

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

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Abstract

We provide causal evidence of the impact of changes in pledgeability on the price of an asset. Our empirical strategy utilizes a unique feature of the Chinese corporate bond markets, where bonds with identical fundamentals are simultaneously traded on two parallel but segmented markets, the exchange market and the interbank market, which have different rules for repo transactions. We utilize a policy shock on December 8, 2014, which made a class of AA+ and AA bonds ineligible for repo on the exchange, yet their haircuts were little affected on the interbank market. By examining how bond prices changed across markets and rating classes around this event, we estimate that an increase in haircut from 0 to 100% would result in an increase in bond yields by 30 to 80 bps.

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1 Introduction

It has long been recognized, e.g., by [Duffie \(2010\)](#), that equilibrium asset prices depend not only on asset fundamentals but also “liquidity” factors that are broadly related to the frictions prevalent in modern financial markets. Among these liquidity considerations, asset pledgeability, which measures the ability of an asset to serve as collateral for financing, has received arguably the most attention thanks to its close link to the studies of financial constraints in macroeconomics (see e.g., [Kiyotaki and Moore, 1997](#)). Our paper aims to offer an empirical estimate on how much do changes in asset pledgeability affect the equilibrium prices.

The role of pledgeability in asset pricing is better understood by the example of bonds, which, besides spot transactions, are often involved in repurchase agreement transactions, or repos. Repo transactions, as explained in [Krishnamurthy \(2009\)](#), are essentially collateralized borrowing with the bond in transaction as the collateral. Lenders often set a “haircut” over the market price of the collateral bond; the lower the haircut, the greater the pledgeability of the collateral bond. As a result, in a world where collateralized borrowing exhibits advantage over uncollateralized borrowing, perhaps for a cheaper borrowing cost, the bond in question essentially carries some convenience yield for the bond owners, and this convenience yield should be reflected in the equilibrium pricing on the spot market. This logic is in the same spirit as the specialness in [Duffie \(1996\)](#) and Treasury convenience yield in [Fleckenstein, Longstaff, and Lustig \(2014\)](#). Haircut-implied funding costs have also been used by [Chen, Cui, He, and Milbradt \(2018\)](#) to endogenize the holding costs (and in turn the liquidity discounts) of illiquid assets.

Though potential theoretical mechanisms via which asset pledgeability boosts asset prices are clear, it remains challenging to empirically estimate the effect of pledgeability on pricing. The endogeneity issue is a major obstacle, as asset pledgeability is clearly an endogenous object that depends on asset fundamentals, various market frictions, and the interactions between the two. We overcome this issue by exploiting a set of unique institutional features on the Chinese bond market, together with a largely unexpected policy shock on asset pledgeability.

The Chinese bond market has experienced an astonishing growth phase in the past decade, and is now ranked third in the world, behind the U.S. and Japan. The most distinct feature of the Chinese bond market is the co-existence of two segmented bond markets, the OTC-based interbank market and the centralized exchange market. The interbank bond market, resembling what we observe in developed countries like the U.S., is a wholesale market serving institutional investors including banks and non-bank financial institutions. In contrast, the exchange bond market, as a part of the Stock

Exchanges in Shanghai and Shenzhen, is populated by non-bank financial institutions like mutual funds and insurance companies, together with retail investors.¹ Regarding repo transactions, the interbank market works just like the standard tri-party repo market widely adopted in the U.S., where the key transaction terms (e.g., collateral, haircuts, repo rates) are negotiated bilaterally. In contrast, for repo transactions on the exchange market, the exchange acts the Central Counter-Party (CCP) to all repo buyers and sellers. Furthermore, the exchange unilaterally determines the list of eligible collateral and their respective haircuts, which are standardized across all repo investors.

Enterprise bonds are one type of corporate bonds that are dual-listed on these two markets. Simultaneous trading of these dual-listed corporate bonds is important for our empirical methodology, as it allows researchers to isolate the valuation changes due to the variations in asset pledgeability from potentially unobservable time-varying asset fundamentals in response to the policy shock studied in this paper. This motivates “exchange premium,” defined as the yield on the interbank market minus that on the exchange market for the same bond with simultaneous trading prices in the two markets, as the main object of our study. This is essentially the empirical counterpart of [Garleanu and Pedersen \(2011\)](#) who study equilibrium pricing for assets with otherwise identical fundamentals but different margins. A positive (negative) exchange premium means that the bond is traded at a higher (lower) price on the exchange market relative to its interbank counterpart.

What is equally important to our empirical design is the cross-sectional heterogeneity of pledgeability of Chinese corporate bonds, and the distinct mechanisms that determine their pledgeability in these two markets. More specifically, we find that on the exchange market, bond haircuts, which are publicly posted by the exchange, are almost exclusively explained by bond ratings. The higher the bond rating, the greater (lower) the asset pledgeability (haircut). It is not surprising: the centralized nature of CCP on the exchange market implies that haircuts can depend on security-level characteristics only, and these characteristics tend to be objective — e.g., bond ratings that are provided by third-party rating agencies. As a result, even individual investors can borrow using AAA corporate bonds at a haircut of 90% on the exchange market, while bonds with AA- ratings has almost no pledgeability even if they are owned by the most reputable mutual funds.

In its perhaps the sharpest contrast, since repo transactions on the interbank market are done in a bilateral way, haircuts are determined by not only bond characteristics but also the identity of counter-parties. For instance, in the interbank market, less powerful

¹For more details on a brief history of the development and evolution of these two bond markets in China, see [Amstad and He \(2018\)](#).

institutional participants with limited government support find it difficult in using AAA corporate bonds as collateral for repo transactions, while those biggest state-owned commercial banks can easily borrow against bonds with AA- ratings.

The above cross-market comparison implies that, relative to the interbank market, the exchange market offers a greater pledgeability for AAA corporate bonds, but in the mean time also places a severe disadvantage for bonds with AA- ratings. Taking into account the fact that repo with a CCP in the centralized exchange market features greater transparency in bonds pledgeability, together with better liquidity on the exchange market in the sense of a higher spot-trading frequency, we expect a higher (lower) exchange market price and hence a positive (negative) exchange premium for AAA (AA-) bonds. This is indeed the case in the data (before the policy shock, as explained shortly): consistent with this hypothesis, we find that a positive AAA premium of 36 bps and a negative AA- premium of -22 bps. What is more, the exchange premia, which presumably are free from bond credit qualities, were monotone in bond ratings: we also find a positive AA+ premium of 16 bps and AA premium of 5 bps. This monotone pattern offers some indirect support for the pledgeability effect in asset pricing.

We now explain the second major component of our empirical design, which exploits a policy shock regarding the asset pledgeability on the exchange market only. In the after-hours on Dec 8th, 2014, the exchange market suddenly announced to slash the pledgeability of enterprise bonds with ratings below AA+ from that day on. Two points are worth emphasizing regarding this policy shock. First, this policy was aimed at the pledgeability of the exchange market only; second, this policy affects the pledgeability of bonds only for certain rating groups. These two features allow us to conduct a Diff-in-Diff study on exchange premia across rating groups during the window of the policy shock.

In our Diff-in-Diff framework, bonds with middle ratings (AA+ and AA) form the treatment group, while AAA bonds are free from the policy shock and hence form our control group. But bonds with AA- ratings enter our control group as well; this is because bonds with AA- ratings has zero pledgeability already before the policy shock. We show that bonds with AAA and AA- ratings had similar trends with our treatment middle rating groups (AA+ and AA) before the Dec 2014 shock; but during the first week after the shock, the exchange premia of both AAA and AA- ratings rose but that of treatment groups tanked. This suggests that this rating-dependent pledgeability shock adversely affected the bond prices with middle ratings only. It is interesting 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 monotone in asset qualities (here, credit ratings).

As the main empirical contribution to the literature, we then use this policy shock as

an instrument to estimate the effect of pledgeability on asset prices — in our context, the exchange premia. The constructed rating-dependent pledgeability shock is a bond-day level dummy variable, which takes 1 if and only if the date is after December 8, 2014 *and* the bond has the rating of either AA+ or AA. Based on the standard two-stage OLS approach, we find that cutting the pledgeability from full to zero (i.e., a unit increase of haircut) leads to a 30 bps (0.3%) to 60 bps (i.e., 0.6%) increase of the bond yield, depending on regression specifications (e.g., which rating groups are included as control). Take the average effect of 45 bps, this implies a 2.81 dollar of drop for a 100-RMB-valued corporate bond in our sample with typical maturity, coupon, and yield.

Although exchange premia of dual-listed bonds presumably are free from the unobservable bond fundamental and hence address an important endogeneity concern, the exchange-premia-based Instrumental Variable (IV) estimate for the pledgeability effect suffers an important downward bias. One leading concern is that despite significant trading frictions hence limits to arbitrage between these two markets in the short-run, the policy shock on the exchange market will be transmitted to the interbank as long as some institutional investors are engaging arbitrage activities. This implies that our exchange premium, by benchmarking to the affected interbank-market yield, likely to produce an underestimate for the price impact per unit change of haircut.

We address this concern by finding another “benchmark” for the treatment group (AA+ and AA), so that the resulting IV estimate following the same procedure is likely to be an “overestimate” for the price impact of pledgeability. More specifically, we take the matched benchmark to be policy-shock-free AAA bonds traded in the same exchange market, with similar haircuts and yields in the pre-event sample as those AA+/AA bonds. Because it is arguably true that these matched AAA bonds are with better unobservable fundamentals (relative to the treatment middle rating group), Section 4.4 offers several plausible alternative mechanisms via which the IV estimate based on the premium over matched AAA bonds are likely to be upward biased.² The resulting (over)estimate suggests that cutting the pledgeability from full to zero leads to a 80 bps (i.e., 0.8%) increase of yield, or 5.07 dollar of drop for a typical corporate bond in our sample. Together with the (under)estimate obtained based on the exchange premium, our paper suggests that a full pledgeability contributes to about a 0.55% of yield change.

²For instance, a potential flight to quality effect in response to the policy shock tends to boost the price of AAA bonds, leading to an overestimate of pledgeability. A similar logic applies to the case where the regulator has the private information that AA+/AA rated bonds are worse than the market believes.

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 \(2018\)](#).

2.1 Overview of the Chinese Bond Markets

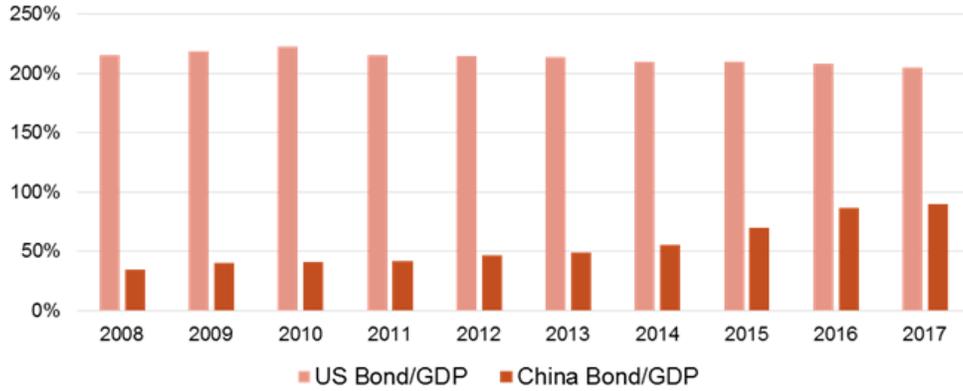
Over the past twenty years, especially the past decade, China has taken enormous strides to develop its bond market as an integral step of the financial reforms, along with the efforts in interest rate liberalization and the internationalization of its domestic currency. Panel A of [Figure 1](#) shows the recent growth path of Chinese bond market capitalization scaled by GDP, which rises from 35% in 2008 to more than 90% in 2017. For comparison, the U.S. bond market has been staying slightly above 200% of the U.S. GDP during the same time period.

There are three major categories of fixed-income securities in the Chinese bond markets based on issuing entities: government bonds, financial bonds, and corporate (non-financial) bonds.³ Panel B of [Figure 1](#) shows the notional outstanding and market shares of the different types of corporate bonds. In the aggregate social financing statistics released by the PBoC, Corporate bonds correspond to “bonds,” contributing 11% of financing to the real sector as shown in Panel C of [Figure 1](#).

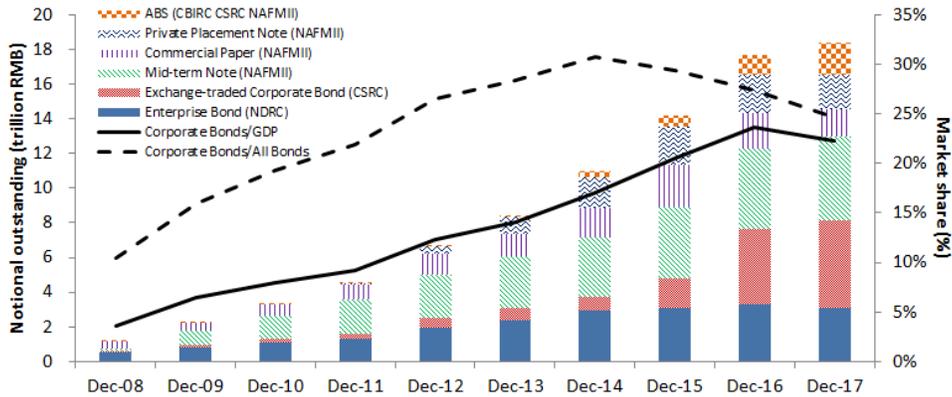
Our paper focuses on enterprise bonds, a type of corporate bonds issued by non-listed State-Owned-Enterprises (SOEs). They account for 15% of total corporate bonds outstanding (or 4% of total bonds outstanding) by 2017. For our analysis, it is important to understand the following features of the Chinese bond markets: (1) the co-existence of the exchange and interbank bond markets; (2) the dual-listing of bonds on the two markets; and (3) the different ways that repo transactions are conducted on these two markets.

³Government bonds are issued by formal government agencies (e.g., Ministry of Finance and policy banks in China) and account for 56% of bonds outstanding in 2017. Financial bonds, which account for 17% of bond outstanding in 2017, are issued by financial institutions which are almost all state-owned. Corporate bonds, which represent 27% of the market, are issued by non-financial firms. Though corporate bonds in some international context also include long-term bonds issued by financial institutions, we specifically separate out bonds issued by financial institutions, given that almost all entities in Chinese financial sector are state-owned. 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.

Panel A: Bond outstanding as % of GDP



Panel B: China's corporate bond outstanding by category



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

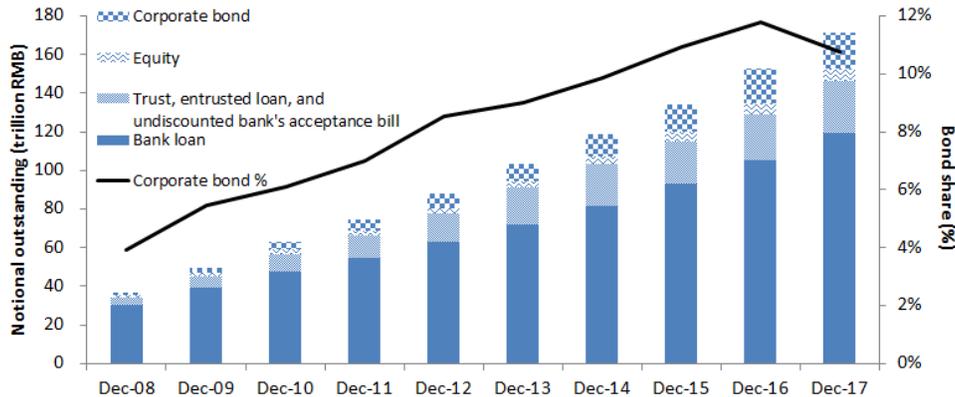


Figure 1: **China's Bond Market.** This figure plots statistics of China's bond market from 2008 to 2017. Panel A plots the bond outstanding as a percentage of GDP in China and US, Panel B plots China's corporate bond outstanding by category, and Panel C plots PBOC aggregate social financing outstanding by category.

2.2 Co-Existence of Exchange and Interbank Market

For historical reasons, there are two distinct and largely segmented markets in today’s Chinese bond markets: the Over-the-Counter based interbank market and the centralized exchange market. The interbank market is largely a “wholesale” market, similar to the interbank markets in developed economies like the United States, while the exchange market is more “retail” oriented.

The exchange bond market resides within the Shanghai and Shenzhen stock exchanges, which were established in 1990 in the wake of the SOE reforms. Repo (repurchase agreement) transactions, which allow investors to borrow against the bond collateral, have been popular on the exchange since its inception. The interbank market was established in 1997. During the first half of 1997, the Chinese stock market experienced an unprecedented boom (with the Shanghai Stock Exchange composite index rising by over 50% from January to May). Due to the concern that repo financing might have fueled the stock market boom, in June 1997 the People’s Bank of China (PBoC), the central bank in China, ordered all commercial banks to fully switch from the exchange to the newly established interbank market.⁴

Both markets have grown significantly in the next twenty years, although the interbank market has become the dominant player of the two by most measures. By the end of 2017, about 89% of the total bonds outstanding in China are traded on the interbank market, while the rest of 11% are on the exchange. As [Figure 2](#) shows, the interbank market accounts for more than 95% of the volume of spot transactions for all bonds, and over 70% of all repo transactions. The participants on the interbank market grew from the 16 head offices of commercial banks initially in 1997 to a total of 3,469 financial institutions, including insurance companies, urban and rural credit cooperatives, and securities firms by the end of 2017. At the same time, the exchange market has been aggressively competing with its dominant rivalry, the interbank market. One product of this competition is dual-listed enterprise bonds, which we discuss in [Section 2.3](#).

As mentioned earlier, the wholesale interbank market is participated by only large and sophisticated financial institutions like commercial banks, mutual funds, insurance companies, and securities firms. It adopts an quote-driven Over-the-Counter trading protocol, in which the terms of trades are finalized through bilateral bargaining between relevant parties. In contrast, the participants on the exchange market includes non-bank financial institutions, corporate and retail investors.⁵ The trading protocol on

⁴Though technically speaking the interbank market is self-regulated by the National Association of Financial Market Institutional Investors (NAFMII), the PBoC is the de-facto gate keeper of this market.

⁵Although 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

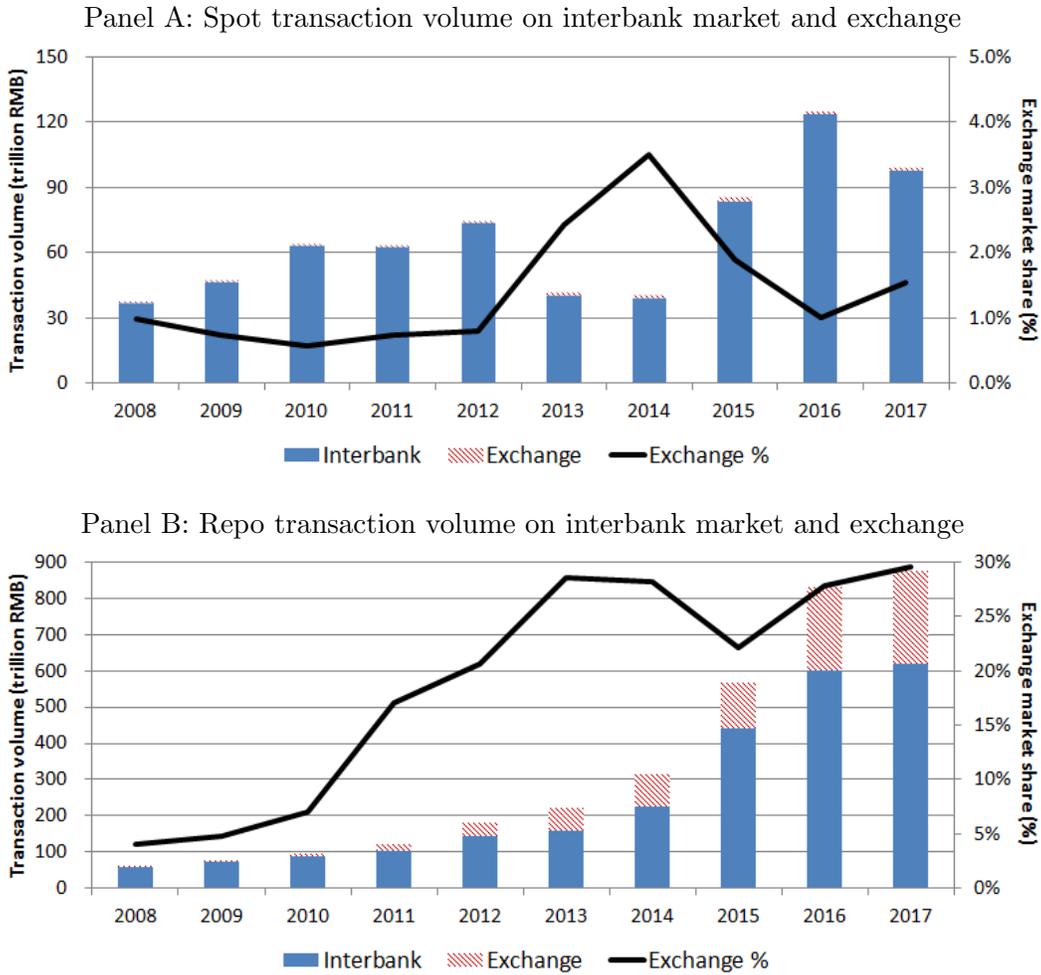


Figure 2: **China’s Interbank and Exchange Bond Markets.** This figure plots China’s two bond markets from 2008 to 2017. Panels A and B plot spot and repo transaction volume of all bonds on the interbank and exchange markets.

the exchange is facilitated by a transparent order-driven mechanism, with electronic order books aggregating bids from all participants. Matched trades are settled via China Securities Depository & Clearing Corporation (CSDC), which provides the depository and settlement services for the exchange market. Since the CSDC is fully owned by the Shanghai and Shenzhen exchanges, we treat the “CSDC” and “exchange” as the same entity.

Secondary market liquidity wise, there are significantly more trading activities on the exchange market, but the trading volume is much thinner. This is because retail investors engage in speculative trading on the exchange, while on the interbank market sophisticated

nowadays and the presence of commercial banks in the exchange market is negligible. In particular, commercial banks are still prohibited from repo transactions on the exchange market.

financial institutions only trade whenever they need to, and in large quantities when they do. As a result, the interbank market is deeper but lacks immediacy relative to the exchange. When comparing the secondary market liquidity in two Chinese bond markets with that in the U.S., we find similarity across two countries. The interbank market is significantly larger by both spot and repo transaction volume. See [Table A1](#) in the Appendix for more details on the market liquidity comparison.

2.3 Dual-listing of Enterprise Bonds

Due to the possibility of dual-listing, the exchange and interbank market 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 the SOE reforms in China. The interbank market, after its establishment in 1997, became the only market where enterprise bonds were issued and traded, as most SOEs were not publicly listed at that time and hence excluded from the exchange market. In 2005, to expand the potential investor base, the NDRC carried out a series of financial reforms that granted non-listed SOEs access to the exchange market. The exchange market embraced this reform with great enthusiasm, and applications for dual-listing on the exchange are almost always approved. Consequently, over 90% of the enterprise bonds outstanding are dual-listed.

Limits to arbitrage Despite having identical fundamentals, the prices of a dual-listed bond on the two markets can differ significantly, and such differences can persist for a long time. This is because there are major frictions that prevent “textbook” cross-market arbitrages.

As explained in the previous section, commercial banks, the largest financial institutions in China, are prohibited from conducting repo transactions on the exchange and are virtually nonexistent in spot trading on the exchange. That leaves only a subset of investors (i.e., mutual funds, insurance companies, and securities firms) who can trade bonds on both markets.

Even for those investors with access to both markets, there exist significant frictions for cross-market arbitrage, the most significant one being the settlement delays. Suppose an investor wants to sell her exchange bond holdings to the interbank market (or use it to do repo on the interbank market). To do so, she needs to apply for transfer of depository from the exchange to the interbank market, which takes two to three working days in

2014.⁶ A transfer in the opposite direction takes even longer (up to seven working days). Such delays expose an arbitrageur to significant price risks. Moreover, due to limited liquidity, it is quite difficult to simultaneously buy and sell a large quantity of the same bond on the two markets.

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 markets are a major factor that causes the prices to differ in the first place. To explain this point, we next turn to the differences in repo transactions on the two markets.

2.4 Repos on the Exchange and the Interbank Market

A repurchase agreement, or “repo”, is the sale of a security coupled with a commitment by the seller to buy 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 2](#), repos are quite active on both the exchange and interbank market. In 2017, repo transactions account for 90% of total volume of bond transactions in China (include 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 agreement on the terms of trade based on bilateral bargaining. 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 the role of the third-party agent who processes the post-trading settlement.⁷ As explained in [Section 2.2](#), the interbank market is dominated by large institutions who have 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

⁶The depository and clearing agency in the interbank market is China Central Depository & Clearing Co. Ltd (CCDC), 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 which took about six to eight working days.

⁷Tri-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 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.

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-4 banks.⁸ Unfortunately, we do not have access to trade-level repo data on the interbank market.

Repos on the exchange For repos on the Chinese exchange market, the exchange (specifically the CSDC) not only facilitates the transactions, as the CCDC does for interbank repos, but also acts as the Central Counter-Party (CCP) to all repo buyers and sellers. Different from 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)).

Furthermore, unlike on the interbank 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.⁹ Suppose a bond has face value FV and market price P . We can translate its conversion rate into the haircut using the following formula:

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

Notice that haircut moves in the opposite direction with conversion rate; a haircut of 100% implies zero pledgeability for that security. Effectively, 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 on each other and on the actual composition of the collateral pool (the exchange does not publish such information), the counterparty risk component in the repo rates should be negligible due to the exchange's implicit government backing. Consequently, the exchange repo rates mainly reflect the market

⁸The Big-4 banks are Commercial and Industrial Bank of China, China Construction Bank, Bank of China, and Agricultural Bank of China.

⁹For instance, suppose Treasuries receive a conversion rate of 1, while that of a 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 RMB from the exchange.

supply and demand for short-term funding.

It is interesting to observe that Panel A and Panel B in [Figure 2](#) indicate that compared to the interbank market, repo (as opposed to spot trading) is relatively popular in the exchange market. This is consistent with the fact that the exchange’s CCP structure offers counterparty-risk-free repo transactions with desirable transparent standardization.

3 Data and Research Design

After describing our dataset in this section, we describe the identification challenge in estimating the pledgeability effect on asset pricing. We then explain our research design to tackle this empirical challenge.

3.1 Data

Our empirical analysis focuses on the enterprise bonds that are dual-listed on the interbank and exchange markets. We obtain enterprise bond characteristics and exchange-market trading data from WIND. Data on interbank market trading are from the China Foreign Exchange Trade System (CFETS), the platform for all interbank bond trading. Our sample period ranges from June 9, 2014 to June 8, 2015, a twelve-month window around the event date (the policy shock on December 8, 2014). This sample covers 82.7% of the total trading volume of all the enterprise bonds during the same period (79.3% in terms of outstanding notional), or 28.8% of the total volume of all corporate bonds (27.1% in terms of outstanding notional).

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. 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 \(2017\)](#) and [Liu, Lyu, and Yu \(2017\)](#).¹⁰ Bonds issued by the China Development Bank, the largest one 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 its superior liquidity,¹¹ the CDB yield curves are commonly

¹⁰Specifically, 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.

¹¹During our one year sample period, total trading volume for CDB bonds is 15.3 trillion RMB, versus

used as the benchmark by the bond market participants in China, especially institutional investors. All of our empirical results are robust to using Treasury yields instead of CDB yields.

As the main empirical object, we construct the “exchange market premium,” or simply “exchange premium” 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. The exchange premium for each pair is calculated as the yield on the interbank market minus the exchange market counterpart. See Appendix A.2 for details on the construction of the simultaneous trading sample. In the robustness test, we also repeat our empirical exercises using a more strict same-day trading and hence a smaller sample, which requires the trades of the very same bond in two markets take place on the same day.

We also conduct analysis on an alternative spread measure, called “spread over matched AAA,” which is the spread between the yields of AA/AA+ rated bonds and that of the matched AAA bonds but with similar haircuts and yields, both traded in the same exchange market (for more details, see Section 4.4).

Other market variables, including the standardized collateral repo rates and volume on the exchange market,¹² Shanghai Interbank Offering Rate (SHIBOR), term spread between 10-year Treasury yield and 3-month Treasury yield, and the aggregate stock market returns are from WIND, while the interbank market repo rates and volume are from CFETS.¹³

Table 1 provides detailed definitions of variables, and Table 2 reports the summary statistics for the simultaneous trading sample. The summary statistics for the same-day trading sample are reported in Table A3 in the Appendix. In Table 2, we separately report the summary statistics for exchange premia, conversion rates, and haircuts before and after the policy shock, which we explain next.

6.5 trillion RMB for Treasury bonds.

¹²A total of 18 standardized collateral repo products are available on the exchange market, including 9 on the Shanghai stock exchange (“GC” series) and 9 on the Shenzhen stock exchange (“R” series). These products have maturities of 1, 2, 3, 4, 7, 14, 28, 91, and 182 days. The one-day repo transactions account for 85% to 90% of total exchange market transactions.

¹³CFETS reports daily transaction volume and volume-weighted repo rates for the interbank market. “R” series represents collateralized repo transactions for all participants in the interbank market and “DR” series represents collateralized repo transactions between two deposit-type institutions. Maturity ranges from 1, 7, 14, and 21 days to 1, 2, 3, 4, 6, and 9 months, to 1 year.

3.2 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 that are rated below AAA.¹⁴

The background of this policy shock is the local government debt problem in China. In 2009, Beijing responded to the 2007/08 global financial crisis with the four-trillion RMB stimulus package, in which Local Government Financing Vehicles (LGFVs, which are state-owned enterprises) funded heavy infrastructure investment mainly through bank loans. Three to five years later, the back-to-normal credit policy forces LGFVs to turn to the bond market and aggressively issue Municipal Corporate Bonds (MCBs) — a type of enterprise bonds issued by non-listed SOEs — to either refinance the maturing bank loans or continue the ongoing long-term infrastructure projects (Chen, He, and Liu (2017)).¹⁵ As a result, the bond market became flooded with MCBs, with the share of enterprise bonds rising from about 52% in 2012 to about 76% by the end of 2017.

Increasingly concerned about local government debt problems, the government released the tone-setting guideline “Document 43” in 2014, which explicitly banned the backing of MCBs by local governments. Soon it became a coordinated effort by other financial regulators to support Beijing on this agenda. At that time, MCBs were quite popular on the exchange market, for their low perceived credit risk (thanks to the implicit guarantee) and transparency in pledgeability (thanks to centrally published haircuts). To 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. This sudden move by the CSDC surprised the exchange market investors to a large extent. It is well documented that the local government debt problem is rooted in the commercial banking system (Bai, Hsieh, and Song (2016); and Chen, He, and Liu (2017)), which heavily relies on the interbank market for liquidity management. Consequently, market participants were expecting some tightening in the competing interbank market instead.

As shown in Figure 3, the policy change on December 8, 2014 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

¹⁴Among the AAA bonds, those with below-AA issuer ratings or having an AA issuer rating but with negative outlooks also lost their repo eligibility. In this paper, we reclassify these two types of AAA enterprise bonds as AA- bonds. See Appendix A for details.

¹⁵MCBs, also known as Urban Construction Investment Bonds or Chengtou Bonds, are one of the perfect examples of the mixture between planning and market in today’s Chinese economy: in a strict legal sense they are issued by LGFVs, which are regular corporations, yet the market views them as being implicitly backed by the corresponding local governments.

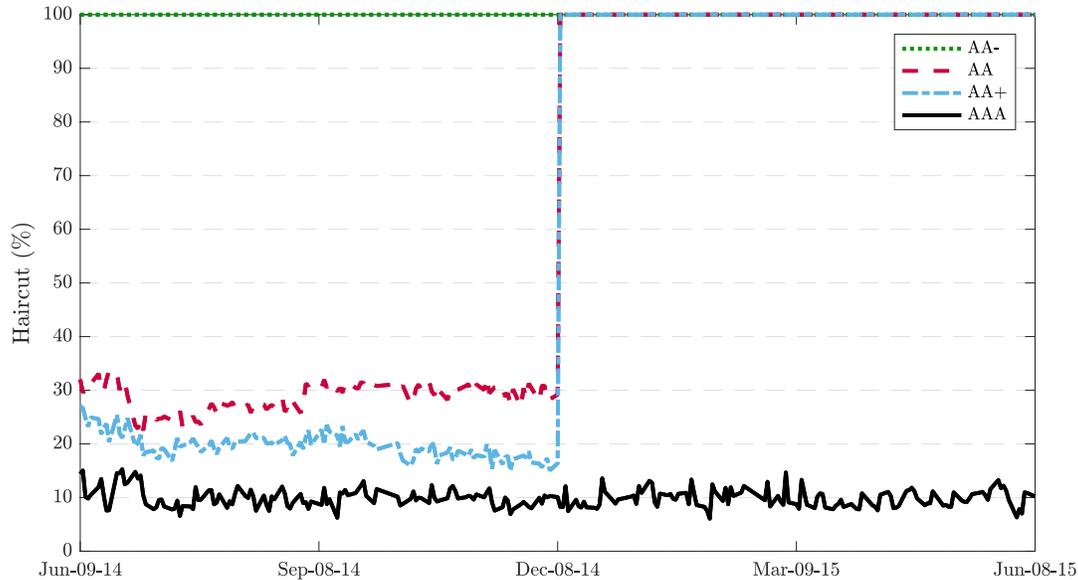


Figure 3: **Average repo haircut on the exchange market.** This figure plots the daily average haircuts on the exchange repo market across dual-listed enterprise bonds in each of the four rating categories.

the event. Finally, since AA- bonds were already ineligible as repo collateral on the exchange in six months before the event, their haircuts were also unaffected by the new policy.

In contrast to the dramatic changes in haircuts on the exchange, there were only minor changes in the haircuts on the interbank market during the same period. Table 3 reports the average conversion rates for enterprise bonds on the interbank market during the 1-month and 6-month windows before and after December 8, 2014, which are based on all the repo transactions conducted by an anonymous major dealer. The average conversion rates fell by about 10% for AAA bonds and 3-5% for the other rating categories, which likely reflected the tightening of liquidity on the interbank market.¹⁶

To see whether the dramatic adjustments in exchange haircuts were a surprise to the market, as a first pass, we examine the average credit spreads for all enterprise bonds in the four rating categories around the event. Figure 4 plots the time-series of average credit spreads on the exchange (Panel A) and interbank market (Panel B) on daily frequency around this policy event. On the exchange, the average credit spreads for AA+ and AA bonds visibly jumped up on the event date (by 55 and 50 bps, respectively) and remained higher afterwards; the average spreads for AAA and AA- bonds fell temporarily

¹⁶Since the repo terms are bilaterally negotiated, one would ideally like to control for the credit quality of the dealer's counter-parties when comparing the interbank market conversion rates from two different periods. Unfortunately this is not feasible due to the lack of trade-level data. Anecdotal evidence shows that the counterparties for this major dealer remained stable over this period.

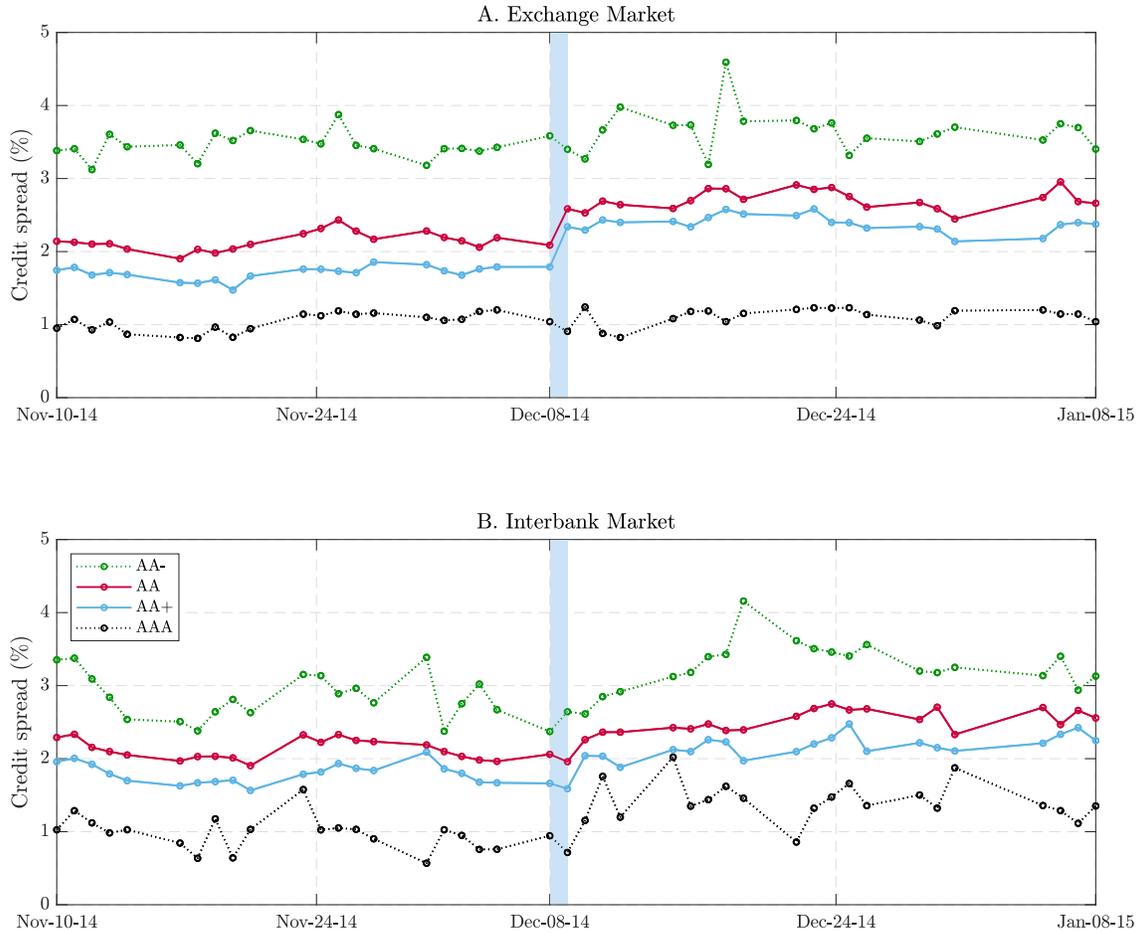


Figure 4: **Credit Spreads on the Exchange and the Interbank Market.** This figure plots average daily credit spread for dual-listed enterprise bonds in a two-month window around the event. Panels A and B plot average daily credit spread of non-zero trading observations for the exchange market and interbank market, respectively. The sample period is 11/10/2014 to 1/8/2015.

on the event date (by 13 and 18 bps, respectively), but are roughly at the same levels before and after the event. In contrast, on the interbank market, the average credit spreads for AA+ and AA bonds actually fell slightly on the event date (by 7 and 10 bps); this is consistent with the premise that the policy shock hit the exchange market only. In the one-month window, the average credit spreads rose significantly more for AA+ and AA bonds on the exchange, but by similar amount across ratings on the interbank market.¹⁷

¹⁷On the exchange, the changes in the average credit spreads for the four rating categories from the month before to after the event are 8, 68, 57, and 20 bps, respectively. On the interbank market, the corresponding changes are 42, 35, 37, and 40 bps.

3.3 Research Design

To identify the effects of changes in pledgeability on bond pricing, we would ideally like to compare how the price of the same bond behaves with and without an exogenous shock to its haircut. As is evident in [Figure 3](#), the policy shock brought drastic changes to the haircuts of AA+ and AA bonds, while leaving those of AAA and AA- bonds largely unaffected. It is tempting to use the policy shock as an instrument to examine how the prices of the treated bonds (e.g., AA+ and AA bonds on the exchange) and non-treated bonds (e.g., AAA bonds on the exchange) behaved differently with the changes in haircuts.

The problem is that the bonds in the treatment group are obviously 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 instrument will be correlated with unobserved determinants of the changes in bond prices and hence violates the exclusion restriction. Then we may not be able to attribute the relative changes in yields of the treated bonds to the changes in haircuts.

We tackle this challenge by the following ways. As the main empirical strategy, we first exploit the advantage of dual-listed bonds, so that the cross-market yield spread (i.e., exchange premia) are free of any potentially unobservable variations of asset fundamentals and hence only reflect the changes in their pledgeability across two markets.

However, the resulting IV estimates based on the exchange premia are likely to be downward biased; one of the leading concerns is the cross-market (limited) arbitrage activities. To offer an overestimate of the pledgeability effect, we then repeat the IV estimate procedure on an alternative spread, benchmarking the treated bonds to non-treated AAA bonds but with similar haircuts and credit spreads. All plausible theoretical mechanisms suggest upward biases in the resulting estimate, and hence our approach allows us to provide a range (which turns out to be quite tight) for the economic magnitude of the pledgeability effect.

3.3.1 Exchange premia based on dual-listed bonds

With dual-listed bonds, the price of the same bond on the interbank market provides an ideal control for all the fundamental factors of its exchange counterpart. This is because any information related to the fundamentals should affect the pricing of the bond in

the two markets similarly. At the same time, as discussed in 2.3, market segmentation implies that the differences in haircuts on the exchange and the interbank market will lead to persistent differences in prices for the same bond on the two markets.

Thus, our main empirical strategy is to focus on the cross-market price difference for the dual-listed enterprise bonds while using the policy shock as an instrument for changes in haircuts. We define the exchange premium measure, $ibex_{ijt}$, as the cross-market difference in credit yields for bond i from rating category j on day t ,

$$ibex_{ijt} = yield_{ijt}^{IB} - yield_{ijt}^{EX}, \quad (2)$$

where $j \in \{AAA, AA+, AA, AA-\}$. A positive premium means the price of a bond is higher on the exchange than on the interbank market. With common fundamentals, $ibex_{ijt}$ should reflect the differences in pledgeability on the two markets, plus the differences in other liquidity factors (e.g., trade size and frequency).

Let D_{jt} be the dummy variable for the treatment-group rating categories and post-policy-shock periods, i.e.,

$$D_{jt} = \begin{cases} 1 & j \in \{AA+, AA\} \quad \& \quad t > 12/08/14 \\ 0 & otherwise \end{cases} \quad (3)$$

To use D_{jt} as an instrument to estimate the impact of changes in haircuts on the exchange premium, we first estimate the first stage as follows:

$$haircut_{ijt} = \rho_i + \eta_t + \beta D_{jt} + X'_{i,t}\gamma + v_{ijt}. \quad (4)$$

The regression includes bond fixed effects, weekly time fixed effects,¹⁸ bond-level controls including maturity, turnover, price, and volatility, and market-level controls including CDB spot rates, term spreads, short-term interbank lending rates, and stock market returns.

The dependent variable in (4), $haircut_{ijt}$, is the exchange haircut for bond i from rating category j on day t . Ideally, we would like to use the differences in haircuts between the exchange and the interbank market, but we do not have access to the latter at bond level. Thus, if the haircuts on the interbank market also changed during this period, it will likely lead to a bias in the estimator $\hat{\beta}$, which in turn biases the 2SLS estimator. We will return to this issue shortly in this section.

¹⁸Daily time fixed effects are too stringent due to scarcity of bond trading in our sample.

The second stage of the 2SLS is

$$ibex_{ijt} = \alpha_i + \lambda_t + \delta \widehat{haircut}_{ijt} + X'_{it}\theta + \xi_{ijt}, \quad (5)$$

where $\widehat{haircut}_{ijt}$ are the first-stage fitted values for bond haircuts.

For D_{jt} to be a valid instrument, besides a strong first stage, we need to assume that any unobservable fundamental or liquidity factors either affect the bond prices on the two markets in the same way (so that they cancel out in the exchange premia), or that they share common variations between the treated and untreated bonds over time (so that they are captured by the time fixed effects).

We construct the exchange premia $ibex$ in (2) by further restricting our dual-listed bond sample to those that were traded on the two markets simultaneously. 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 and compute the exchange premium measure. In the robustness section, we also consider a more stringent “same-day trading sample;” all of our main results are robust to the two different samples.¹⁹

Potential downward biases of $\hat{\delta}$. As mentioned above, our estimator $\hat{\beta}$ in the first stage is likely biased if the haircuts on the interbank market also changed after the policy shock. The evidence in Table 3 suggests that this is indeed the case, where the haircuts on the interbank market after the event rose moderately (by between 3-10% in the 1-month window, less in the 6-month window). This means that the first stage will likely overstate the relative changes in haircuts on the exchange, which would in turn understate the effect of the relative changes in haircuts on the exchange premia. In other words, the estimator $\hat{\delta}$ in (5) is likely downward biased.

Another perhaps more relevant reason that $\hat{\delta}$ is downward biased is the (limited) cross-market arbitrage activities. To the extent that prices of treated bonds with AA+/AA ratings on the interbank market in Panel B Figure 4 were gradually moving in the same direction as their prices on the exchange following the policy shock, the exchange premia which uses the interbank bond as the benchmark would have understated the effect of pledgeability changes on bond prices on the exchange market.

¹⁹See Appendix A.2 for details on the construction of these two trading samples. The “same-day” trading requires that 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 on both markets, this definition significantly limits the sample size to about 3500 bond-day observations, compared to about 10,000 bond-day observations in the simultaneous trading sample.

3.3.2 Premia over matching AAA exchange-market bonds

With the consideration of the downward bias of the 2SLS estimator in mind, we consider the following alternative approach that is designed to deliver an upward-biased estimate. Recall that the unexpected policy shock only applied to enterprise bonds on the exchange market by dis-qualifying AA+ and AA bonds' pledgeability while not affecting AAA bonds. We hence construct the pledgeability premium of AA+ and AA enterprise bonds using similar exchange-traded AAA bonds as the benchmark on the exchange market only. The rest of IV estimation procedure is the same.

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 yield spread during the pre-event window.²⁰ The pledgeability premium is thus the difference between a treatment bond's (AA+ or AA) exchange market yield and the average yield of all matched AAA bonds on the same day of trade. Detailed procedures for matching are in Appendix A.3.

This alternative exchange-market AAA benchmark improves our previous estimate in addressing the downward-bias problem, as we can perfectly control for the haircuts of matched AAA bonds (as the benchmark AAA bonds are on the exchange market now), and there is no cross-market arbitrage involved between the treatment bonds and benchmark bonds. What is more, Section 4.4 argues that several leading endogeneity concerns all points to an upward bias of this alternative approach. For instance, as mentioned above, suppose that the policy makers had private information about the rising risks of the treated AA+/AA bonds and the market repriced the treated bonds downward accordingly; then this methodology will attribute this fundamental-driven effect to the pledgeability effect, leading to an upward bias.

Finally, since in the end this approach delivers an estimate of $\hat{\delta}$ that is slightly greater than the downward-biased estimate (based on the exchange premia), our paper offers a relatively tight estimation range for the economic magnitude of the pledgeability effect.

²⁰Our matching method delivers very similar pre-event haircut and yield spread for treatment group (AA+ and AA) and benchmark group (AAA) enterprise bonds. The average haircuts are 12.99% and 12.76% for treatment and benchmark bonds, respectively; the numbers are 5.30% and 5.39% for the 10th percentile; and the numbers are 29.65% and 27.83% for the 90th percentile. The average yield spreads are 1.309% and 1.255% for treatment and benchmark bonds; the numbers are 0.783% and 0.745% for the 10th percentile; and the numbers are 1.799% and 1.749% for the 90th percentile.

4 Empirical Results

We present our main empirical results in this section. After explaining the tight relation between haircuts and bond ratings, we show that bond exchange premia are monotone in ratings, reflecting the pledgeability-driven exchange premia. We then perform the IV estimate for the pledgeability effect on asset prices.

4.1 Haircuts and Credit Ratings

Before studying the impact of changes in exchange haircuts on bond prices, it is important to understand the determinants of haircuts on the exchange during normal times. 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 depend on security-level characteristics exclusively. The CSDC used to publish the exact formula for the conversion rates, which involves the bond’s credit rating, market price, and its volatility.²¹ However, the CSDC also made it clear that the formula was only suggestive; by inserting an opaque term called “discount coefficient,” the CSDS reserved the discretion in setting the conversion rate for each bond.

To check the extent that one can “recover” the conversion rate formula prior to the policy shock, in the half-year period before the policy shock we regress the conversion rates on four bond rating dummies (AAA, AA+, AA, AA-), market price, coupon, maturity, volatility, and turnover, issuer characteristics such as size and leverage, plus additional market variables such as CDB spot rate, term 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 are credit ratings. For the full sample of dual-listed enterprise bonds, the rating dummies explain 96.8% of the total variation in conversion rates, while the a kitchen-sink type regression only raises the R^2 to 97%. The results are quite similar in the simultaneous trading sample.

[Insert Table 4]

The fact that bond haircuts largely depend on credit ratings implies that the policy shock that explicitly targets 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 IV. Among

²¹The exact definitions of “market price” and “volatility” are given by the relevant regulatory documents and slightly different from what are commonly accepted in academia. We replicate these variables and use them in later regressions.

the reasons that the CSDC appears to rely primarily on credit ratings when setting the conversion rates, the leading ones are perhaps the poor secondary market liquidity and the transparency and third-party objectiveness of credit ratings.

4.2 Rating-dependent Exchange Market Premia

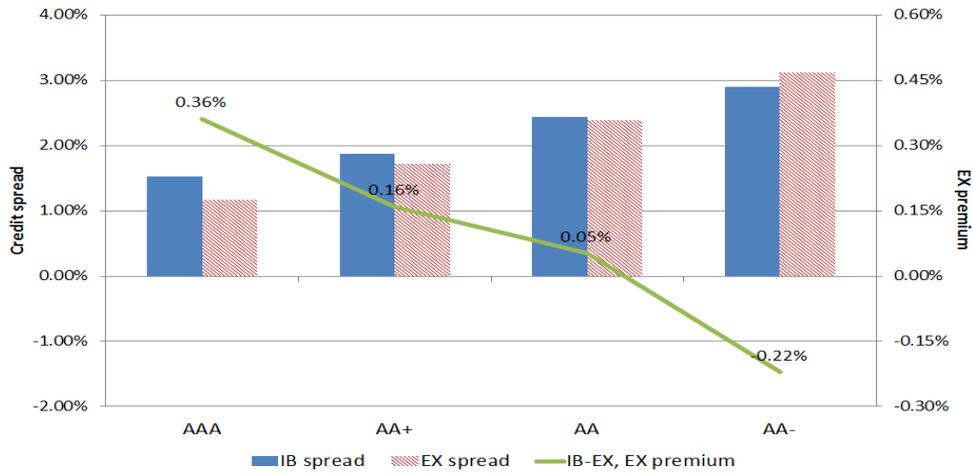
Next, we examine the impact of the policy shock on the exchange premia across ratings in the raw data (without controls). In Panel A of [Figure 5](#), we plot the average credit spreads on the two markets, along with the average exchange premia, in the 6 months prior to the policy shock. The sample is restricted to the dual-listed enterprise bonds that satisfy the simultaneous trading criterion defined in [Section 3.3](#). The AAA bonds enjoy a positive exchange premium of 36 bps, which, at roughly a third of the average credit spread of these high quality bonds, is highly significant in terms of economic magnitude. The exchange premia decline monotonically with lower credit ratings: 16 bps for AA+ bonds, 5 bps for AA bonds, and -22 bps for AA- bonds.

To understand the intriguing pattern of rating-dependent exchange premia, we examine how pledgeability differs on the two markets for bonds with high and low ratings (assuming the other components of exchange premia are common across ratings). On the exchange, the pledgeability of a bond is essentially determined by the haircut. We have explained that the Central Counter-Party system on the exchange features fungibility across various bond securities. In other words, the CSDC treats Treasuries and corporate bonds with different ratings the same way after adjusting for their conversion rates. In addition, the conversion rates are set in a relatively transparent manner, are available to all non-retail investors on the exchange, and are committed by the CCP. Such standardization helps improve the liquidity of repo transactions on the exchange.

On the interbank market, however, the haircut for a bond can vary significantly for different counter-parties. The less powerful institutional participants – especially those local rural credit unions or small security firms without explicit support from the central government – often complained about the difficulty of using even AAA corporate bonds as collateral for repo transactions, whereas the large commercial banks can get very favorable haircuts on the same type of bonds.²² Thus, despite the fact that the average haircut for AAA bonds based on the reported repo transactions on the interbank market

²²Large commercial banks are in a dominating position in 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 bond 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 about 7.5%, and security firms about 1%.

Panel A: Credit spread and exchange market premia, 6/9/2014-12/8/2014



Panel B: Credit spread and exchange market premia, 12/9/2014-6/8/2015

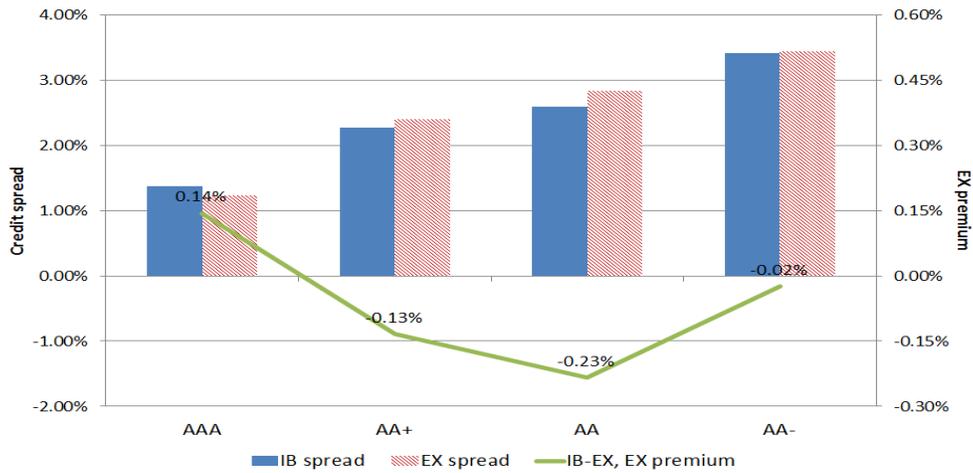


Figure 5: **Exchange Market Premia** This figure plots exchange market premia for the simultaneous trading sample by rating. Exchange market premium is defined as the interbank market credit spread minus the exchange market credit spread. Panels A and B plot two markets' credit spreads and the exchange premia for the subsamples before and after the event date 12/8/2014, respective.

(about 5%, see [Table 3](#)) is lower than the quoted values on the exchange (about 10%, see [Table 4](#)), the AAA bonds will actually be 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, which contributes to the positive exchange premium.

On the other end of the rating spectrum, while the 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 are 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, which contributes to a negative exchange premium.

If the exchange premia are indeed driven by the rating-dependent haircut policy employed 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 5](#). After the policy shock, exchange premia turned negative for bonds with both AA+ and AA ratings, consistent with these two type of bonds completely losing their pledgeability edge on the exchange. In contrast, the exchange premia for the two control groups either did not drop as much (AAA bonds) or rose (AA- bonds) after the policy shock.²³

[Figure 5](#) represents the first-cut of a simple Diff-in-Diff analysis. While the results in [Figure 5](#) are consistent with the interpretation that the drop in pledgeability on the exchange lowers the bond prices there, there are also important limitations. They do not control for the potential changes in the composition of the sample before and after the event. To have a higher chance of being included in the simultaneous trading sample, a bond needs to be traded relatively frequently on the two markets. The trading frequencies are endogenous and could change with market conditions and the policy shock. For example, the trading of corporate bonds, especially AAA bonds, became more frequent after the event, which could have raised the average quality of the AAA bonds in the simultaneous trading sample. Such composition effect can help reconcile the different findings in [Figure 5](#) and [Figure 4](#): the average AAA spreads appear to have fallen on both markets after the event based on the simultaneous trading sample while gone up on both markets in the full sample.

To address the above concerns, we control for bond-level and firm-level characteristics as well as market variables in a formal Diff-in-Diff analysis set tightly around the time of the policy shock. To get more information on the dynamics of the exchange premia, we divide the trading days into 4 sub-periods of 5 trading days (or, weekly) with the event day as midpoint. The event withdraws the pledgeability of the bonds within adjusted rating groups AA+ and AA, denoted as the “Mid Rating” Group. The unaffected “High Rating” and “Low Rating” groups are two control groups to rule out the alternative explanation that macro shocks and lower-rating bonds are just more sensitive, instead of the pledgeability effect. We plot the average exchange premium in each of the sub-periods

²³In particular, the rise in exchange premium for AA- bonds in the absence of any meaningful change in haircuts on the exchange suggests that either liquidity on the interbank market deteriorated following the event, or haircuts for AA- bonds on the interbank market rose in ways not captured by [Table 3](#).

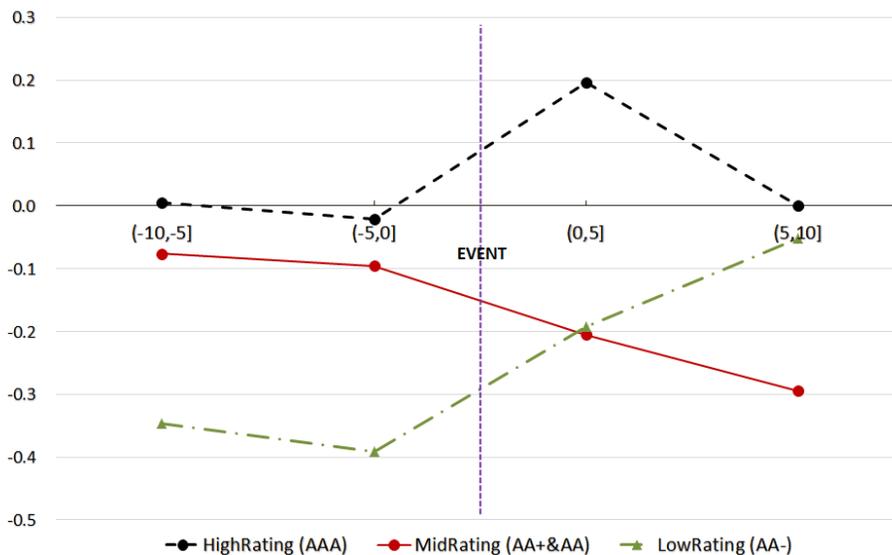


Figure 6: **Difference-in-Difference Estimation of Exchange Market Premia.** This figure presents estimated exchange market premia using difference-in-difference method with controls. The sample of simultaneous trading is a $[-10,10]$ trading-day window around the event date 12/8/2014 and divided into 4 subsamples of 5 trading days each.

(i.e., the estimated weekly fixed effects around the event) for High, Mid and Low Rating groups, respectively.

Figure 6 shows the results. The exchange premia for the treatment group fell by 10 bps in the first 5 days after the event and continued to fall in the following 5-day window. In contrast, the exchange premia for both control groups rose by about 20 bps in the first 5 days after the event. In the next 5 days, the exchange premium fell back to pre-event level for AAA bonds but kept rising for AA- bonds. The rise in exchange premia for the control group in the absence of any major changes in exchange premia likely reflected the significant impact that the policy shock had on interbank market liquidity. For example, some institutional investors on the interbank market might have chosen to reduce their holdings of enterprise bonds of all ratings in the wake of the event, which could have temporarily raised the credit spreads on the interbank market and hence the exchange premia.

We test for the significance of the difference in the changes of the exchange premia between the treatment group and the two control groups. For the comparison between mid-rating group (AA+ and AA) and high-rating group (AAA), the F-statistic is 33.55 with p-value below 0.001; for the comparison between mid-rating group and low-rating group (AA-), the F-statistic is 17.33 with p-value below 0.001 (we use bond-week two-way cluster in calculating the standard deviations). Both tests strongly reject the null that

the exchange premia for the treatment group and control group moved in the same way around the event.

4.3 Pledgeability and Asset Prices: Exchange Premia

Next, we conduct the IV estimation following the procedure outlined in Section 3.3. The results are shown in Table 5. We report the estimation results based on three different samples. The first (columns 1 and 2) is the full simultaneous trading sample. The second (columns 3 and 4) is the subsample that excludes AAA bonds (i.e., using only AA- bonds as the control group). The third (columns 5 and 6) is the subsample with AA+ and AA bonds. With only treated bond groups in this sample, the identification comes entirely from time-series variations. By comparing the results across the three samples, we can learn about the sensitivity of the IV to the assumption that how the exchange premia of the treated group and that of the two control groups share common variations over time.

[Insert Table 5]

For each of the three samples, we always include rating fixed effects and time fixed effects at the weekly level.²⁴ We then report the results based on two different specifications, one without bond fixed effects or other bond and market level regular controls, the other with. The regular control variables include bond level characteristics (coupon, leverage, size, time to maturity, turnover ratio) and various macro factors (term spread, SHIBOR, CDB yield, stock market index, etc).

The first stage, which regresses bond-level haircuts on the exchange on the policy shock dummies and other controls (see Eq. (4)), is quite strong. This is to be expected given the strong dependence of bond-level haircuts on credit ratings (see Table 4) and the nature of the policy shock (specifically targeting rating). The magnitude of the coefficient on the policy shock dummy is consistent across all three samples. Without bond fixed effects and the regular controls, the value of around 70% reflects the average rise in haircut for AA+ and AA bonds (see Figure 3). The magnitude of the coefficient drops slightly after the bond level controls are included, likely reflecting the changes in the composition of the sample due to the “simultaneous trading” requirement.

In the second stage, we regress the exchange premia on the fitted haircuts $\widehat{haircut}$ from the first-stage regression (see Eq. (5)), with the coefficient δ measuring the effect of changes in haircut on exchange premia. The coefficient estimate is again quite stable across different samples and specifications. In the full sample, the estimated $\hat{\delta}$ of -0.004

²⁴The sparsity of our sample prevents us from using time fixed-effects at the daily level.

implies that a rise in haircut from 0 to 100% would raise the bond yields on the exchange by 40 bps.

Next, dropping the AAA bonds from the sample raises the magnitude of the estimated $\hat{\delta}$ to -0.006 . This is consistent with the diff-in-diff results presented earlier (see [Figure 6](#)), where we saw the average exchange premium of AA- bonds rising more than that of the AAA bonds after the event. Recall that our identification assumption is that any residual (uncontrolled) movements in the exchange premia of the control group are shared by the treated group. Thus, a more pronounced increase in the AA- exchange premia implies that there has been more deterioration in liquidity on the interbank market relative to the exchange during this period, which in turn means that the haircut increases must have caused a larger decline in prices on the exchange relative to the interbank market in order to offset the effects of liquidity changes.

Finally, when restricting the sample to AA+/AA bonds, we are assuming that the common unobservable “residual” component in the exchange premia for the treated bonds did not change after the event. The estimated $\hat{\delta}$ is -0.003 . This is the most conservative estimate among the three samples, implying that a rise in haircut from 0 to 100% would raise the bond yields on the exchange by 30 bps.

We also re-do our exercises in this section using a same-day trading sample and all the findings are quantitatively similar. Results of the same-day sample are reported in [Table A4](#).

4.4 Pledgeability and Asset Prices: Matching AAA Bonds

The exchange premium, defined as the spread between the interbank yield and the exchange yield of the same bond with simultaneous trading, takes out the unobservable bond quality and hence addresses the important endogeneity concern caused by asset difference in fundamentals. This, together with the quasi natural experiment of policy shock on the pledgeability of bonds with certain ratings, forms the basis of our IV estimate for the effect of pledgeability on bond pricing in the previous section.

Nevertheless, our IV estimate for the pledgeability is likely biased downward. [Figure 4](#) shows that although there lacked any reactions on the interbank market for AA+ and AA rated bonds on the day of the policy shock, the yield spreads of these rating classes rose slowly in the days afterwards, potentially due to arbitrage activities between these two markets. In other words, the interbank-market yield spreads could also be adversely affected by the policy shock on the exchange. This implies that our results based on the exchange premium are likely to underestimate the price impact of the increases in haircuts.

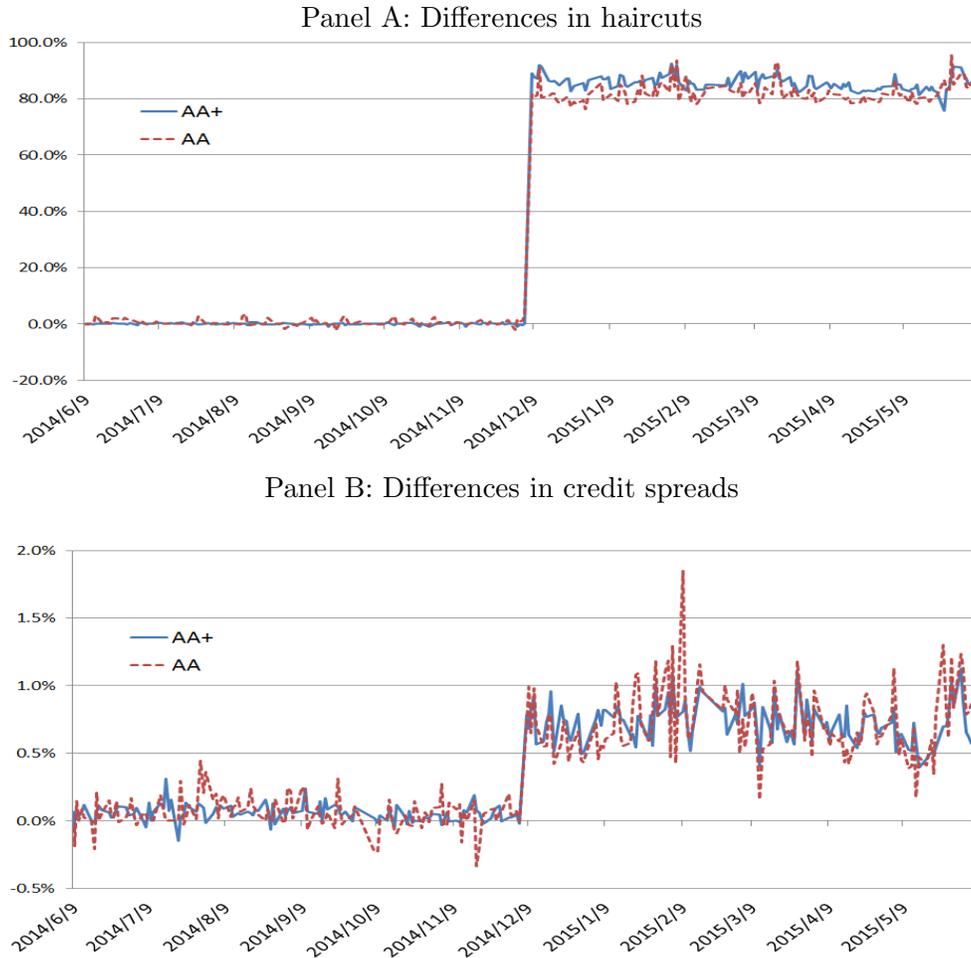


Figure 7: **Differences in Haircuts and Exchange Credit Spreads between the AA+/AA and Matched AAA Bonds.** This figure plots differences of AA+/AA dual-listed enterprise bonds’ haircut and exchange market credit spread w.r.t matched AAA bonds. Panels A and B plot the difference in haircut and credit 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 the Appendix. The sample period is 6/9/2014 to 6/8/2015.

In this section, we consider an alternative benchmark for the treatment group (AA+ and AA) enterprise bonds to construct their exchange pledgeability premium, whereby the resulting estimate is likely to be an overestimate for the price impact of haircut changes. We choose the benchmark to be the “matched” AAA enterprise bonds traded on the exchange. These matched AAA bonds have similar haircuts and yield spreads as those AA+/AA bonds (the treatment group) on the same day of trades in the six-month pre-event window, but their haircuts were largely intact after December 8, 2014. [Figure 7](#) shows the differences in haircuts and yield spreads of the bonds in the treatment group and those matched AAA bonds. For detailed matching procedure, see [Appendix A.3](#).

The rationale for our empirical design is as follows. For the treatment AA+/AA group, we want to find those AAA bonds with the same pledgeability and prices before the policy shock, so that the pledgeability premium components in the prices of the bonds from the treatment group and the control group are comparable in magnitude prior to the event. The policy shock completely eliminates the pledgeability of the treatment group AA+/AA bonds while leaving that of the matched AAA bonds untouched. Hence, the spread increase of the treated AA+/AA bonds relative to the matched AAA bonds should reflect the value of pledgeability.

In contrast to the exchange premium studied in Section 4.3, the premium over the matched AAA bonds tends to be upward biased. To illustrate this point, consider the following decomposition of the premium, which is the yield of matched AAA-bonds minus that of treated AA+/AA rated bonds:

$$\begin{aligned} \text{Yield}_{it}^{AAA} - \text{Yield}_{it}^{AA+/AA} &= \left(\text{Pledgeability}_{it}^{AAA} - \text{Pledgeability}_{it}^{AA+/AA} \right) \\ &+ \left(\text{Fundamental}_{it}^{AAA} - \text{Fundamental}_{it}^{AA+/AA} \right). \end{aligned} \quad (6)$$

Here, the first difference on pledgeability of these two groups of bonds is what our empirical design tries to pick up. The second bracket, which concerns the unobservable difference between these two bond groups, is what challenges identification in general. Note, given the Diff-in-Diff nature of our empirical methodology (our IV is a policy shock), researchers only need to worry about potential correlations between the second bracket and the policy shock (on pledgeability).

The advantage of our approach is that we are interested in an overestimate of the value of pledgeability; in other words, we are tolerant on potential mechanisms which produce a positive correlation between the second bracket and the policy shock (which is a negative shock to pledgeability). All plausible mechanisms in our context seem to satisfy this condition. The following are three leading endogeneity concerns that could contaminate our estimate; however, all of them are generating overestimate of the value of pledgeability:

1. Suppose that the policy maker has some private information that AA+/AA rated bonds are with worse quality than the market believes, and hence released the liquidity-tightening rules on these bonds. The market viewed the policy shock as the negative signal of the treated AA+/AA bonds, leading to a spike of spreads of AA/AA+ bonds and hence a negative shock to the second term. This implies a negative shock to the premium (yield of AAA over that of treated AA/AA+), hence a positive correlation between the second bracket and the negative policy

shock.

2. Alternatively, suppose that the policy shock represents a liquidity-tightening event, and the resulting flight-to-liquidity lowers the yield of matched AAA bonds, perhaps due to better uncontrolled fundamentals (i.e., beyond the observable controls we add in the regressions). This again leads to a negative shock to the premium and hence a positive correlation in consideration.
3. Finally, suppose that the matched AAA bonds are with better fundamentals and hence with a smaller beta than treated AA/AA+ bonds. Since the liquidity-tightening policy shock represents a negative aggregate market shock (this can be confirmed in [Figure 4](#)), the difference in beta translates the tightening policy shock to a positive fundamental shock. Since higher fundamentals correspond to lower yields, this mechanism again gives rise to a positive correlation between the second bracket and the negative policy shock.

[Table 6](#) reports the results of the two-stage IV estimation using the matched AAA bonds as benchmark. The first-stage is reported in Panel A and confirms the 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 1% increase in haircut of AA+/AA bonds transfers to a 0.8 bps decrease in the pledgeability premium,²⁵ the effect of which is larger than that of 0.3 bps when the interbank yield spread of the simultaneous trading sample is used as benchmark (Column 6 of [Table 5](#)). Overall, our IV estimation provides a lower bound of 30 bp and an upper bound of 80 bps on bond yields when the haircut increases from 0 to 100%. Taking the two numbers together, the average impact on yield spread for a 100% increase in haircut is around 55 bp, which translates to 3.45 RMB price change for an average dual-listed enterprise bond.²⁶

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 bonds with identical fundamentals are simultaneously traded in two parallel markets, the centralized exchange

²⁵To be consistent with the definition of IB-EX premium and the interpretation of the economic magnitude, we sign the exchange premium as the negative value of the yield difference of AA+/AA enterprise bonds minus matched AAA enterprise bonds.

²⁶An average dual-listed enterprise bond in China's bond market has a face value of 100, a maturity of 7.6 years, a coupon rate of 6.62%, and a YTM of 6.45%.

market, and the decentralized OTC interbank market. The differences in pledgeability lead to identical corporate bonds having different prices on the two markets. By exploiting a policy shock that dramatically reduced the pledgeability of bonds rated below AAA and above AA- on the exchange market, we are able to establish a causal effect of asset pledgeability on prices. Estimates based on instrumental variables imply that a 100% increase in haircut increases yield spreads by 30-80 bps.

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Table 1: Definition of Variables

Variables	Definition
<u>Dependent variables</u>	
EX premium	Exchange market premium in terms of percentage is the interbank market yield spread minus the simultaneous exchange market yield spread
EX premium _{pre}	Exchange market premium of the subsample before the policy shock from 6/9/2014 to 12/8/2014
EX premium _{post}	Exchange market 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 yield spread minus the matched AAA-rated bond yield spread
<u>Explanatory variables</u>	
Haircut	The percentage of 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
<u>Bond-day level variables</u>	
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 interbank and 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 divided by the average of the two over the past five non-zero trading days of the exchange market
<u>Day level variables</u>	
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
SHIBOR	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 2: Summary Statistics

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

Panel A: All variables						
	N	Mean	STD	P10	Median	P90
EX premium	10077	-0.03	0.50	-0.63	-0.02	0.51
EX premium _{pre}	4914	0.08	0.43	-0.38	0.05	0.57
EX premium _{post}	5163	-0.14	0.53	-0.75	-0.12	0.42
Haircut	10077	63.67	38.51	14.11	100.00	100.00
Haircut _{pre}	4914	32.04	23.17	7.33	30.49	44.25
Haircut _{post}	5163	93.78	22.92	100.00	100.00	100.00
Conversion	10077	38.39	40.90	0.00	0.00	91.00
Conversion _{pre}	4914	72.03	24.89	59.00	74.00	98.00
Conversion _{post}	5163	6.36	23.92	0.00	0.00	0.00
IB spread	10077	2.40	0.80	1.40	2.41	3.41
EX spread	10077	2.44	0.87	1.30	2.49	3.47
Matched spread	9961	0.56	0.68	-0.12	0.47	1.40
Matched spread _{pre}	2176	0.05	0.15	-0.12	0.04	0.26
Matched spread _{post}	7785	0.70	0.70	-0.12	0.71	1.50
Matched spread _{AA+}	7246	0.55	0.65	-0.11	0.45	1.38
Matched spread _{AA}	2715	0.58	0.75	-0.18	0.50	1.48
Maturity	10077	5.10	1.62	2.95	5.27	6.74
Turnover	10077	0.08	0.08	0.01	0.05	0.17
Market price	10077	105.06	5.67	100.42	105.36	110.85
Volatility	10077	0.02	0.02	0.00	0.01	0.04
CDB _{spot}	10077	4.36	0.52	3.80	4.15	5.18
Term spread	10077	0.54	0.31	0.27	0.44	0.95
SHIBOR	10077	2.57	0.69	1.25	2.68	3.33
Ret _{stock}	10077	0.40	1.59	-1.13	0.33	2.41

Panel B: Exchange premium by rating (%)						
AAA	558	0.23	0.56	-0.33	0.09	0.87
AA+	3104	0.02	0.47	-0.53	0.01	0.56
AA	5224	-0.08	0.49	-0.70	-0.04	0.46
AA-	1191	-0.07	0.50	-0.65	-0.06	0.48

Panel C: Haircut by rating (%)						
AAA	558	10.49	8.69	5.23	6.72	25.96
AA+	3104	60.61	40.62	7.15	100.00	100.00
AA	5224	63.12	35.57	26.41	43.29	100.00
AA-	1191	100.00	0.00	100.00	100.00	100.00

Table 3: Conversion Rates on the Interbank Market

This table reports the average conversion rates on the interbank market one and six months prior to and post the policy shock on the exchange on December 8, 2014. The average values are computed based on all the enterprise bond repo transactions conducted by an anonymous major bank on the interbank market. The numbers in parentheses are standard errors.

Sample period	AAA	AA+	AA	AA- & below
11/09/14 – 12/08/14	96.34 (0.87)	92.31 (2.13)	74.35 (2.96)	70.11 (11.92)
12/09/14 – 01/08/15	86.34 (1.03)	87.33 (2.39)	71.14 (2.56)	66.93 (20.19)
06/09/14 – 12/08/14	95.52 (0.45)	91.12 (0.85)	71.23 (1.23)	68.11 (6.27)
12/09/14 – 06/08/15	90.23 (0.49)	89.81 (1.01)	72.44 (1.18)	66.96 (8.14)

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 (3) includes all dual-listed enterprise bonds' daily observations including those without transaction. The sample in Columns (4) to (6) includes daily observations with simultaneous trading within a two-day window in two markets. Heteroscedasticity consistent t -statistics clustered by bond are reported in parentheses. *, **, 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)	(5)	(6)
Dummy _{AAA}	91.406*** (125.22)		36.131*** (3.13)	94.352*** (23.23)		-86.925*** (-3.34)
Dummy _{AA+}	80.825*** (89.78)		26.672** (2.26)	82.213*** (47.86)		-98.120*** (-3.90)
Dummy _{AA}	72.525*** (178.62)		18.850 (1.60)	71.968*** (68.01)		-105.861*** (-4.20)
Dummy _{AA-}	1.887 (1.10)		-49.744*** (-4.32)	3.836 (1.01)		-170.354*** (-7.09)
Market price		0.711*** (98.04)	0.567*** (4.94)		0.697*** (41.60)	1.434*** (6.10)
Volatility		-26.308 (-0.88)	-48.561** (-2.36)		-121.348** (-2.42)	-74.398** (-2.34)
MCB			-2.026** (-2.27)			-2.752 (-1.28)
Coupon			-0.929 (-1.34)			-2.430* (-1.81)
Maturity			0.277 (1.17)			1.165 (1.45)
Turnover			386.220*** (5.67)			3.590 (0.68)
Yield _{matching} ^{CDB}			53.234 (0.25)			992.205* (1.94)
Size			1.214*** (2.85)			1.022 (1.26)
Leverage			-8.747*** (-3.42)			-6.412 (-0.94)
CDB _{spot}			-2.472 (-1.23)			-7.884 (-1.54)
Term spread			-2.946** (-2.55)			-2.825 (-0.67)
SHIBOR			4.166*** (6.84)			12.063*** (4.15)
Ret _{stock}			0.121*** (4.65)			0.145 (0.58)
Industry FE	No	No	YES	No	No	YES
N	117780	117780	117780	4914	4914	4914
R-square	0.968	0.921	0.970	0.952	0.898	0.958

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. Columns (3) and (4) present the results using a subsample of AA+, AA, and AA- bonds. Columns (5) and (6) present the results using a subsample of AA+ and AA bonds. The sample period is 6/9/2014 to 6/8/2015. Heteroscedasticity consistent t -statistics clustered by bond and week are reported in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: First stage						
Dependent:	Full		AA+ & AA & AA-		AA+ & AA	
Haircut	(1)	(2)	(3)	(4)	(5)	(6)
Shock	71.436*** (51.12)	66.237*** (25.35)	70.141*** (40.99)	62.400*** (16.34)	71.331*** (68.31)	68.424*** (30.53)
Controls	No	Yes	No	Yes	No	Yes
Rating FE	Yes	Yes	Yes	Yes	Yes	Yes
Week FE	Yes	Yes	Yes	Yes	No	No
Bond FE	No	Yes	No	Yes	No	Yes
N	10077	9905	9519	9368	8328	8182
R-square	0.922	0.963	0.915	0.959	0.900	0.961

Panel B: Second stage						
Dependent:	Full		AA+ & AA & AA-		AA+ & AA	
Exchange premia	(1)	(2)	(3)	(4)	(5)	(6)
$\widehat{Haircut}$	-0.004*** (-3.10)	-0.004*** (-3.09)	-0.006*** (-5.70)	-0.006*** (-5.10)	-0.004*** (-7.09)	-0.003*** (-3.08)
Maturity		-0.717 (-1.01)		-1.116 (-1.20)		0.146 (1.12)
Turnover		0.084 (0.82)		0.057 (0.58)		0.077 (0.61)
Market price		0.002 (0.56)		0.000 (0.06)		0.003 (0.92)
Volatility		0.082 (0.12)		-0.216 (-0.30)		-0.501 (-0.58)
CDB_{spot}		-0.070 (-0.53)		-0.025 (-0.21)		-0.074 (-1.37)
Term spread		-0.035 (-0.66)		-0.094*** (-2.92)		-0.031 (-0.47)
SHIBOR		-0.075* (-1.69)		-0.048 (-1.22)		0.007 (0.25)
Ret_{stock}		0.000 (0.13)		-0.001 (-0.33)		0.004 (0.81)
Rating FE	Yes	Yes	Yes	Yes	Yes	Yes
Week FE	Yes	Yes	Yes	Yes	No	No
Bond FE	No	Yes	No	Yes	No	Yes
N	10077	9905	9519	9368	8328	8182
R-square	0.133	0.494	0.124	0.476	0.093	0.461

Table 6: IV Estimation using Matched AAA Bonds as Benchmark

This table reports the results of IV regressions using the matched AAA bonds as benchmark. The pledgeability premium is the credit spread between AA+/AA dual-listed enterprise bonds and their matched AAA bonds, where the matching criteria include yield spread and haircut before 12/8/2014. 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 t -statistics clustered by bond and week are reported in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: First stage		
Dependent: Haircut	(1)	(2)
Shock	86.886*** (71.00)	85.871*** (58.31)
Controls	No	Yes
Rating FE	Yes	Yes
Bond FE	No	Yes
N	9961	9916
R-square	0.983	0.989
Panel B: Second stage		
Dependent: Pledgeability premium	(1)	(2)
$\widehat{Haircut}$	-0.007*** (-13.50)	-0.008*** (-11.10)
Maturity		-0.026 (-0.21)
Turnover		4.529*** (3.42)
Market price		0.005** (2.50)
Volatility		0.351 (0.36)
CDB_{spot}		-0.034 (-0.86)
Term spread		0.006 (0.10)
SHIBOR		-0.034 (-1.15)
Ret_{stock}		0.005 (1.19)
Rating FE	Yes	Yes
Bond FE	No	Yes
N	9961	9916
R-square	0.156	0.656

Appendix

A Details of Data Construction

A.1 Bond rating classification

Multiple bond ratings or issuer ratings. In China, there are five major rating agencies offering rating services to bond issuers.²⁷ Moreover, credit ratings are available at both the bond level and the issuing entity level. Consequently, not only can a bond have multiple bond ratings, it can also have multiple issuer ratings. We use the following procedure to determine the unique bond and issuer rating for a given bond on a given day. First, for bond rating, we follow the market convention of “lowest rating principle.” That is, if there are multiple ratings available for the same bond on a given day, we use the lowest rating as the bond rating.

We then determine the issuer rating for this bond. For the sample before October 24, 2014, the issuer rating would be the one from the same rating agency where the lowest bond rating is obtained. The CSDC refers to this as the “issuer-bond rating matching principle.” For the sample after October 24, 2014, following the new CSDC policy, we set the issuer rating to be the lowest one among all the issuer ratings for the same bond.

Bond rating reclassification. As explained in Section 3.2, on the evening of December 8, 2014, the exchange not only made the enterprise bonds rated below AAA ineligible as repo collateral, but also disqualified the AAA enterprise bonds with below-AA issuer ratings or having an AA issuer rating but with negative outlooks. To be conservative, we reclassify these two types of AAA bonds as AA- bonds in the after-event period.

Our final sample has four re-defined rating groups for each bond-day observation: AAA, AA+, AA, and AA- (including those bonds with below AA- rating). AA+ and AA bonds are classified as treatment group and AAA and AA- bonds are classified as control group.²⁸ We also drop observations whose bond rating switches between treatment group and control group within the [-2,2] month window around the event date.

The exchange’s criteria regarding repo eligibility of various bonds have changed several times just in 2014. Before June 27, 2014, bonds with both the issuer rating and bond

²⁷These 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 \(2018\)](#).

²⁸AA- bonds are included in the control group as few AA- bonds are pledgeable even before the policy shock.

rating no lower than AA were eligible as repo collateral on the exchange. Regulations released on May 29 and June 27 that year required that starting from June 27, bonds in pledge with issuer rating of AA should have the issuer status either “Positive” or “Stable” (instead of “Negative”). The issuer rating refers to the rating given by the specific rating agency that rates its bond. However, as more and more firms issue more than one bond, it is highly probable that one issuer has conflicting issuer rating from different agencies rating different bonds that the firm issues. Therefore, the policy released by CSRC on October 24 further designate the issuer rating as the lowest one among all these applicable ratings. In accordance with the policies, we make adjustment to the bond rating grouping to guarantee the consistency of bonds’ pledgeability. Specifically, for the trading days after October 24, we define the issuer rating according to the “Lowest Rule”; and by jointly considering bond rating, issuer rating and status, we re-categorize all the bonds without repo eligibility into the “Low Rating” group.²⁹

A.2 Construction of exchange market premium

The exchange market premium is the yield 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:

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

²⁹Since for certain reasons, certain bonds not reaching the pledgeability criteria shows positive converting rate, we perform a conservative practice in rating adjustment that only re-categorize those below-criteria with very low converting rate (below 0.1) bonds into the “Low Rating” group.

between day t-1 (t-2) interbank market yield spread and day t exchange market yield spread.

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 yield spread. The matching is conducted at bond-day level in the six-month window before the event date, i.e., from June 9 to December 8, 2014. For any AA+/AA bond that was ever traded in the six-month window after the event date (December 9, 2014 to June 8, 2015), the average yield 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 yield. 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 $AAA_{i,t}^{haircut}$.
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 yield 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 yield 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 yield spread difference between an AA+ or AA bond and the candidate AAA bond is larger than the median value of all

absolute yield spread differences. The candidate AAA bond pool for the AA+ or AA bond i on day t is denoted by $AAA_{i,t}^{yieldspread}$.

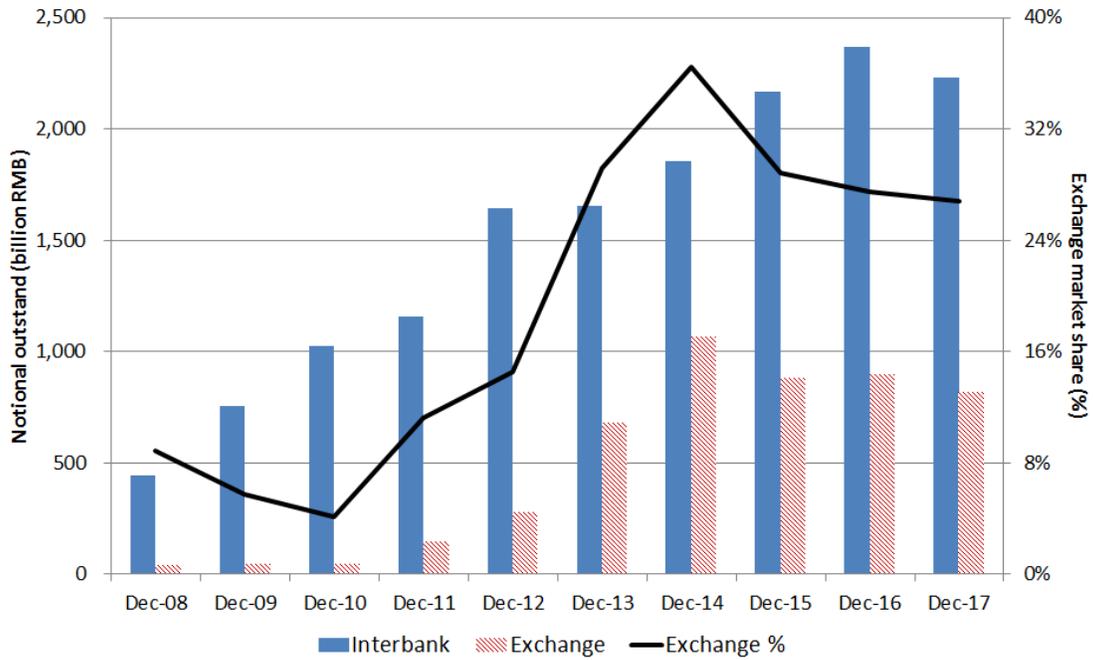
5. AAA bonds that belong to both $AAA_{i,t}^{haircut}$ and $AAA_{i,t}^{yieldspread}$ are denoted as matched set of AAA bonds for AA+ or AA bond i on day t , $AAA_{i,t}^{matched}$.
6. For any AA+ or AA bond i day t observation in the six-month pre-event window, the average yield of AAA bonds belonging to $AAA_{i,t}^{matched}$ is taken as the benchmark yield.
7. For any AA+ or AA bond i , the union of all its matched bond sets $AAA_{i,t}^{matched}$ across its non-zero trading days T_i is denoted by $AAA_i^{matched} = \bigcup_{t \in T_i} AAA_{i,t}^{matched}$.
8. For any AA+ or AA bond i day τ observation in the six-month post-event window, the average yield of AAA bonds with non-zero trading on day τ belonging to $AAA_i^{matched}$ is taken as the benchmark yield.

B Additional Results

Figure A1: China's Dual-listed Enterprise Bond Market

This figure plots China's dual-listed enterprise bond market from 2008 to 2017. Panel A plots enterprise bond outstanding in interbank and exchange markets. Panel B plots all enterprise bond issuance and dual-listed enterprise bond issuance.

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



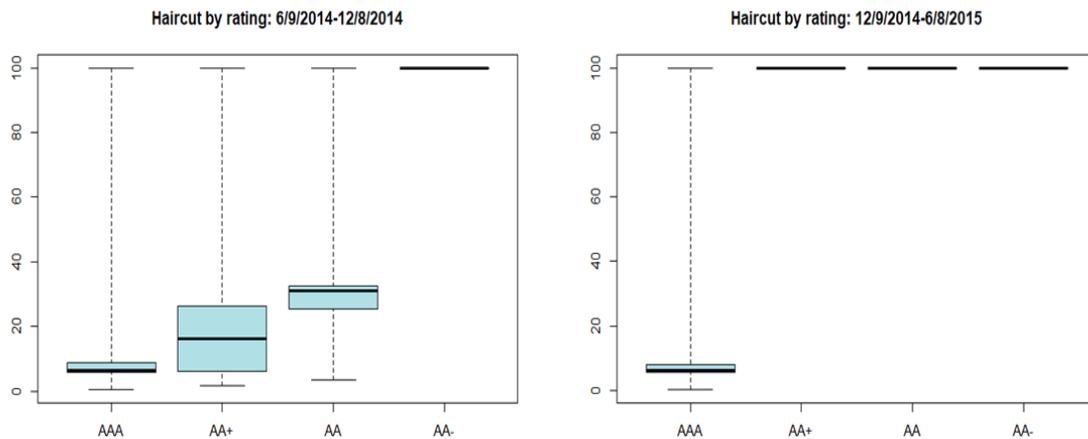
Panel B: Enterprise bond issuance (billion RMB)



Figure A2: Haircut Distribution

This figure presents box plots of haircut by rating. Panel A presents the box plots using the dual-listed enterprise bond sample with non-zero trading. Panel B presents the box plots using the simultaneous trading sample. The pre-event subsample is 6/9/2014 to 12/8/2014 and the post-event subsample is 12/9/2014 to 6/8/2014.

Panel A: Dual-listed enterprise bond sample



Panel B: Simultaneous trading sample

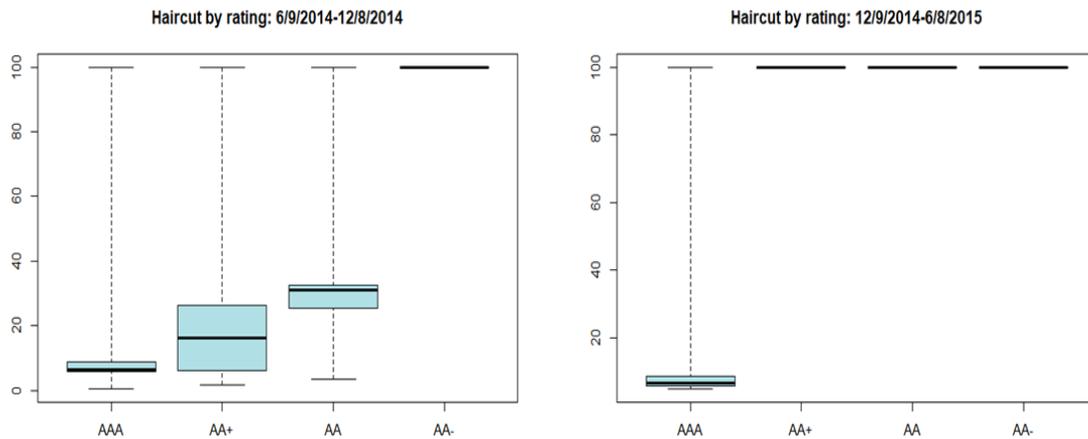


Table A1: China's Bond Market Liquidity

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. 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 10⁶. 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
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
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
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: Sample Coverage

This table reports the sample coverage by rating. Panel A presents the simultaneous sample coverage at bond-day and bond level of exchange and interbank markets over all dual-listed enterprise bonds. 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: Simultaneous-trading sample relative to dual-listed sample					
	All	AAA	AA+	AA	AA-
Bond-day					
Exchange	13.3%	6.3%	11.3%	17.2%	14.3%
Interbank	23.5%	18.4%	29.6%	20.1%	35.4%
Bond					
Exchange	64.4%	45.7%	64.8%	69.8%	59.8%
Interbank	51.7%	43.5%	54.0%	53.2%	46.3%

Panel B: Dual-listed sample relative to all enterprise bonds					
	All	AAA	AA+	AA	AA-
Number of bonds	82.7%	63.2%	83.8%	86.7%	89.9%
Notional value	79.3%	60.4%	85.5%	87.2%	90.5%
Days with trades	91.7%	83.2%	91.9%	92.8%	95.8%
RMB trading volume	82.6%	55.1%	78.4%	90.7%	92.4%

Panel C: Enterprise bonds relative to all corporate bonds					
	All	AAA	AA+	AA	AA-
Number of bonds	28.8%	20.6%	33.6%	38.8%	15.0%
Notional value	27.1%	19.7%	35.7%	50.7%	10.1%
Days with trades	41.6%	24.0%	48.2%	51.4%	28.2%
RMB trading volume	26.7%	13.2%	28.7%	59.6%	6.4%

Table A3: Summary Statistics: Same-day Sample

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

Panel A: All variables						
	N	Mean	STD	P10	Median	P90
EX premium	3445	-0.06	0.49	-0.66	-0.03	0.50
EX premium _{pre}	1667	0.07	0.43	-0.39	0.03	0.58
EX premium _{post}	1778	-0.18	0.51	-0.79	-0.13	0.40
Haircut	3445	64.62	38.57	14.59	100.00	100.00
Haircut _{pre}	1667	32.37	24.17	7.28	30.43	45.59
Haircut _{post}	1778	94.86	21.10	100.00	100.00	100.00
Conversion	3445	37.43	40.93	0.00	0.00	90.00
Conversion _{pre}	1667	71.58	25.97	57.00	74.00	99.00
Conversion _{post}	1778	5.41	22.24	0.00	0.00	0.00
IB spread	3445	2.46	0.80	1.45	2.47	3.48
EX spread	3445	2.52	0.87	1.36	2.58	3.50
Maturity	3445	5.11	1.58	3.05	5.22	6.75
Turnover	3445	0.08	0.09	0.02	0.06	0.18
Market price	3445	104.96	5.66	100.18	105.19	110.79
Volatility	3445	0.01	0.02	0.00	0.01	0.03
CDB _{spot}	3445	4.37	0.52	3.80	4.15	5.19
Term spread	3445	0.55	0.31	0.29	0.46	0.97
SHIBOR	3445	2.55	0.71	1.18	2.67	3.31
Ret _{stock}	3445	0.42	1.59	-1.13	0.31	2.44

Panel B: Exchange market premium by rating						
AAA	169	0.24	0.57	-0.36	0.08	0.99
AA+	1052	-0.01	0.47	-0.58	0.00	0.54
AA	1796	-0.11	0.47	-0.70	-0.06	0.45
AA-	428	-0.09	0.51	-0.69	-0.06	0.50

Panel C: Haircut by rating						
AAA	169	10.02	7.51	5.07	6.70	25.56
AA+	1052	62.14	40.71	7.01	100.00	100.00
AA	1796	62.98	35.97	18.85	43.76	100.00
AA-	428	100.00	0.00	100.00	100.00	100.00

Table A4: IV Estimation: Same-day Sample

This table reports the results of IV regressions using the same-day trading sample. The dummy variable, Shock, serves as the instrument variable for bond haircut, which equals 1 for the treatment group (bonds with rating AA+ and AA) after the regulation change date 12/8/2014 and 0 otherwise. Panels A and B present the results for the first and second stage regressions. Columns (1) and (2) present the results using full sample. Columns (3) and (4) present the results using a subsample of AA+, AA, and AA- bonds. Columns (5) and (6) present the results using a subsample of AA+ and AA bonds. The sample period is 6/9/2014 to 6/8/2015. Heteroscedasticity consistent t -statistics clustered by bond and week are reported in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: First stage						
Dependent:	Full		AA+ & AA & AA-		AA+ & AA	
Haircut	(1)	(2)	(3)	(4)	(5)	(6)
Shock	72.854*** (62.83)	68.264*** (22.70)	71.961*** (64.31)	65.123*** (15.47)	72.022*** (59.37)	70.654*** (30.27)
Controls	No	Yes	No	Yes	No	Yes
Rating FE	Yes	Yes	Yes	Yes	Yes	Yes
Week FE	Yes	Yes	Yes	Yes	No	No
Bond FE	No	Yes	No	Yes	No	Yes
N	3445	3180	3276	3030	2819	2584
R-square	0.926	0.969	0.920	0.966	0.903	0.967
Panel B: Second stage						
Dependent:	Full		AA+ & AA & AA-		AA+ & AA	
EX premia	(1)	(2)	(3)	(4)	(5)	(6)
$\widehat{Haircut}$	-0.005*** (-3.30)	-0.005*** (-3.14)	-0.007*** (-4.89)	-0.008*** (-4.88)	-0.004*** (-7.16)	-0.004*** (-3.29)
Maturity		-0.308 (-1.07)		-0.333 (-1.15)		0.088 (0.61)
Turnover		0.029 (0.22)		0.007 (0.06)		0.015 (0.09)
Market price		0.003 (0.77)		0.002 (0.42)		0.008* (1.76)
Volatility		-0.537 (-0.63)		-0.911 (-1.04)		-1.385 (-1.05)
CDB _{spot}		-0.240 (-1.45)		-0.191 (-1.20)		-0.119** (-2.01)
Term spread		-0.150* (-1.81)		-0.226*** (-2.83)		-0.034 (-0.45)
SHIBOR		-0.096 (-1.36)		-0.086 (-1.16)		0.027 (0.78)
Ret _{stock}		-0.007 (-1.64)		-0.009** (-2.06)		-0.002 (-0.33)
Rating FE	Yes	Yes	Yes	Yes	Yes	Yes
Week FE	Yes	Yes	Yes	Yes	No	No
Bond FE	No	Yes	No	Yes	No	Yes
N	3445	3180	3276	3030	2819	2584
R-square	0.150	0.534	0.142	0.517	0.110	0.486