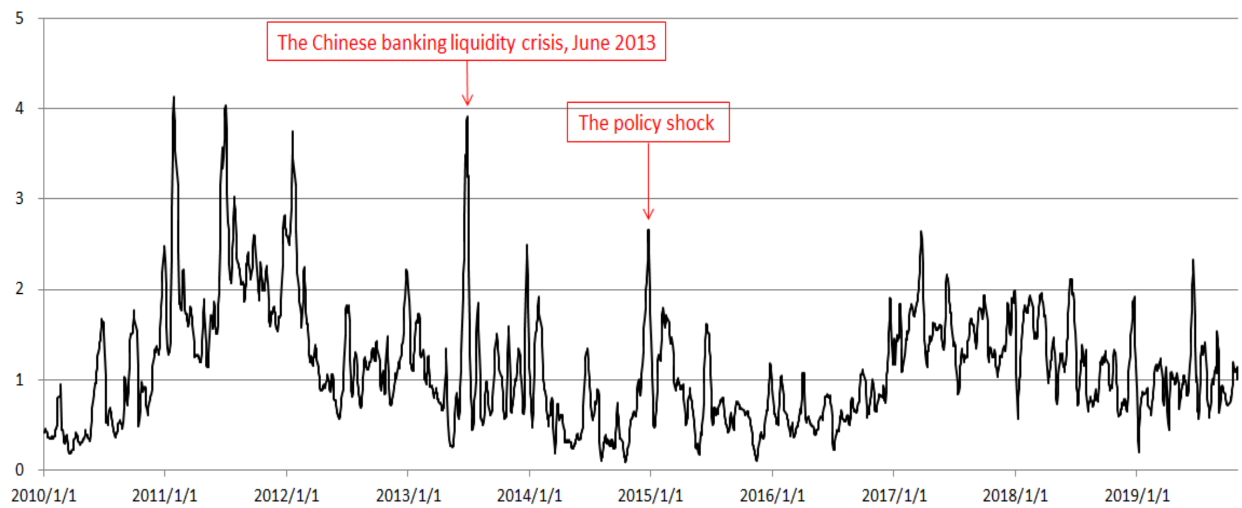

Figure 6: **Spread between the interbank market repo rate and the CDB bond yield, as percentages.** This figure plots the daily spread between the one-month interbank market repo rate for all financial institutions ("R1m") and the CDB bond yield calculated from CDB bonds with one-month maturity. Two events, the CDSC policy shock on 12/8/2014 studied by this paper and the Chinese banking liquidity crisis during 06/2013 analyzed in Hachem and Song (2021), are indicated. The sample period is from 1/1/2010 to 10/31/2019.

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, we can convert δ into the shadow cost of capital λ in Eq. (3). We extend the formula for the shadow value of margin constraint in Gârleanu and Pedersen (2011) to take into account the fact that the marginal investor borrows against her bonds only when hit by liquidity shocks,

$$\text{Pledgeability premium} = \text{Freq. of liq. shocks} \times \text{shadow cost of capital} \times (1 - \text{haircut}).$$

The pledgeability premium will be higher when the marginal investor is more frequently in a liquidity-constrained state, and/or when she faces higher shadow cost of capital in the constrained state. The shadow cost of capital is the gap between the interest-rate spread of collateralized and uncollateralized financing—that is, a form of 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 investors on 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, then the pledgeability premium 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 pledgeability premium 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 6; 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 policy shock as indicated in Figure 6. In the longer sample, we also see other periods (e.g., the Chinese banking liquidity crisis during June 2013 indicated in the figure) with even higher repo spreads. The pledgeability premium is likely to be significantly higher during these crisis episodes.

5 Conclusion

The equilibrium price of an asset not only depends on its fundamentals but also its pledgeability. The Chinese corporate bond markets provide an ideal laboratory to study the effect of pledgeability empirically thanks to the fact that some bonds with identical fundamentals are simultaneously traded in two parallel markets—centralized exchange market and 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 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 non-zero 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	10270	-0.04	0.48	-0.63	-0.02	0.50
EX premium_{pre}	5069	0.07	0.40	-0.39	0.04	0.55
EX premium_{post}	5201	-0.15	0.53	-0.76	-0.12	0.42
Haircut	10270	68.74	37.99	15.78	100.00	100.00
Haircut_{pre}	5069	42.32	32.60	8.12	30.90	100.00
Haircut_{post}	5201	94.50	21.70	100.00	100.00	100.00
Conversion	10270	33.13	40.35	0.00	0.00	88.00
Conversion_{pre}	5069	61.22	34.79	0.00	73.00	97.00
Conversion_{post}	5201	5.76	22.76	0.00	0.00	0.00
IB spread	10270	2.41	0.79	1.42	2.44	3.40
EX spread	10270	2.45	0.86	1.34	2.51	3.48
Matched spread	9940	0.55	0.68	-0.15	0.47	1.38
Matched spread_{pre}	2227	0.06	0.16	-0.13	0.04	0.27
Matched spread_{post}	7713	0.69	0.71	-0.16	0.70	1.49
Matched spread_{AA+}	7570	0.54	0.67	-0.14	0.46	1.37
Matched spread_{AA}	2370	0.56	0.71	-0.16	0.48	1.43
Maturity	10270	5.10	1.61	2.97	5.26	6.72
Turnover	10270	0.08	0.08	0.02	0.05	0.17
Market price	10270	104.98	5.76	100.37	105.37	110.75
Volatility	10270	0.02	0.02	0.00	0.01	0.04
CDB_{spot}	10270	0.04	0.01	0.04	0.04	0.05
Term spread	10270	0.01	0.00	0.00	0.00	0.01
GC001-SHIBOR	10270	0.02	0.04	0.00	0.01	0.06
Ret_{stock}	10270	0.00	0.02	-0.01	0.00	0.02

Panel B: Exchange premia by rating (%)

AAA	478	0.10	0.37	-0.37	0.03	0.59
AA+	3088	0.01	0.48	-0.55	0.00	0.55
AA	5182	-0.09	0.50	-0.71	-0.05	0.47
AA−	1522	-0.02	0.45	-0.49	-0.01	0.47

Panel C: Haircuts by rating (%)

AAA	478	11.30	10.04	5.48	6.81	26.28
AA+	3088	62.45	40.57	7.45	100.00	100.00
AA	5182	68.61	35.44	29.85	100.00	100.00
AA−	1522	100.00	0.00	100.00	100.00	100.00

Table 3: Market reactions of the policy shock and black-list announcements

This table reports the average market reactions by rating and market of the policy shock and the five black-list announcements, as well as the interbank market haircuts. The policy shock was on 2014/12/8 and the five announcements were made on 2014/5/29, 2014/6/27, 2014/8/1, 2014/9/5, and 2014/11/3. The average one-day post-announcement changes in credit spreads for the policy shock are reported in Panel A. Average haircuts on the interbank market six months prior to and after the policy shock are reported in Panel B. The average one-day post-announcement changes in credit spreads across the five announcements are reported in Panel C. Standard errors are reported in parentheses. The symbols *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: Market reactions of the 12/8 policy shock

	EX market				IB market			
	AAA	AA+	AA	AA−	AAA	AA+	AA	AA−
ΔSpread$^{12/8}$	-14.69	61.61***	37.64***	60.52***	-24.33	-7.97	-9.12	23.87
	(17.40)	(12.19)	(13.50)	(18.86)	(31.10)	(13.31)	(8.18)	(21.49)

Panel B: Haircuts on the interbank

Sample period	AAA	AA+	AA	AA− & below
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)

Panel C: Market reactions of the five black-list announcements

	EX market				IB market			
	AAA	AA+	AA	AA−	AAA	AA+	AA	AA−
ΔSpread$^{five\ lists}$	-0.24	3.30	4.60	8.37	-4.42	8.14	4.89	-16.15
	(7.19)	(4.56)	(5.05)	(8.04)	(11.63)	(6.47)	(3.58)	(22.00)

Table 4: Determinants of conversion rate

This table reports the regression results of dual-listed enterprise bonds' exchange market conversion rates on rating dummies and control variables. The sample in Columns (1) to (2) includes all dual-listed enterprise bonds' daily observations including those without transaction. The sample in Columns (3) to (4) includes daily observations with simultaneous trading within a two-day window in two markets. 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 sample period is 6/9/2014 to 12/8/2014.

	Full		Simultaneous	
	(1)	(2)	(3)	(4)
Dummy_{AAA}	88.84***	31.15***	89.40***	-33.96
	(0.22)	(1.81)	(1.34)	(23.66)
Dummy_{AA+}	76.95***	24.40***	79.40***	-42.66*
	(0.28)	(1.76)	(1.06)	(23.63)
Dummy_{AA}	69.98***	19.17***	66.92***	-53.85**
	(0.06)	(1.98)	(0.72)	(23.39)
Dummy_{AA-}	0.00	-49.73***	0.00	-118.96***
	(0.00)	(1.83)	(0.00)	(22.86)
Invoice		0.47***		0.90***
		(0.01)		(0.18)
Vol		-44.76***		-27.30
		(6.24)		(25.05)
MCB		-1.59***		-3.72***
		(0.19)		(1.33)
Age		0.24***		0.06
		(0.03)		(0.37)
Nbond		-1.59***		-0.35***
		(0.07)		(0.10)
OTR		-0.73***		-1.06
		(0.14)		(0.74)
Maturity		0.38***		1.54***
		(0.02)		(0.28)
Turnover		-2.59		-0.37
		(2.02)		(4.84)
Size		5.69***		3.40***
		(0.06)		(0.79)
Leverage		-16.55***		-16.54***
		(0.25)		(3.57)
Issuance		-0.29***		1.94**
		(0.05)		(0.72)
CDB_{spot}		-0.69***		267.39**
		(0.09)		(105.47)
Term spread		0.04		489.75*
		(0.20)		(286.43)
GC001 - SHIBOR		-0.01		-8.08
		(0.00)		(5.91)
Ret_{stock}		0.04		-4.85
		(0.03)		(36.42)
Industry FE	–	✓	–	✓
R-square	0.93	0.94	0.90	0.91
N	133582	133582	5069	5069

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 (or by rating and week) are reported in parentheses (brackets). 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	67.89	68.28	68.38	68.00	75.05	63.57
	(0.57)***	(0.74)***	(0.76)***	(0.74)***	(0.98)***	(1.28)***
	[4.94]***	[5.78]***	[6.18]***	[7.20]***	[1.01]***	(0.69)***
Controls	–	✓	✓	✓	✓	✓
Bond FE	–	✓	✓	✓	✓	✓
Rating FE	✓	✓	✓	✓	✓	✓
Week FE	✓	✓	✓	✓	✓	✓
R-square	0.85	0.95	0.95	0.95	0.97	0.96
N	10270	10107	9651	8584	5008	7065

Table 5 (cont.): IV estimation

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	-0.32	-0.40	-0.38
	(0.05)***	(0.05)***	(0.05)***	(0.08)***	(0.05)***	(0.09)***
	[0.03]***	[0.04]***	[0.04]***	[0.14]**	[0.04]***	[0.06]***
Maturity		2.12	2.34	2.52	2.82	1.08
		(0.71)***	(0.73)***	(0.83)***	(0.85)***	(0.79)
		[1.28]*	[1.17]**	[1.31]*	[2.25]	[1.04]
Turnover		0.12	0.10	0.13	0.20	0.10
		(0.09)	(0.09)	(0.11)	(0.14)	(0.09)
		[0.06]**	[0.05]**	[0.09]	[0.17]	[0.06]
Market price		-0.00	-0.00	-0.00	-0.01	-0.00
		(0.00)	(0.00)	(0.00)	(0.00)*	(0.00)
		[0.00]	[0.00]	[0.00]	[0.00]***	[0.00]
Volatility		-0.04	-0.13	0.13	-0.86	0.24
		(0.95)	(0.97)	(1.03)	(1.47)	(0.75)
		[1.14]	[1.14]	[0.73]	[1.13]	[0.77]
CDB_{spot}		-12.95	-13.01	-15.76	-14.30	-9.90
		(8.60)	(8.68)	(11.29)	(12.63)	(8.97)
		[14.68]	[21.28]	[12.64]	[12.50]	[14.25]
Term spread		3.14	1.16	4.18	-5.63	12.25
		(7.17)	(6.45)	(7.72)	(13.81)	(8.06)
		[21.33]	[16.64]	[20.64]	[50.42]	[9.50]
GC001-SHIBOR		-0.19	-0.21	-0.15	-0.15	-0.23
		(0.12)	(0.11)*	(0.13)	(0.14)	(0.15)
		[0.17]	[0.11]*	[0.12]	[0.16]	[0.12]
Ret_{stock}		0.11	0.08	0.18	0.05	0.11
		(0.27)	(0.29)	(0.34)	(0.40)	(0.35)
		[0.68]	[0.40]	[0.45]	[0.31]	[0.33]
Bond FE	–	✓	✓	✓	✓	✓
Rating FE	✓	✓	✓	✓	✓	✓
Week FE	✓	✓	✓	✓	✓	✓
R-square	0.12	0.48	0.47	0.49	0.41	0.53
N	10270	10107	9651	8584	5008	7065

Table 6: 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 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. 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***
	(0.96)	(1.32)	(0.95)	(1.48)
Controls	–	✓	✓	✓
Bond FE	–	✓	✓	✓
Rating FE	✓	✓	✓	✓
R-square	0.98	0.99	0.99	0.98
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***	-0.85***	-0.84***	-0.84***
	(0.03)	(0.05)	(0.05)	(0.09)
Maturity		0.03	0.07	-0.09
		(0.11)	(0.10)	(0.21)
Turnover		2.22***	1.23*	5.94***
		(0.82)	(0.73)	(2.13)
Market price		-0.00	-0.00	0.01
		(0.00)	(0.00)	(0.01)
Volatility		0.12	-1.03	2.19**
		(0.83)	(1.05)	(1.05)
CDB_{spot}		-10.28***	-10.32***	-7.96
		(3.78)	(3.43)	(9.25)
Term spread		-0.91	-3.54	5.72
		(4.97)	(4.51)	(8.94)
GC001-SHIBOR		-0.17	-0.12	-0.43
		(0.31)	(0.26)	(0.55)
Ret_{stock}		0.77	1.00*	0.11
		(0.55)	(0.51)	(0.89)
Bond FE	–	✓	✓	✓
Rating FE	✓	✓	✓	✓
R-square	0.15	0.55	0.56	0.54
N	9940	9897	7548	2349

Appendix

A Data Construction

A.1 Bond rating classification

Multiple bond ratings. There are five major rating agencies offering rating services to bond issuers in China.[35] 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 in one of the five black lists, its bond rating is adjusted to AA− and 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 following (the case of "same-day" 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 in 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.

[35] 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 agency, see Amstad and He (2020).

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 benchmark in two dimensions: haircut and matching CDB credit spread. The matching is conducted at bond-day level in the six-month window before the event date, i.e., from June 9th to December 8th, 2014. For any AA+/AA bond that was ever traded in the six-month window after the event date (December 9th, 2014 to June 8th, 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, five non-zero trading AAA-rated bonds that have the five 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, five non-zero trading AAA-rated bonds that have the five 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 by $\text{AAA}_{i,t}^{yieldspread}$.

5. AAA bonds that belong to both $\text{AAA}_{i,t}^{haircut}$ and $\text{AAA}_{i,t}^{yieldspread}$ are denoted as 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 τ observation in the six-month post-event window, the average credit spread of AAA bonds with non-zero trading on day τ 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. 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.

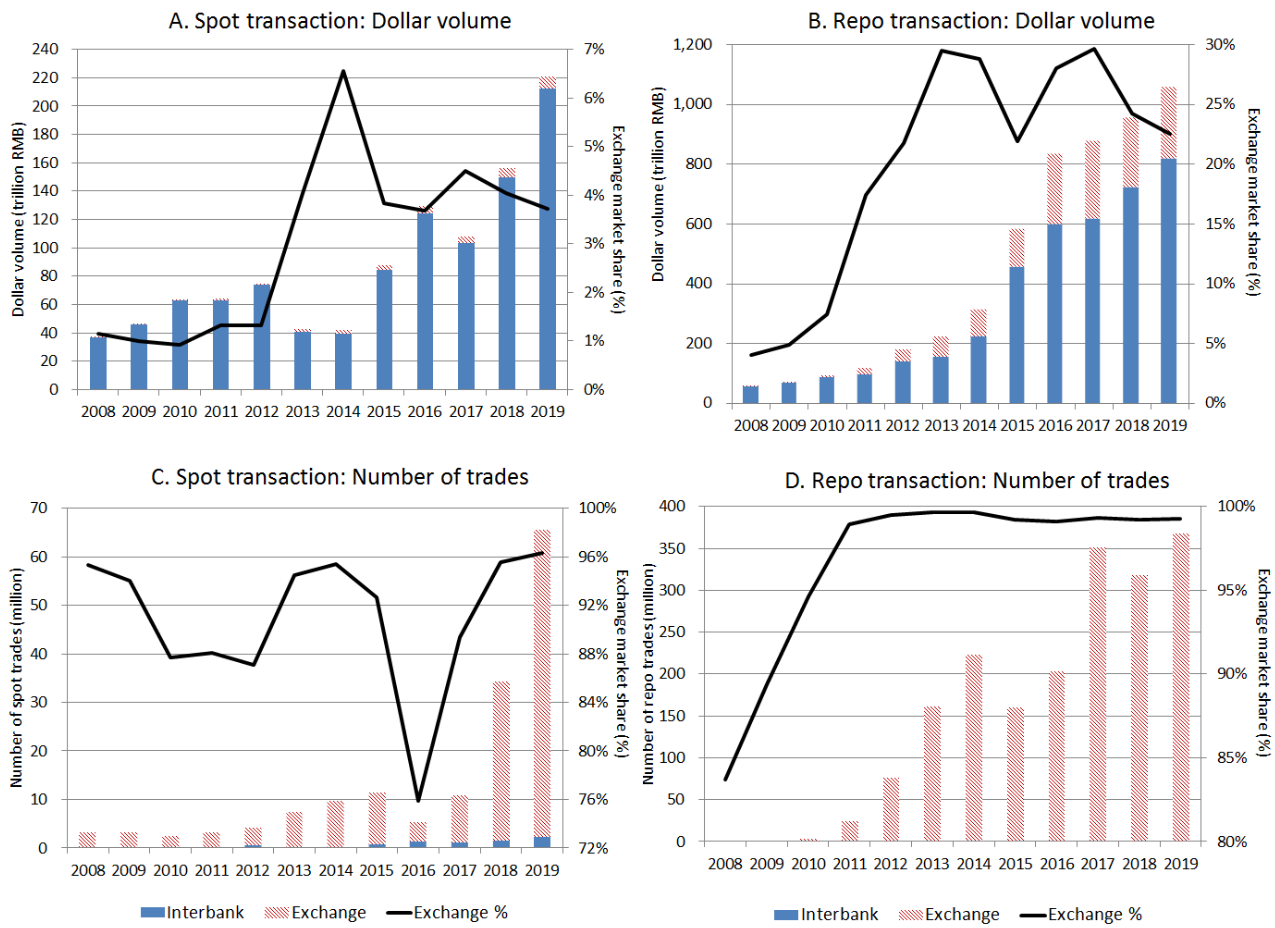
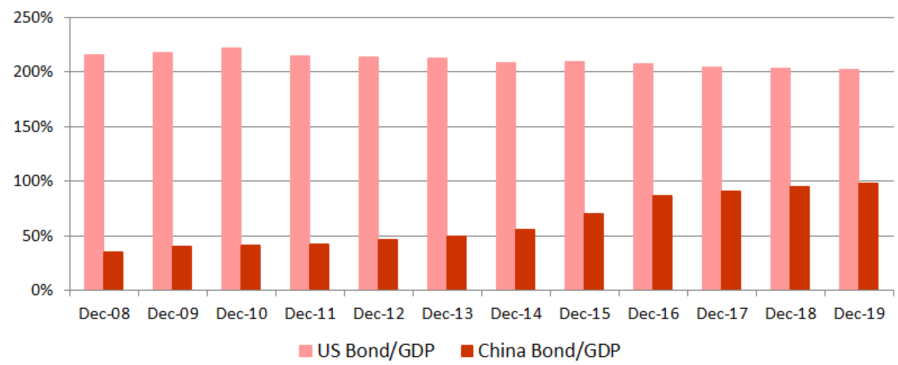


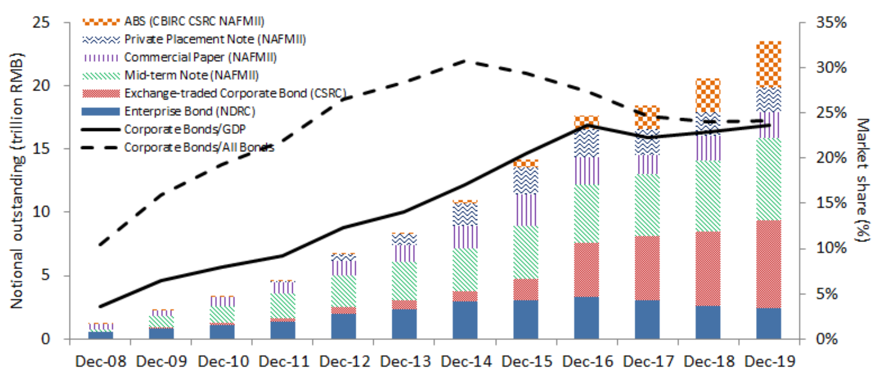
Figure A2: China's bond market

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

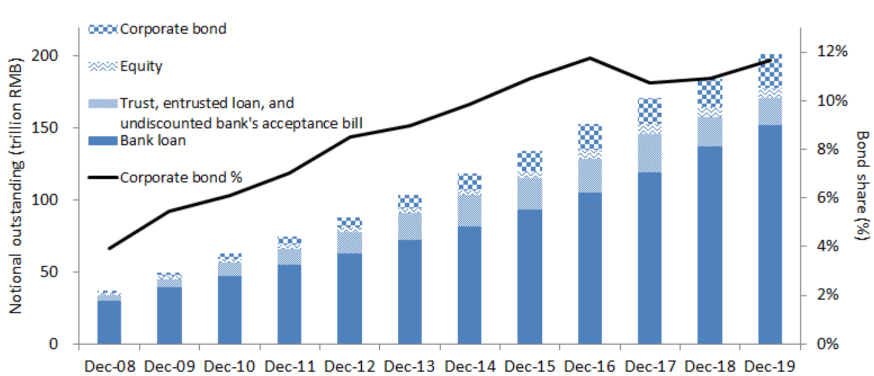


Table A1: China's bond market liquidity

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 2014/5/29, 2014/6/27, 2014/8/1, 2014/9/5, and 2014/11/3. MCBs are indicated with *.

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

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 premium$_{pre}$	Exchange premium of the subsample before the policy shock from 6/9/2014 to 12/8/2014
EX 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
Haircut$_{pre}$	Haircut of the subsample before the policy shock from 6/9/2014 to 12/8/2014
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
Conversion$_{pre}$	Conversion rate of the subsample before the policy shock from 6/9/2014 to 12/8/2014
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
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	
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
Ret$_{stock}$	Daily return of Shanghai Composite Index as of the day of trade

Table A4: 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	67.89***	68.26***	68.35***	67.99***	74.99***	63.43***
	(0.57)	(0.77)	(0.81)	(0.73)	(0.99)	(0.86)
Controls	–	✓	✓	✓	✓	✓
Bond FE	–	✓	✓	✓	✓	✓
Rating FE	✓	✓	✓	✓	✓	✓
Week FE	✓	✓	✓	✓	✓	✓
R-square	0.85	0.95	0.95	0.95	0.97	0.96
N	10270	10107	9651	8584	5008	7065

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***	-0.32***	-0.40***	-0.38***
	(0.05)	(0.05)	(0.05)	(0.08)	(0.05)	(0.05)
Maturity		2.12***	2.34***	2.51***	2.80***	1.11
		(0.71)	(0.73)	(0.83)	(0.89)	(0.78)
Turnover^{ex}		0.96**	0.91**	0.93**	1.16	0.96*
		(0.40)	(0.40)	(0.45)	(0.95)	(0.51)
Turnover^{ib}		0.10	0.09	0.11	0.17	0.08
		(0.09)	(0.09)	(0.11)	(0.15)	(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		-0.03	-0.12	0.14	-0.86	0.25
		(0.95)	(0.97)	(1.03)	(1.48)	(0.75)
$\text{Turnover}^{ex}_{rating}$		6.52	9.67	-33.20	23.33	8.50
		(13.32)	(13.62)	(22.31)	(20.64)	(11.14)
$\text{Turnover}^{ib}_{rating}$		0.94	0.89	1.54	2.88	-0.65
		(1.97)	(1.99)	(2.31)	(2.80)	(1.96)
CDB_{spot}		-13.33	-13.40	-15.32	-15.66	-10.45
		(8.74)	(8.84)	(11.23)	(13.05)	(8.89)
Term spread		3.36	1.44	4.45	-4.07	12.32
		(7.20)	(6.50)	(7.69)	(14.79)	(7.93)
GC001-SHIBOR		-0.18	-0.20*	-0.16	-0.13	-0.22
		(0.11)	(0.11)	(0.13)	(0.14)	(0.14)
Ret_{stock}		0.11	0.07	0.18	0.02	0.10
		(0.27)	(0.28)	(0.34)	(0.42)	(0.35)
Bond FE	–	✓	✓	✓	✓	✓
Rating FE	✓	✓	✓	✓	✓	✓
Week FE	✓	✓	✓	✓	✓	✓
R-square	0.12	0.48	0.47	0.49	0.41	0.53
N	10270	10107	9651	8584	5008	7065

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 Marginal Investors

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

Figure IA2 Panel A plots the share of enterprise bonds held by the marginal investors over deposited enterprise bonds on each market. Over the one-year window from 2014/6/30 to 2015/6/30, enterprise bonds held by those marginal investors account for more than 50% of interbank market deposited enterprise bonds, and the number is higher than 70% on the exchange market. Figure IA2 Panel B plots the share of enterprise bond spot transaction by marginal investors over the four quarters around the policy shock. Marginal investors' spot transactions account for 30% to 50% of all interbank market enterprise bond trades, and these numbers are around 80% for the exchange market. Overall, mutual funds, insurance companies, and securities firms are important traders of enterprise bonds on 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 2014:6 to 2015:5. Those marginal investors also actively participate in the repo transactions on the interbank market: around 20% of repo and 7% of reverse-repo transactions were conducted by them. We do not have detailed repo transaction data by participant type for the exchange market. But according to a research report issued by Shanghai Stock Exchange,[1] those three groups of marginal investors account for 58.9% of repo

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

transactions in 2014, while natural persons are the single largest lenders on the reverse-repo market (44.5%), followed by general legal entities (17.4%), and trusts (10.4%). Therefore, those three groups of institutions are important net borrowers, i.e., leverage users, in both interbank and exchange repo markets.

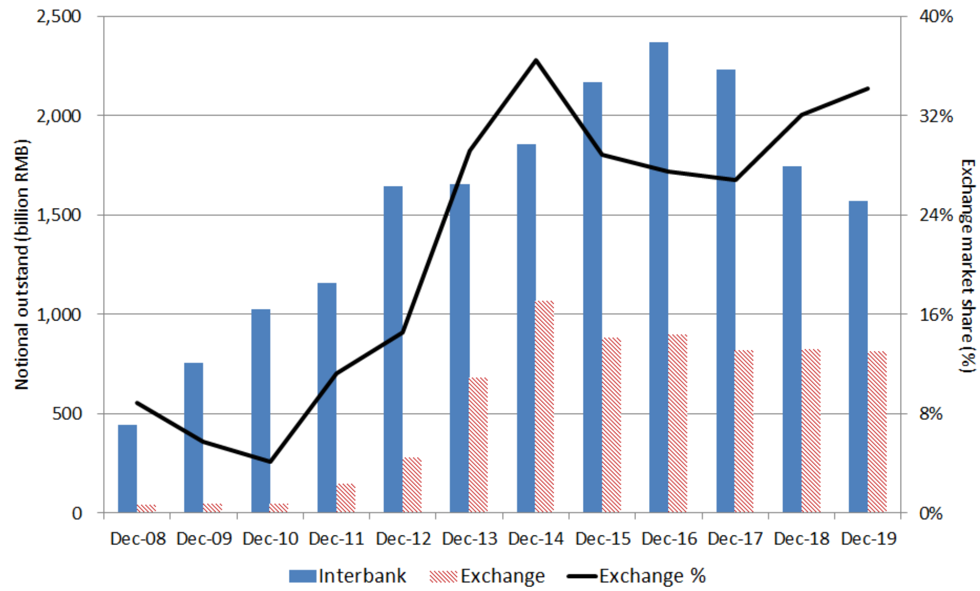
IA2 Additional Results

In this section, we present additional empirical results. Table IA3 reports the results for OLS regressions, Table IA4 reports the results with the [−3,3]-month estimation window, Table IA5 and Table IA6 report the results using the same-day sample without and with rating-day level controls, respectively, and Table IA7 reports the results using the sample of matched AAA bonds as benchmark with rating-day level controls.

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)

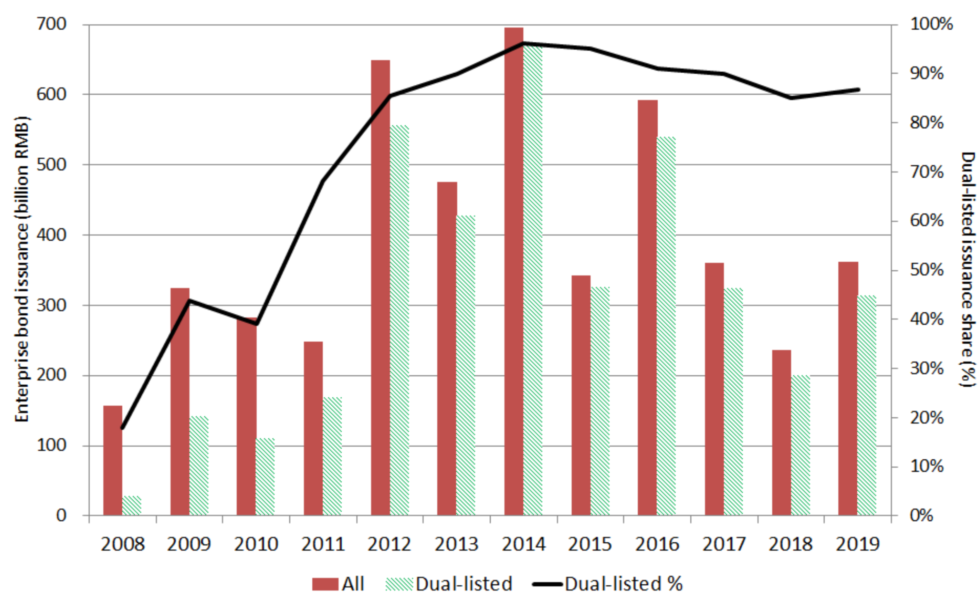
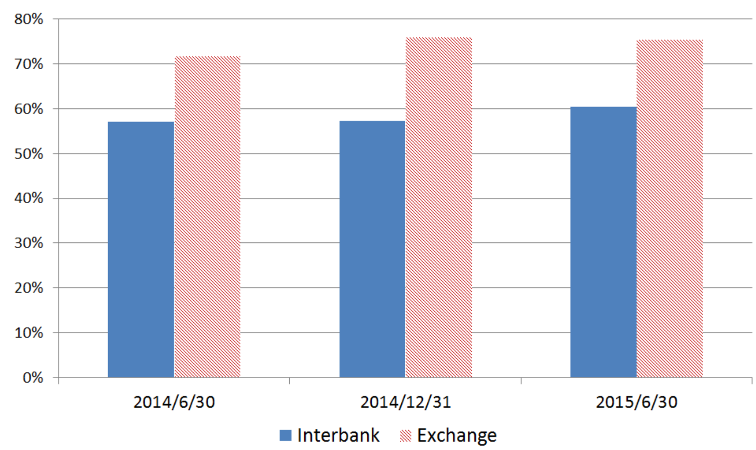


Figure IA2: Marginal investors' holding and spot transaction shares on the two markets

This figure plots marginal investors' holding share and spot transaction share of enterprise bonds on the interbank and exchange markets. Three groups of marginal investors include mutual funds, insurance companies, and securities firms. Panel A plots the aggregate holding share of enterprise bonds by marginal investors over the deposited enterprise bond outstanding on each market as of 2014/6/30, 2014/12/31, and 2016/6/30. Panel B plots marginal investors' spot transaction share of enterprise bonds on the two markets in the four quarters from 2014Q3 to 2015Q2. Data on marginal investors' holding and spot transaction shares of enterprise bonds on the exchange market are from Shanghai and Shenzhen exchanges. Data on marginal investors' holding share of enterprise bonds on the interbank market are from the CCDC. Data on marginal investors' 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 marginal investors for all bonds on the interbank market; (3) marginal investors' 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: Marginal investors' holding share of enterprise bonds



Panel B: Marginal investors' spot transaction share of enterprise bonds

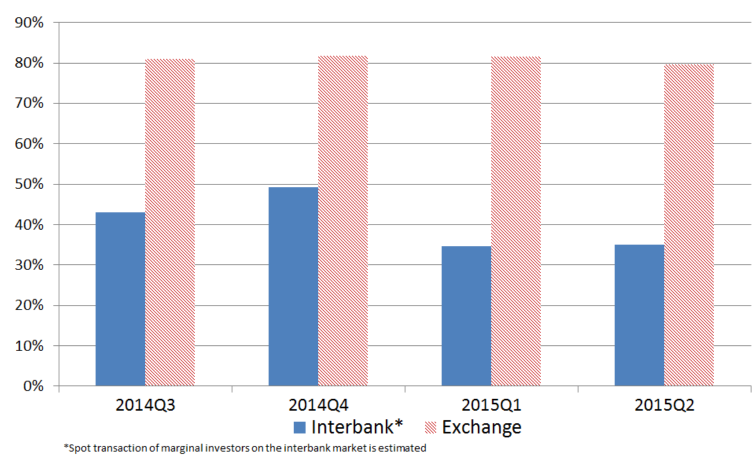
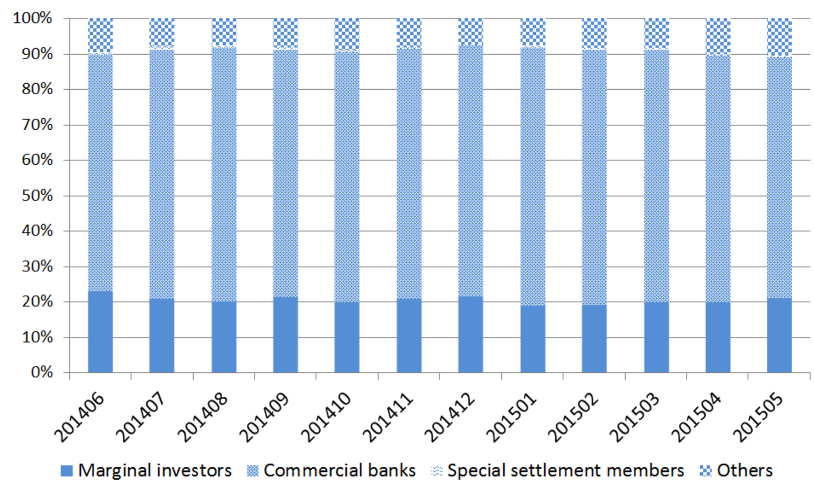


Figure IA3: Repo and reverse-repo transaction shares on the interbank market

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

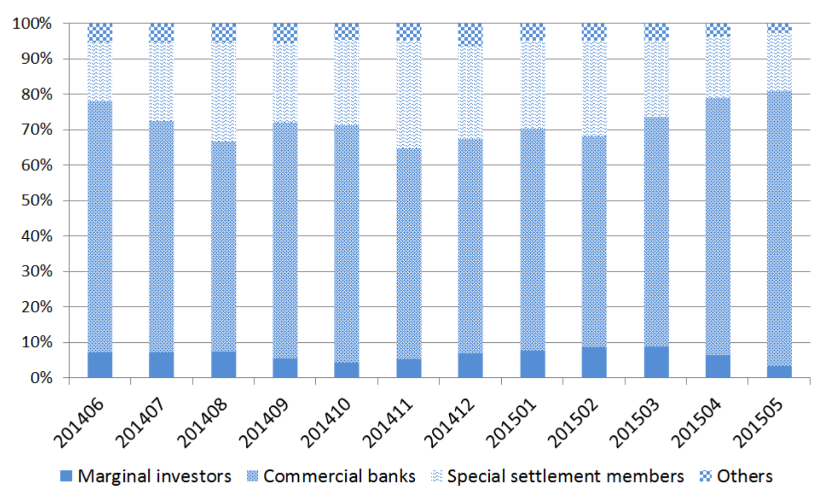


Table IA1: Summary statistics: Same-day sample

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 premium_{pre}	1719	0.06	0.40	-0.39	0.03	0.56
EX 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
Haircut_{pre}	1719	43.80	33.89	8.10	30.87	100.00
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
Conversion_{pre}	1719	59.54	36.13	0.00	73.00	97.00
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
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
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 of 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 2014/5/29, 2014/6/27, 2014/8/1, 2014/9/5, and 2014/11/3. The average one-day post-announcement changes in credit spreads are reported in basis point. No IB transaction was on 2014/5/30 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−
$\Delta\text{Spread}^{5/29}$	-7.97	0.46	0.86	3.23	33.26	-3.84	10.06	
	(16.97)	(9.35)	(8.43)	(−)	(26.19)	(12.95)	(9.03)	
$\Delta\text{Spread}^{6/27}$	1.24	4.54	14.71	2.92	-16.75	-3.91	-1.13	-8.34
	(19.52)	(10.65)	(11.39)	(59.72)	(21.42)	(11.55)	(8.03)	(−)
$\Delta\text{Spread}^{8/1}$	-17.73	-0.30	-3.79	1.65	-40.21	-1.30	2.34	33.58
	(18.14)	(9.79)	(13.93)	(21.08)	(26.01)	(16.49)	(8.19)	(63.92)
$\Delta\text{Spread}^{9/5}$	6.41	1.53	3.45	5.91	-51.78**	8.21	1.08	-21.89
	(11.47)	(11.44)	(15.22)	(12.07)	(24.22)	(19.53)	(7.29)	(50.03)
$\Delta\text{Spread}^{11/3}$	9.06	7.79	8.70	13.32	21.05	40.09***	16.68**	-4.25
	(13.59)	(9.64)	(10.38)	(11.45)	(29.52)	(14.02)	(7.82)	(30.82)

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***	-0.33***	-0.42***	-0.33***
	(0.03)	(0.04)	(0.04)	(0.06)	(0.05)	(0.05)
Maturity		2.15***	2.37***	2.50***	2.78***	1.15
		(0.70)	(0.73)	(0.82)	(0.84)	(0.79)
Turnover		0.12	0.10	0.13	0.20	0.10
		(0.09)	(0.09)	(0.11)	(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		-0.05	-0.14	0.14	-0.84	0.22
		(0.95)	(0.97)	(1.02)	(1.47)	(0.75)
CDB_{spot}		-13.44	-13.62	-15.34	-13.70	-11.05
		(8.72)	(8.80)	(11.07)	(12.59)	(9.04)
Term spread		3.61	1.75	3.81	-6.37	13.34*
		(7.08)	(6.37)	(7.36)	(13.68)	(7.87)
GC001-SHIBOR		-0.19	-0.21*	-0.14	-0.15	-0.23
		(0.12)	(0.11)	(0.14)	(0.14)	(0.14)
Ret_{stock}		0.12	0.09	0.16	0.04	0.13
		(0.27)	(0.29)	(0.33)	(0.39)	(0.34)
Bond FE	–	✓	✓	✓	✓	✓
Rating FE	✓	✓	✓	✓	✓	✓
Week FE	✓	✓	✓	✓	✓	✓
R-square	0.12	0.48	0.47	0.49	0.41	0.53
N	10270	10107	9651	8584	5008	7065

Table IA4: IV estimation: [−3,3]-month event window

This table reports the results of IV regressions using the simultaneous trading sample in the [−3,3]-month window around the event day. 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 9/9/2014 to 3/8/2015. 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	67.82***	66.37***	66.34***	66.92***	74.52***	61.11***
	(0.65)	(1.24)	(1.26)	(1.29)	(1.51)	(1.51)
Controls	–	✓	✓	✓	✓	✓
Bond FE	–	✓	✓	✓	✓	✓
Rating FE	✓	✓	✓	✓	✓	✓
Week FE	✓	✓	✓	✓	✓	✓
R-square	0.83	0.95	0.95	0.94	0.97	0.96
N	4628	4450	4240	3603	2351	3154

Panel B: Second stage

Dependent: EX Premia	Full		Exclude AAA	Exclude AA-	Exclude AA	Exclude AA+
	(1)	(2)	(3)	(4)	(5)	(6)
$\widehat{Haircut}$ $	-0.23***	-0.22***	-0.24***	-0.07	-0.23***	-0.21**
	(0.05)	(0.07)	(0.08)	(0.07)	(0.07)	(0.09)
Maturity		3.70***	4.00***	4.61***	4.26***	2.21
		(1.20)	(1.22)	(1.57)	(1.36)	(1.41)
Turnover		0.24	0.23	0.25	0.41*	0.08
		(0.15)	(0.15)	(0.21)	(0.23)	(0.10)
Market price		0.01**	0.01*	0.01**	0.01*	0.01**
		(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Volatility		-0.93	-0.99	-1.15	-1.77	0.45
		(1.50)	(1.54)	(1.54)	(1.93)	(1.37)
CDB_{spot}		-12.44	-13.11	-20.75	-18.88	-2.34
		(10.45)	(10.81)	(14.13)	(16.81)	(9.77)
Term spread		52.05**	48.89**	62.31**	52.61*	49.84*
		(22.95)	(22.11)	(24.46)	(26.37)	(27.21)
GC001-SHIBOR		0.05	0.07	-0.04	0.01	0.14
		(0.10)	(0.08)	(0.16)	(0.16)	(0.12)
Ret_{stock}		-0.10	-0.06	0.08	-0.28	-0.06
		(0.44)	(0.49)	(0.50)	(0.48)	(0.53)
Bond FE	–	✓	✓	✓	✓	✓
Rating FE	✓	✓	✓	✓	✓	✓
Week FE	✓	✓	✓	✓	✓	✓
R-square	0.08	0.49	0.48	0.49	0.43	0.54
N	4628	4450	4240	3603	2351	3154

Table IA5: 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	67.03***	69.16***	69.29***	68.19***	75.41***	64.79***
	(0.87)	(0.95)	(0.98)	(1.08)	(1.37)	(1.20)
Controls	–	✓	✓	✓	✓	✓
Bond FE	–	✓	✓	✓	✓	✓
Rating FE	✓	✓	✓	✓	✓	✓
Week FE	✓	✓	✓	✓	✓	✓
R-square	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***	-0.22*	-0.42***	-0.35***
	(0.06)	(0.07)	(0.07)	(0.12)	(0.08)	(0.08)
Maturity		-0.60	-0.42	-0.77	-0.64	-0.36
		(1.18)	(1.22)	(1.36)	(1.92)	(1.27)
Turnover		0.03	0.02	0.10	0.13	-0.01
		(0.13)	(0.12)	(0.15)	(0.21)	(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		-1.62	-1.81	-1.38	-2.82	-0.79
		(1.39)	(1.41)	(1.50)	(2.14)	(1.28)
CDB_{spot}		-34.67**	-38.23**	-38.78**	-32.98	-32.32**
		(15.07)	(15.77)	(19.02)	(26.66)	(13.42)
Term spread		-2.88	-3.97	2.06	-34.67	10.59
		(13.32)	(13.12)	(14.28)	(25.55)	(10.66)
GC001-SHIBOR		-0.17	-0.20	-0.23	-0.05	-0.11
		(0.26)	(0.26)	(0.27)	(0.28)	(0.40)
Ret_{stock}		-0.22	-0.40	-0.22	-0.30	-0.04
		(0.46)	(0.45)	(0.45)	(1.00)	(0.49)
Bond FE	–	✓	✓	✓	✓	✓
Rating FE	✓	✓	✓	✓	✓	✓
Week FE	✓	✓	✓	✓	✓	✓
R-square	0.15	0.53	0.53	0.53	0.48	0.59
N	3514	3257	3137	2688	1613	2314

Table IA6: 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. Turnover^{ex}/Turnover^{ib} is the bond-day-market level turnover. Turnover$^{ex}_{rating}$/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	67.03***	69.12***	69.22***	68.21***	75.35***	64.53***
	(0.87)	(1.01)	(1.06)	(1.13)	(1.36)	(1.22)
Controls	–	✓	✓	✓	✓	✓
Bond FE	–	✓	✓	✓	✓	✓
Rating FE	✓	✓	✓	✓	✓	✓
Week FE	✓	✓	✓	✓	✓	✓
R-square	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***	-0.23**	-0.42***	-0.34***
	(0.06)	(0.07)	(0.07)	(0.12)	(0.08)	(0.08)
Maturity		-0.58	-0.39	-0.75	-0.56	-0.33
		(1.13)	(1.17)	(1.33)	(1.88)	(1.22)
Turnover^{ex}		1.35**	1.36**	1.59**	1.54	0.98
		(0.55)	(0.58)	(0.67)	(1.63)	(0.65)
Turnover^{ib}		0.02	0.00	0.08	0.12	-0.01
		(0.13)	(0.13)	(0.16)	(0.21)	(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		-1.64	-1.82	-1.39	-2.82	-0.81
		(1.39)	(1.40)	(1.49)	(2.15)	(1.28)
Turnover$^{ex}_{rating}$		-8.65	-3.79	-98.14*	5.62	-1.97
		(18.93)	(18.85)	(55.74)	(25.99)	(18.14)
Turnover$^{ib}_{rating}$		-3.96	-3.89	-5.58	-1.86	-4.64
		(3.13)	(3.16)	(3.98)	(4.96)	(2.88)
CDB$_{spot}$		-35.39**	-39.04***	-36.77**	-33.66	-33.21**
		(14.50)	(15.27)	(17.99)	(26.60)	(13.09)
Term spread		-3.69	-4.42	0.77	-34.75	9.92
		(12.79)	(12.65)	(13.78)	(25.68)	(10.41)
GC001-SHIBOR		-0.17	-0.19	-0.32	-0.03	-0.11
		(0.26)	(0.26)	(0.28)	(0.28)	(0.40)
Ret$_{stock}$		-0.24	-0.42	-0.28	-0.30	-0.07
		(0.46)	(0.45)	(0.45)	(1.01)	(0.49)
Bond FE	–	✓	✓	✓	✓	✓
Rating FE	✓	✓	✓	✓	✓	✓
Week FE	✓	✓	✓	✓	✓	✓
R-square	0.15	0.53	0.53	0.53	0.48	0.59
N	3514	3257	3137	2688	1613	2314

Table IA7: 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***
	(0.96)	(1.32)	(0.91)	(1.45)
Controls	–	✓	✓	✓
Bond FE	–	✓	✓	✓
Rating FE	✓	✓	✓	✓
R-square	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***
	(0.03)	(0.05)	(0.05)	(0.08)
Maturity		-0.02	0.04	-0.14
		(0.09)	(0.09)	(0.14)
Turnover		2.23***	1.22*	5.99***
		(0.81)	(0.73)	(2.13)
Market price		-0.00	-0.00	0.01
		(0.00)	(0.00)	(0.01)
Volatility		0.12	-0.96	1.96*
		(0.81)	(1.05)	(1.10)
Maturity_{bmk}		0.03***	0.02***	0.07***
		(0.01)	(0.01)	(0.02)
Turnover_{bmk}		-4.30**	-2.20	-11.51***
		(2.02)	(1.64)	(2.72)
$\text{Market price}_{bmk}$		0.00***	0.00***	0.00**
		(0.00)	(0.00)	(0.00)
Volatility_{bmk}		-3.32***	-3.33***	-4.37*
		(1.23)	(1.08)	(2.30)
$\text{Turnover}^{ex}_{rating}$		31.53	52.98	-156.53
		(61.70)	(62.30)	(114.01)
$\text{Turnover}^{ib}_{rating}$		-0.85	-0.73	-4.27
		(5.22)	(5.42)	(7.19)
CDB_{spot}		-8.55***	-9.24***	-5.44
		(3.32)	(3.25)	(6.23)
Term spread		1.59	-0.99	11.01
		(5.25)	(4.51)	(9.38)
GC001-SHIBOR		-0.10	-0.04	-0.26
		(0.27)	(0.23)	(0.50)
Ret_{stock}		0.80	0.98*	0.18
		(0.56)	(0.52)	(0.89)
Bond FE	–	✓	✓	✓
Rating FE	✓	✓	✓	✓
R-square	0.15	0.56	0.57	0.57
N	9940	9897	7548	2349