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

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ABSTRACT

We provide causal evidence for the value of asset pledgeability. Our empirical strategy is based on a unique feature of the Chinese corporate bond markets, where bonds with identical fundamentals are simultaneously traded on two segmented markets that feature different rules for repo transactions. We utilize a policy shock on December 8, 2014, which rendered a class of AA+ and AA bonds ineligible for repo on one of the two markets. By comparing how bond prices changed across markets and rating classes around this event, we estimate that an increase in the haircut from 0 to 100% would result in an increase in bond yields in the range of 40 to 83 bps. These estimates help us infer the magnitude of the shadow cost of capital in China.

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1 Introduction

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

Our paper aims to offer an empirical estimate for the value of asset pledgeability. Our study focuses on bonds, which, besides spot transactions, are often involved in repurchase agreements, or repos. Repos are essentially collateralized loans, with the assets in transaction (typically fixed income securities) serving as the collateral.[1] Lenders often set a haircut over the market price of the collateral bond to determine the amount of credit extended; the smaller the haircut, the greater the pledgeability of the bond.

In a world where collateral helps reduce the costs of borrowing for a financially constrained investor (relative to default-adjusted uncollateralized borrowing), pledgeable bonds carry a convenience yield. We refer to this type of convenience yield as the *pledgeability premium*, which is jointly determined by the frequency of the liquidity shocks, the degree of pledgeability (the haircut), and the shadow cost of capital (the gap in financing costs between collateralized and default-adjusted uncollateralized borrowing). The pledgeability premium should be reflected in the equilibrium pricing of the bonds. This logic has been used to explain repo specialness (Duffie, 1996), Treasury convenience yields (Longstaff, 2004; Fleckenstein, Longstaff, and Lustig, 2014; Lewis, Longstaff, and Petrasek, 2017; Jiang, Krishnamurthy, and Lustig, 2018), and "basis" across assets with different margins (Gârleanu and Pedersen, 2011). Haircut-implied funding costs have also been used by Chen, Cui, He, and Milbradt (2018) to endogenize the holding costs of illiquid assets, which in turn helps account for the liquidity premium in corporate bonds.

Though the theoretical mechanisms through which pledgeability boosts asset values are relatively clear, it is challenging to measure the effect empirically. Asset pledgeability is endogenous and, in general, will depend on asset fundamentals, various market frictions, and the interactions between the two. We overcome this endogeneity issue by exploiting a policy shock on asset pledgeability together with a set of unique institutional features in the Chinese bond markets.

The Chinese bond markets have experienced tremendous growth during the past

[1] A key difference between repos and collateralized loans is that the repo collateral is exempt from an automatic stay in the event of bankruptcy. See, e.g. Adrian, Begalle, Copeland, and Martin (2012).

decade and are now ranked second in the world only behind the US bond markets. A distinct feature of the Chinese bond markets is the co-existence of two bond markets, the OTC-based interbank market and the centralized exchange market. The interbank bond market is a wholesale market serving only institutional investors including banks and non-bank financial institutions; on the other hand, the exchange bond market, as a part of the Shanghai and Shenzhen Stock Exchanges, is populated by non-bank financial institutions as well as retail investors. What is relevant to our study is that non-bank financial institutions, including mutual funds, securities firms, and insurance companies, are active institutional investors on both markets, though the restrictions on market access and trading frictions cause the two markets to be largely segmented (for more details, see Section 2.3).

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

Our main empirical strategy is to exploit these cross-market valuation differences for these dual-listed bonds. Specifically, we define the "exchange premium" as the yield on the interbank market minus that on the exchange market for the same bond with simultaneous transaction prices on the two markets. As we show in Section 4.1, since any unobservable fundamentals affect the pricing of the same bonds on the two markets identically, the exchange premium isolates the effects of the remaining non-fundamental factors, including the differences in pledgeability and potentially other liquidity factors in the two markets.

To further isolate the pledgeability premium, we exploit a policy shock that significantly changed the pledgeability for a set of bonds on the exchange. In the after-hours on

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

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

A main contribution of our paper is to provide an estimate of the effect of changes in pledgeability on asset prices. Using the rating-dependent policy shock as an instrument in a two-stage least squares regression, we find that raising the haircut from 0 to 100% leads to a 40 bps (0.4%) increase in the bond yield, implying a roughly 2.2% drop in price for a typical enterprise bond in our sample.

While the exchange premia–based estimates help address the issue of the policy shock's endogeneity related to unobservable bond fundamentals, they are likely downward-biased for several reasons. One leading concern is that despite the limits to cross-market arbitrages in the short-run, the policy shock on the exchange market will be transmitted to the interbank as long as some institutional investors engage in arbitrage activities. As a result, the yields on the interbank market rise to offset the declines in exchange premia, and consequently the price impact of the changes in pledgeability on the exchange is underestimated. Moreover, as we explain in Section 4.2, the flight-to-quality effect—which is stronger in the interbank market in our setting—when using AAA-rated bonds as the control group leads to an underestimate of our pledgeability premium as well.

We address this concern by providing an alternative IV estimate that likely overstates the price impact of changes in pledgeability. Thus, the two sets of IV estimates together plausibly bound the magnitude of the pledgeability premium. Specifically, instead of using the prices of the same bonds on the interbank market as a benchmark, we compare the price changes of the treated bonds against those of the matched policy shock–free AAA bonds on the exchange market. These matched AAA bonds have similar haircuts and credit spreads in the pre-event sample as those treated AA+/AA bonds, but their pledgeability was not affected by the policy shock. It is plausible that these matched AAA bonds have better unobservable fundamentals relative to the treated bonds, which would cause this alternative IV estimate to be upward biased. For instance, a potential flight to quality effect in response to the policy shock can boost the prices of AAA bonds and thus inflate the relative price changes between the treated bonds and the matched AAA bonds, leading to an overestimate of the pledgeability premium. A similar logic applies to the case where the regulator has private information that AA+/AA -rated bonds are worse than the market believes. The resulting IV (over)estimate suggests that raising the haircut from 0 to 100% leads to a 83 bps increase of yield (compared to 40 bps based on the exchange premium), or a roughly 4.6% drop in price for a typical enterprise bond in our sample. These estimates are in the same range as the effect documented in Ashcraft, Gârleanu, and Pedersen (2011) (see more details in the literature review).

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

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

The pledgeability premium is higher when the marginal investor is more frequently in a liquidity-constrained state, and it is higher when the investor faces a high shadow cost of capital in the constrained state. The shadow cost of capital is the gap between the interest-rate spread of collateralized and uncollateralized financing—that is, a form of financing risk premium (n.b., uncollateralized financing is default adjusted as in, for example, Gilchrist and Zakrajsek, 2012). Finally, the premium is higher for assets with smaller haircuts.

Through the lens of the formula above, we can infer the shadow cost of capital for investors on the exchange market. Before the policy shock, about 35% of the enterprise bonds on the exchange were used as repo collateral on a typical day. If we interpret this number as the frequency of being liquidity constrained, then the pledgeability premium estimates of 40 to 83 bps correspond to a shadow cost of capital between 1.1% to 2.4%.

Literature review. Equilibrium asset pricing with financial constraints is a very active research field; we do not aim to provide an exhaustive survey here. Early theoretical contributions include Detemple and Murthy (1997) who study the role of the short-sale limit, a constraint that is intrinsically linked to margin requirements or haircuts in equilibrium. For more recent analysis, see Chabakauri (2015). Gârleanu and Pedersen (2011) consider a general equilibrium model with two assets that have identical cash-flows but may differ in their margins/haircuts, and tie their equilibrium pricing differences (bases) to margin differences modulated by the shadow cost of capital. This model provides the closest theoretical framework to our empirical study. Other equilibrium asset pricing models with financial constraints include Gromb and Vayanos (2002), Basak and Cuoco (1998), He and Krishnamurthy (2013), and Danielsson, Zigrand, and Shin (2002).[2]

There is no doubt that margin constraints or haircuts are endogenously determined by aggregate conditions in financial markets as well as asset characteristics. Influential theoretical contributions include Fostel and Geanakoplos (2008) and Geanakoplos (2010), in which riskless lending arises endogenously due to heterogeneous beliefs. [3] Brunnermeier and Pedersen (2009) relate the haircut of assets to a Value-at-Risk constraint and highlight the downward spiral in a general equilibrium model with endogenous leverage constraints.

Our paper contributes to the literature that connects pledgeability to asset prices. The related empirical studies include Gorton and Metrick (2012), who document the repo runs during the 2007/08 financial crisis. In contrast, Copeland, Martin, and Walker (2014) show that there were not systemic runs on tri-party repo—which is the major segment of this market—during the crisis, except for the funding of Lehman in September 2008. Krishnamurthy, Nagel, and Orlov (2014) study the repo funding extended by money market funds (MMF) before and during the 2007/2008 financial crisis. Relatedly, there are also a few empirical studies on the failure of the law of one price and its connections to margin constraints and liquidity. Examples include Longstaff (2004) and Lewis, Longstaff, and Petrasek (2017), who document the premium of Treasury securities over agency or

[2]Our paper is also more broadly related to the macroeconomics literature where assets also serve the role of collateral (for instance, Kiyotaki and Moore, 1997; Caballero and Krishnamurthy, 2001). More generally, equilibrium asset pricing terms can also be endogenously determined in a framework with over-the-counter search markets (Duffie, Gârleanu, and Pedersen, 2005; Lagos and Rocheteau, 2009; He and Milbradt, 2014, among others), of which the Chinese interbank market is one. Based on this framework, Vayanos and Wang (2007) and Vayanos and Weill (2008) study the premia of on-the-run Treasuries as a symptom of the failure of the law of one price. Previous studies have also documented empirically how price dispersion arises in the OTC municipal and corporate bond markets due to dealers' market power (Green, Hollifield, and Schürhoff, 2007a,b), bond characteristics (Harris and Piwowar, 2006), selling pressure (Feldhütter, 2012), and more recently, trading networks (Di Maggio, Kermani, and Song, 2017; Hendershott, Li, Livdan, and Schürhoff, 2017; Li and Schürhoff, 2019).

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

corporate bonds that are guaranteed by the US government; Krishnamurthy (2002), who documents the on-the-run Treasury premium; Bai and Collin-Dufresne (2019), who study the CDS-bond basis which is the pricing difference between a corporate bond and its synthetic replicate (buying Treasury and selling CDS). For a more recent study on the link between pledgeability and asset pricing in the US equity market, see Ai, Li, Li, and Schlag (forthcoming).

Ashcraft, Gârleanu, and Pedersen (2011) present a model where the haircut, which represents asset pledgeability, can be used as an effective monetary policy tool in addition to the interest rate. By exploring one of the Term Asset-Backed Securities Loan Facility (TALF) programs in 2009, they also empirically examine the price impact of lowering the haircuts of some eligible mortgage-backed securities. Based on market reactions of bonds that were rejected by the program (which might carry some additional information), the authors find that an increase in the haircut from 0 to 100% would result in an increase of 28 to 52 bps in bond yields.[4] This is close to the range based on our IV estimates. Though our paper has a similar spirit as Ashcraft, Gârleanu, and Pedersen (2011) in investigating the market reactions of some policy, the dual-listed nature of Chinese enterprise bonds, together with two control groups—one with bonds of higher quality and the other with lower—lends support in identifying the causal effect of asset pledgeability on asset prices.

Our paper also makes contribution to the burgeoning literature on the Chinese bond market. Fan and Zhang (2007) study the early phase of the Chinese corporate bond markets during the period of 2000–2005, by exploring the potential mechanisms behind the market segmentation between the exchange and interbank markets. Ang, Bai, and Zhou (2019) offer the first comprehensive study on the pricing of municipal corporate bonds (Cheng-tou Bonds), which constitute a majority of dual-listed enterprise bonds in our sample. Chen, He, and Liu (forthcoming) link China's shadow banking activities to its 2009 stimulus plan by showing that provinces are refinancing maturing 2009-stimulus loans by issuing municipal corporate bonds (MCB). Wang and Xu (2019) develop a model for asset pledgeability and offer empirical support using primary bond market data in China.[5]

[4] The effect of rejection by the TALF is estimated to be around 20 bps; but because the TALF rejection essentially raised the bond haircut by 75% (25% to 100%), the effect of a 100% rise in haircut should be around 28 bps. Ashcraft, Gârleanu, and Pedersen (2011) offer another gauge of the effect of TALF; according to the survey in which both investors and dealers participated, the effect of haircut is at the range of 400 to 500 bps. However, it is hard to compare the survey evidence with the real transaction prices due to the non-binding nature of survey responses.

[5] Asset pledgeability also matters for the stock market in China; Bian, He, Shue, and Zhou (2018) show the role of leveraged margin trading in the 2015 crash of the Chinese stock market. And, complementary to our angle of rating-dependent pledgeability, Liu, Wang, Wei, and Zhong (2019) find that retail investors play a significant role in explaining the pricing wedge between the interbank and exchange markets for the dual-listed bonds. Several papers also look at the implicit government guarantee in

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 markets as an integral step of financial reforms, along with the efforts to liberalize interest rates and internationalize its 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. In comparison, the US bond market has remained slightly above 200% of the US GDP during the same time period.

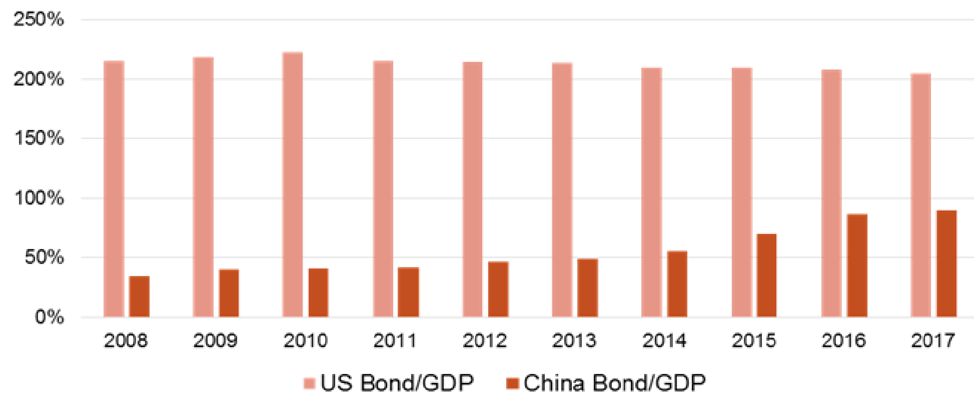
There are three major categories of fixed-income securities in the Chinese bond markets based on issuing entities: government bonds, financial bonds, and (non-financial) corporate bonds.[6] Panel B of Figure 1 shows the notional outstanding and market shares of the different types of corporate bonds. 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.

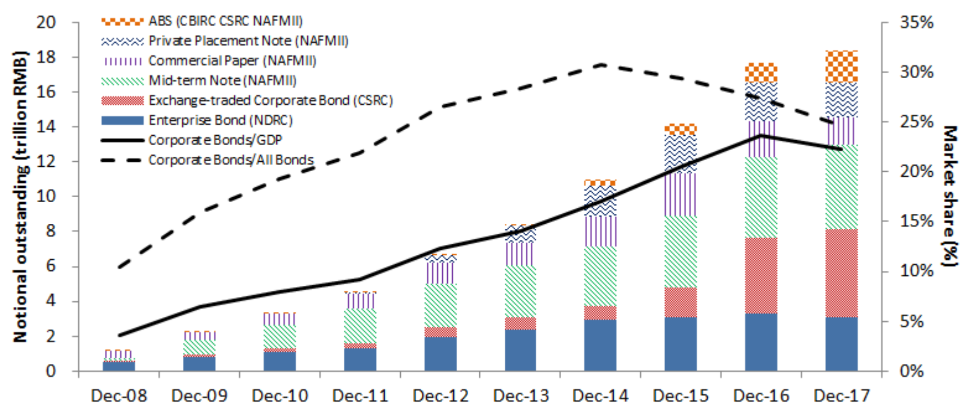
the Chinese bond market. Among them, Liu, Lyu, and Yu (2017) investigate the role of implicit local government guarantees for the above mentioned MCB; Jin, Wang, and Zhang (2018) study the event of first bond default by a central SOE in 2015 to estimate the value of implicit guarantees; and Huang, Huang, and Shao (2018) are after the same question by looking at financial bonds issued by commercial banks.

[6]Government bonds are issued by formal government agencies (e.g., the 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 contexts also include long-term bonds issued by financial institutions, we specifically separate out bonds issued by financial institutions, given that almost all entities in the Chinese financial sector are heavily influenced by the government. 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: Bonds outstanding as % of GDP



Panel B: China's corporate bonds outstanding by category



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

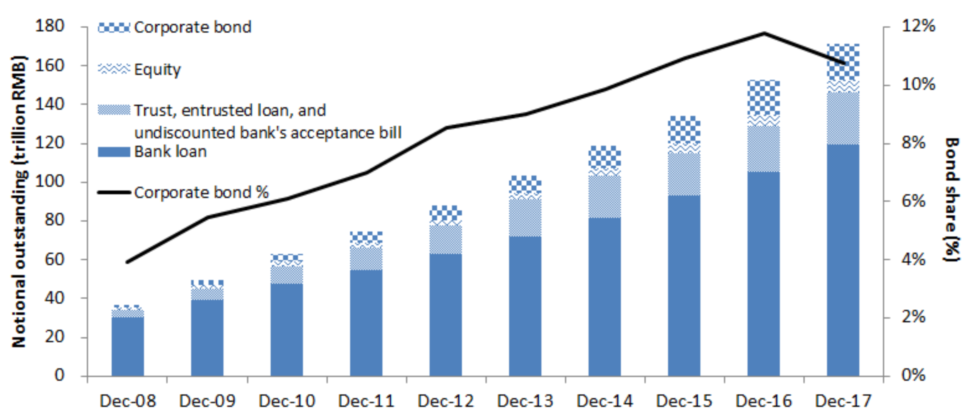


Figure 1: **China's bond market.** This figure plots statistics of China's bond market from 2008 to 2017. Panel A plots the bonds outstanding as a percentage of GDP in China and the US, Panel B plots China's corporate bonds outstanding by category (with corresponding regulators in parentheses), and Panel C plots PBOC aggregate social financing outstanding by category. For more details, see Amstad and He (2018).

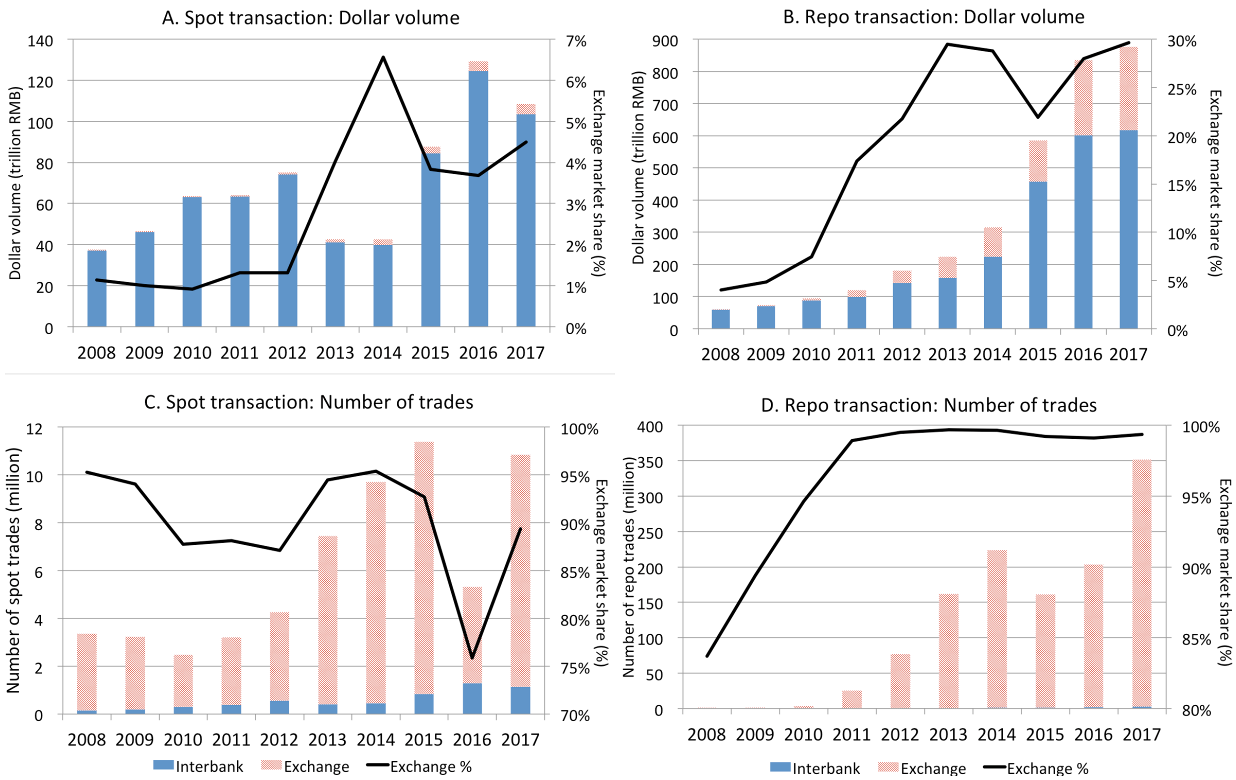


Figure 2: **China's interbank and exchange bond markets.** This figure plots China's two bond markets from 2008 to 2017. Panels A and B plot spot and repo transaction RMB volume, respectively, of all bonds on the interbank and exchange markets. Panels C and D plots the number of trades for spot and repo transactions, respectively, in these two markets. Data on interbank-market transactions are from China Foreign Exchange Trade System and data on exchange-market transactions are from the Statistics Annuals of Shanghai exchange and Shenzhen exchange.

2.2 Co-Existence of Exchange and Interbank Markets

For historical reasons, there are two distinct and largely segmented markets in today's Chinese bond markets: the over-the-counter interbank market and the centralized exchange market. The interbank market is largely a "wholesale" market, similar to the interbank markets in developed economies like the US, while the exchange market is more "retail" oriented (including smaller non-bank financial institutions, high net-worth individual investors with ample investment experience, and normal individual investors).

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 transactions, which allow investors to borrow against bond collateral, have been popular on the exchanges since their inception. 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.[7] Both markets have grown significantly in the twenty years since then. 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 by the end of 2017, including urban and rural credit cooperatives, securities firms, and insurance companies. The participants on the exchange market include non-bank financial institutions (such as mutual funds, insurance companies, and securities firms), corporate investors, and retail investors.[8] The exchange market has aggressively competed with the interbank market. One product of this competition is dual-listed enterprise bonds, which we discuss in Section 2.3.

The interbank market adopts a quote-driven over-the-counter trading protocol, in which the terms of trades are finalized through bilateral bargaining between relevant parties. In contrast, the trading protocol on the exchange is facilitated by a transparent order-driven mechanism, with electronic order books aggregating orders from all participants. Matched trades are settled via China Securities Depository & Clearing Corporation (CSDC), an entity that provides the depository and settlement services for the exchange market.

Consistent with the "wholesale vs. retail" distinction, the average trade size for spot transactions is 100 to 200 million RMB on the interbank market, compared to 0.3 to 1 million on the exchange. For repos, the average trade size is 200 to 500 million RMB on the interbank market and just 1 to 3 million on the exchange. This helps explain the fact that while the interbank market has the dominant market share for both spot and repo transactions based on dollar volume, the opposite is true based on number of trades. As Panel A of Figure 2 shows, the interbank market accounts for more than 90% of the dollar volume of spot transactions for all bonds and over 70% for repo transactions. On the other hand, when it comes to the number of trades (Panel B), the exchange market accounts for 75% to 95% of all spot transactions and over 98% of repo transactions.

Figure 2 highlights that while the two bond markets serve different clienteles with

[7]Technically, the interbank market is now self-regulated by the National Association of Financial Market Institutional Investors (NAFMII). However, the PBoC is the de facto gate keeper of this market.

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

different trading needs, they are both quite active. In short, the wholesale interbank market satisfies infrequent but large transaction needs, while the exchange accommodates frequent but small trades. This is in sharp contrast to the bond markets in the US, where the exchange attracts very limited trading in corporate bonds (see e.g., Biais and Green, 2019).[9] Table A1 in the Appendix provides a more detailed comparison of the secondary market liquidity in the two Chinese bond markets and in the US corporate bond market. Market (il)liquidity is similar between the interbank market and exchange market in China based on the fraction of bonds that do not trade on a given day. Compared to the US corporate bond market, China's bond markets are slightly less liquid based on non-trading days, but are more liquid if we look at turnovers.

2.3 Dual-Listing of Enterprise Bonds

Due to the possibility of dual-listing, the exchange and interbank markets overlap in several key bond products, mainly government bonds and enterprise bonds.

The issuance of enterprise bonds is regulated by the National Development and Reform Commission (NDRC), a powerful government agency which oversees SOE reforms in China. The interbank market, after its establishment in 1997, 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 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. Figure A1 provides more information regarding the notionl outsanding and issuance of dual-listed enterprise bonds.

[9] Over the past decade, a new type of corporate bond trading facility, the electronic-trading platform, has proliferated in both US and China. Broker-dealers used to provide liquidity to the market by taking inventory positions, but they faced increased capital requirements and tighter regulation after the 2007/2008 financial crisis. The electronic-trading platforms, thanks to technological developments in algorithmic-based trading which has dramatically improved trading efficiency, started to intermediate smaller trades in the opaque OTC corporate bond market. According to Greenwich Associates, over 90% of present-day US corporate bond trades of less than $100,000—which account for 70% of total trades—are executed on electronic-trading platforms (see, "The challenge of trading corporate bonds electronically" dated on 2019/5/13, http://www.greenwich.com/printpdf/110646). In China, Quebee (QB) provides a request for quote (RFQ) service in the interbank market and can be viewed as the Chinese counterpart of those e-trading platforms in the US, and anecdotally bond trades through QB accounted for 25% of the total number of trades in the interbank market in 2018.

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

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 settlement delays. Suppose an investor wants to sell some interbank market–acquired bonds on the exchange (or use it to do repo on the exchange). To do so, she needs to apply for transfer of custody from the interbank market to the exchange, which takes five working days or more in 2014.[10] A transfer in the opposite direction is slightly faster and takes two to three working days. Such delays expose an arbitrageur to significant price risks. Moreover, due to liquidity limitations, 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 seller's commitment to purchase the same security back from the buyer at a pre-specified price on a pre-specified future date. It is effectively a form of collateralized borrowing with the security serving as collateral. As shown in Panel B of Figure 2, repos are quite active on both the exchange and interbank markets. In 2017, repo transactions account for 90% of the total volume of bond transactions in China (including both repo and spot trading).

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

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

Repos on the interbank market In a repo transaction on the Chinese interbank market, a seller (the borrower) contacts a buyer (the lender), and both parties reach an agreement on the terms of trade based on bilateral bargaining.[11] The trading protocol is nearly identical to the tri-party repos in the US, with the China Central Depository & Clearing Co., Ltd (CCDC) serving as the third-party agent who processes the post-trading settlement.[12] 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 private bargaining on the interbank market. The haircuts and repo rates primarily reflect the risks of the underlying securities and that of the counter-party. For example, the perceived default risk is almost zero for large state-owned Big Four banks.[13] Unfortunately, we do not have access to trade-level repo data on the interbank market.[14]

Repos on the exchange For repos on the Chinese exchange market, the exchange (specifically the CSDC) not only facilitates transactions—just like the CCDC for interbank repos—but also acts as the Central Counter-Party (CCP) for all repo buyers and sellers. Unlike the third-party agent in tri-party repos, the CCP guarantees that obligations are met to all non-defaulting parties regardless of whether obligations to the CCP have been met or not. This market mechanism is similar to some CCP-based European electronic platforms (Mancini, Ranaldo, and Wrampelmeyer, 2016).

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

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

[12] Tri-party repo is a transaction for which post-trade processing—collateral selection, payment and settlement, custody and management during the life of the transaction—is outsourced by the 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 US, while in Europe they are Clearstream Luxembourg, Euroclear, Bank of New York Mellon, JP Morgan, and SIS.

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

[14] CFETS reports daily aggregate 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.

borrowed amount quoted as a fraction of the face value of the security. For 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. Suppose a bond has face value FV and market price P. We can translate its conversion rate into the haircut using the following formula:

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

Notice that haircut is negatively correlated 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 about each other and the actual composition of the collateral pool (the exchange does not publish such information), the counterparty risk component in the repo rates should be negligible due to the exchange's implicit government backing.[15] Consequently, the exchange repo rates mainly reflect the market supply and demand for short-term funding.[16]

The fact that the exchange's CCP structure offers counterparty risk–free repo transactions with desirable transparent standardization is likely a major reason behind the popularity of the exchange repo market. As Figure 2 shows, in contrast to its small market share for spot transactions (Panel A), which is in the range of 1–4% after 2012, the exchange market's share of repo transactions has been over 20% during the same

[15]The Shanghai and Shenzhen exchanges are owned and run by the CSRC, one of the most powerful government agencies in China at the ministerial level. Of course, rising bond default risk since 2014 triggers concerns whether the CSDC (and the CSRC behind) has the capacity to absorb these losses. Based on realized default and recovery rates since 2014, Chen, Chen, He, and Xie (2018) estimate that, during 2014 and 2015, annual expected losses due to default of bond collaterals constitute about 50% of the CSDC's registered capital. This dwarfs annual non-performing loans as a fraction of the equity capital of China's banking system (which sits slightly below 10%). The CSDC increased its capital from 0.6 billion RMB to 1.2 billion RMB in 2016, and further to 10 billion RMB in 2017, perhaps partly due to this consideration.

[16]A total of eighteen 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. One-day repo transactions account for 85% to 90% of total exchange market transactions. Shanghai bond repo transactions account for 90% to 95% of total exchange market transactions.

period (Panel B). This comparison highlights the significant role that the exchange repo market plays in China's short-term financing market.

2.5 The 2014 Policy Shock in the Exchange Market

To identify the effects of changes in pledgeability on bond pricing, we exploit a policy shock on the exchange market. In a nutshell, after market closing on December 8, 2014, the exchange suspended the repo eligibility of all enterprise bonds rated below AAA.[17]

The background of this policy shock is related to the local government debt problem in China; for more details on this issue, see Chen, He, and Liu (forthcoming). In 2009, Beijing responded to the 2007/08 global financial crisis with a four-trillion RMB stimulus package, in which local government financing vehicles (LGFVs, which are local SOEs) funded heavy infrastructure investment mainly through loans extended by commercial banks. Three to five years later, the back-to-normal credit policy forced LGFVs to turn to the bond market and to aggressively issue MCBs—a type of enterprise bonds—to either refinance the maturing bank loans or continue the ongoing long-term infrastructure projects.[18] As a result, the enterprise bond market became flooded with MCBs, with the share of MCB-type enterprise bonds rising from about 52% in 2012 to about 76% by the end of 2017.

Increasingly concerned about local government debt problems, the State Council of China released the tone-setting guideline No. 43 Document in October 2014, which explicitly banned the backing of MCBs by local governments. Soon financial regulators coordinated an effort 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.[19] This sudden move by the CSDC surprised exchange market investors to a large

[17]Among the AAA-rated bonds, those with below-AA issuer ratings or with an AA issuer rating, but negative outlook 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.

[18]MCB, also known as Urban Construction Investment Bond or Chengtou Bond, is one of the perfect examples of the mixture between planning and market in today's Chinese economy: in a strict legal sense they are issued by LGFVs, which are regular corporations, yet the market views them as being implicitly backed by the corresponding local governments. For more details, see Chen, He, and Liu (forthcoming).

[19]On the evening of December 8, 2014, the CSDC issued No. 149 Document "Notice on the Issues of Risk Management on Enterprise Bond Pledged-Repo Transactions" to immediately disqualify sub-AAA–rated enterprise bonds from being used as collateral in repo transactions in both the Shanghai and the Shenzhen exchanges. In this document, the CSDC raised concerns about the risk of enterprise bonds

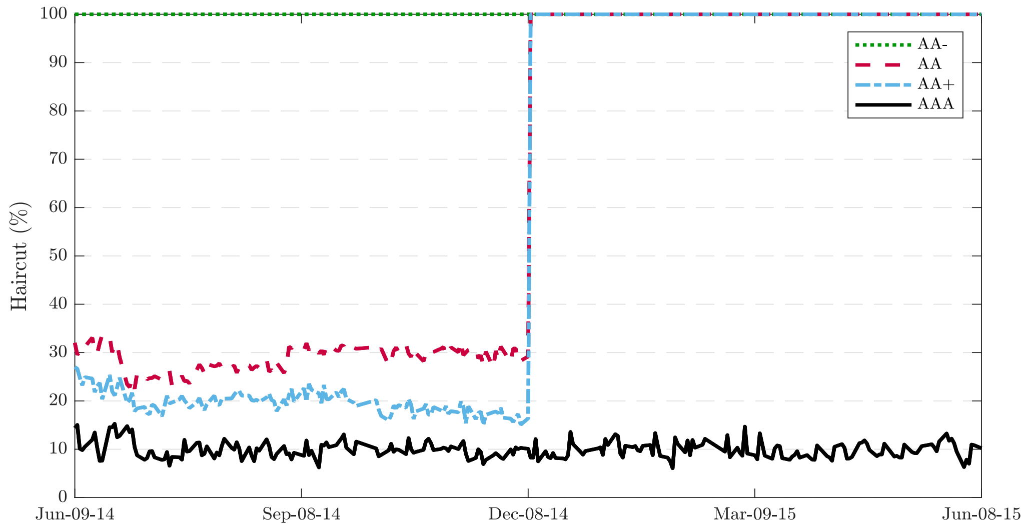


Figure 3: **Average repo haircut on the exchange market.** This figure plots the average daily haircut on the exchange market for dual-listed enterprise bonds in each of the four rating categories. The sample period is from 6/9/2014 to 6/8/2015.

extent, as market participants had expected tightening in the competing interbank market instead. This is because it is well documented that the local government debt problem is rooted in the commercial banking system (Bai, Hsieh, and Song, 2016; Chen, He, and Liu, forthcoming), which heavily relies on the interbank market—not the exchange—for liquidity management.

2.6 Market Reactions to the 2014 Policy Shock

We now explain details of the policy and the reactions from both markets in detail. 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 the event. Finally, since AA− bonds were already ineligible as repo collateral on the exchange six months before the event, their haircuts were also unaffected by the new policy.

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

that were mainly issued by local governments, echoing the No. 43 Document issued two months earlier by the State Council of China, which explicitly banned the backing of MCBs by local governments. According to estimates from Haitong Securities (one of the leading securities firms in China), about 75% of enterprise bonds deposited in the two exchanges lost their pledgeability. Bond market participants viewed this policy change as a "black swan" event—or "zhong-zheng-deng" event—that triggered a market-wide liquidity squeeze.

reports the average haircuts for enterprise bonds on the interbank market during the one-month and six-month windows before and after December 8, 2014, which are based on all the repo transactions conducted by an anonymous major financial institution in China. The average haircuts increased 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.[20]

The adjustments in exchange haircuts by the CSDC were a surprise to the market. As a first pass, we examine the average credit spreads for all dual-listed enterprise bonds in the four rating categories around the event. On the exchange, the average credit spreads for AA+ and AA bonds jumped up on the event date (by 55 and 50 bps, respectively), while the average spreads for AAA and AA− bonds fell on the event date (by 13 and 18 bps, respectively). 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) while AAA and AA− changed in a slightly greater magnitude (−23 bps and 27 bps). These market reactions are consistent with the premise that the policy shock hit AA+ and AA rated bonds on the exchange market only.

3 Exchange Premia

As described in the previous section, the policy shock on December 8, 2014, significantly reduced the pledgeability of AA+ and AA−rated enterprise bonds on the exchange market, yet at the same time their haircuts were largely intact on the interbank market. Such a unique setting provides us with the opportunity to study the impact of shocks to pledgeability on bond pricing through the exchange premia, i.e., the price gap for the dual-listed enterprise bonds between the exchange and interbank markets. In this section, we first describe our data, and then examine the empirical properties of the exchange premia.

3.1 Data

The major part of our empirical analysis focuses on the enterprise bonds that are dual-listed on both markets. We obtain enterprise bond characteristics and exchange-market trading data from WIND. Data on interbank market trading are from the China Foreign

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

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 is on December 8, 2014). This dual-listed enterprise bond sample covers 82.7% of the total trading volume of all the enterprise bonds during the same period (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). Table A2 reports the detailed coverage of our sample.

For each bond-day observation, we obtain the conversion rates quoted by the exchange and convert them into haircuts based on the formula in Eq. (1). We also calculate the enterprise bond yields based on the RMB volume-weighted average clean prices. These yields are winsorized at 0.5% and 99.5% on the exchange and interbank markets, respectively. Following industry practice, the credit spreads of the enterprise bonds are calculated relative to the matching China Development Bank bond (CDB) yields following the similar procedure of Ang, Bai, and Zhou (2019) and Liu, Lyu, and Yu (2017).[21]

As the main empirical object, we construct the "exchange market premium" or simply the "exchange premium," which is defined shortly in Eq. (2) as the yield difference between two markets, based on synchronous trading of dual-listed bonds. On a given day t when there is at least one transaction for a bond on one of the two markets, we use the nearest transaction data from the other market within the time window $[t-2, t]$ to form the pair. We refer to this sample as the "simultaneous trading sample," which contains about 10,000 bond-day observations from 995 unique bonds. The simultaneous trading sample covers 55% of all dual-listed bonds in our sample period; see Table A2 for details. The exchange premium for each pair is calculated as the yield on the interbank market minus the exchange market counterpart. To reduce the potential impact of outliers, we trim the sample at the bottom 0.5% and the top 99.5% in terms of exchange premium. In the robustness test, we also repeat our empirical exercises using a more strict same-day trading window and hence a smaller sample, which requires trades of the very same bond in two markets on the same day.[22]

[21]Bonds issued by the China Development Bank, the largest of the three policy banks in China, are fully backed by the central government, although they do not enjoy the tax-exempt status that Treasuries do. Thanks to this identical tax treatment as well as CDB bonds' superior liquidity, the CDB yield curves are commonly used as the benchmark by the bond market participants in China, especially institutional investors. Specifically, we first compute the implied prices of the CDB bonds with matching cash flows, i.e. the NPV of the same cash flows as promised by the enterprise bond discounted at the CDB bonds' zero-coupon rates, and then calculate the matching CDB yields. All of our empirical results are robust to using Treasury yields instead of CDB yields.

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

We also conduct analysis on an alternative spread measure, called "spread over matched AAA," which is the difference between the credit spreads of AA/AA+-rated dual-listed enterprise bonds and that of the matched AAA-rated ones but with similar haircuts and yields, based on their trading prices on the exchange market (for more details, see Section 4.3).

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

Table 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.

3.2 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 exclusively depend on security-level characteristics. During our sample period, the CSDC published a formula for how the conversion rates were set, which involves the bond's credit rating, market price, and volatility.[23] However, the CSDC also made it clear that the formula was only suggestive; by inserting an opaque term called "discount coefficient," the CSDC effectively reserved the discretion in setting the conversion rate for each bond.

To check the extent that one can reverse-engineer the conversion rate formula prior to the policy shock, in the six-month period before the policy shock, we regress the conversion rates on four bond rating dummies (AAA, AA+, AA, AA−), market price, coupon, maturity, volatility, 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

the sample size to about 3,400 bond-day observations, compared to about 10,000 bond-day observations in the simultaneous trading sample.

[23]The exact definitions of "market price" and "volatility" are given by the relevant regulatory documents and differ slightly from what are commonly accepted in academia. We replicate these variables, which are only used in Table 4 where we show the CSDC's reliance on ratings to determine conversion rates.

shown in Table 4. By far the most important determinant of the conversion rates is credit rating. For the full sample of dual-listed enterprise bonds, the rating dummies explain 96.8% of the total variation in conversion rates, while a kitchen sink regression only raises the R^2 to 97%; the results are quite similar in the simultaneous trading sample. The main reasons that the CSDC appears to rely primarily on credit ratings when setting the conversion rates include the transparency and third-party objectiveness of credit ratings, as well as the poor secondary market liquidity. The fact that bond haircuts largely depend on credit ratings implies that the policy shock that explicitly targeted AA+ and AA bonds will result in significant changes in exchange haircuts across bonds, i.e, a strong first stage for the policy shock as an IV.

[Insert Table 4]

3.3 Exchange Premia and the Policy Shock

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

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

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

Exchange premia before the policy shock For bonds in the simultaneous trading sample, we first plot the average credit spreads (on the two markets) and the average exchange premia for the four rating categories in the 6-month window prior to the policy shock (Figure 4, Panel A). The positive exchange premium of 22 bps enjoyed by the AAA bonds is significant in terms of economic magnitude. It represents roughly one-fifth of the average credit spread of these high quality bonds.[24] The exchange premia decline

[24]Does the average exchange premium of 22 bps for AAA bonds imply a near-arbitrage opportunity? We calculate the returns of a cross-market arbitrage strategy in our sample. Specifically, for the half-year period before the policy shock, consider buying AAA bonds on the interbank market whenever the

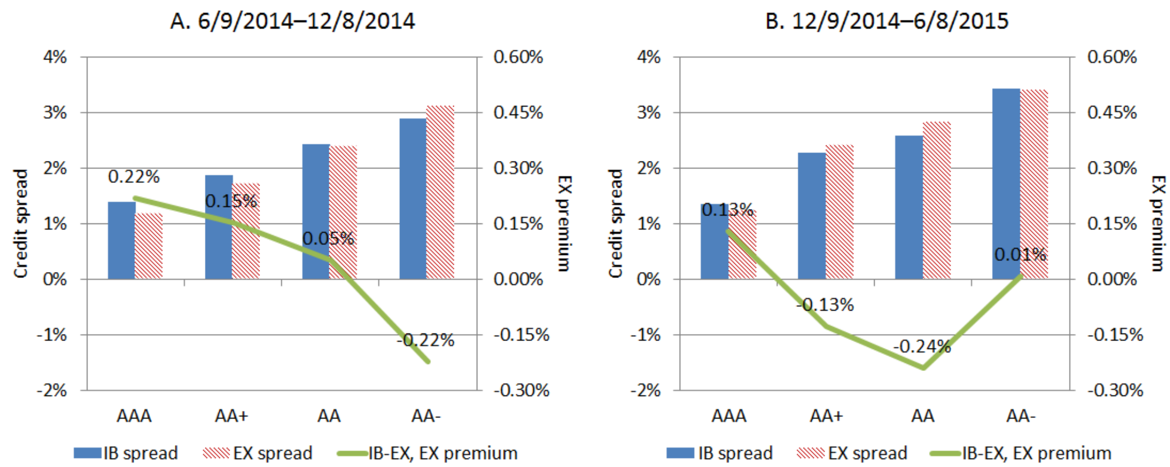


Figure 4: **Exchange premia before and after the event.** This figure plots the average credit spreads for each of the four rating categoris on the interbank market and the exchange, along with the average exchange premium. Panels A and B show the results for the 6 months before and after the event date 12/8/2014, respectively.

monotonically with lower credit ratings: 15 bps for AA+ bonds, 5 bps for AA bonds, and −22 bps for AA− bonds.

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

On the interbank market, however, the haircut for a bond can vary significantly across counter-parties. Smaller institutional investors—especially local rural credit unions or small securities firms—often complain about the difficulty of using even AAA corporate bonds as collateral for repo transactions, whereas large state-owned commercial banks

exchange premium exceeds zero (or 10 bps), holding the bonds for 5 working days, and then selling the holdings on the exchange. We use the volume-weighted average invoice prices on the interbank market as buying prices. The volume-weighted invoice bid prices on the exchange market are used as selling prices. According to industry practice, a minimum trade size of 10 million RMB is assumed on the interbank market. The pace of selling on the exchange is capped at 20% of its daily volume. The annualized Sharpe ratio of this strategy is 0.66 (or 0.72) based on the IID assumption. Taking into account the correlation in returns across bonds will likely further reduce the Sharpe ratio.

can get favorable haircuts on the same type of bonds.[25] Thus, despite the fact that the average haircut for AAA bonds based on the reported repo transactions on the interbank market (about 8%, see Table 3) is lower than the quoted values on the exchange (about 10%, see Table 3), the AAA bonds are actually more pledgeable on the exchange from the point of view of small institutions. Furthermore, due to tighter financial constraints, we expect these small institutions to value asset pledgeability more than the large commercial banks. These factors would tend to raise the valuation for AAA bonds on the exchange relative to the interbank market, contributing to a positive exchange premium.

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

Exchange premia after the policy shock We examine the impact of the policy shock on the exchange premia across ratings in the raw data. If the exchange premia are indeed driven by the rating-dependent haircut policy employed by the CSDC, 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 4. 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. The control groups do not exhibit this behavior: exchange premia did not drop as much for AAA bonds and rose for AA− bonds. In particular, the rise in exchange premium for AA− bonds in the absence of any meaningful change in haircuts on the exchange suggests that liquidity for AA− bonds deteriorated on the interbank market relative to the exchange following the event.

Time-series of exchange premia around the policy shock Next, we plot in Figure 5 the time series of average exchange premia for three rating groups: AAA, AA+/AA (combined into one "mid-rated group"), and AA−. We observe that "mid-rated group" share a similar trend with both the higher credit quality AAA control group and the lower credit quality AA− control group. What is more, while the exchange

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

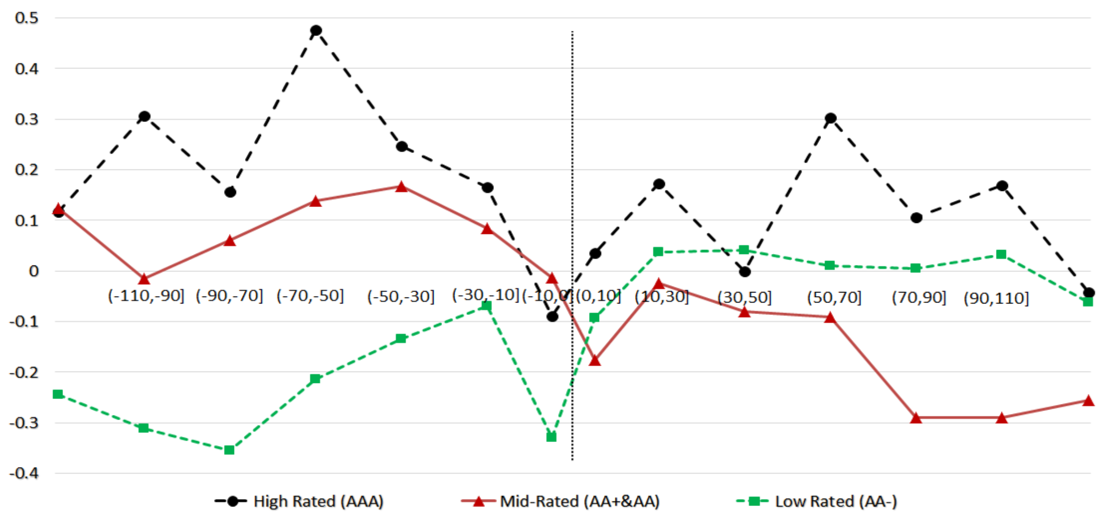


Figure 5: **Exchange premia dynamics.** This figure presents the average exchange premia by bond ratings and subperiods. The three bond-rating groups include the treated group (AA+ and AA), the AAA group, and the AA− group. The sample of simultaneous trading is a [−6,6]-month window around the event day 12/8/2014. The sample is divided into 14 subperiods, with two subperiods of 10 trading days each before and after the event day, and the remaining 12 subperiods of 20 trading days each.

premia for the AA+/AA bonds were in between those of the AAA and AA− bonds before the event, the former fell after the policy shock whereas the latter, which are control groups, rose. We highlight that our unique empirical setting allows us to use higher- and/or lower-credit rating groups as controls to rule out many alternative mechanisms. In these alternative mechanisms, the policy event represents some aggregate fundamental shock, and the treatment and control groups could just differ in their sensitivities to the fundamental shock. However, the implied responses under these alternative mechanisms tend to be monotonic in credit ratings, which is not what the data show.[26]

Notice that the exchange premia for AA− bonds rose after the policy shock, while the AAA exchange premia fell slightly. The rise in AA− exchange premia is mainly due to the rise in the credit spreads for AA− bonds on the interbank market, which is likely because the policy shock made institutional investors more reluctant to hold enterprise bonds or accept them as repo collateral. In contrast, a flight-to-quality effect actually made some institutional investors increase their holdings of AAA bonds on the interbank market, pushing the AAA exchange premia lower. We provide supporting evidence of

[26]Figure 5 also shows that the gap in exchange premia between AAA an AA− bonds closed after the event, which is due to the more significant rise in exchange premia following the event for AA− than AAA bonds. This difference raises the question about which of these two rating categories is a more appropriate control group for our study. We examine the sensitivity of our Diff-in-Diff analysis and the pledgeability premium estimates to alternative control groups in Section 4.2.2.

this view in Section 4.2.2. To the extent that the flight-to-quality is unique to AAA bonds while the reduction in demand of low-grade bonds also applies to AA+/AA bonds, AA− bonds are more suitable as a control group than AAA bonds.

The empirical pattern revealed by the raw data in Figure 5 is encouraging, as it shows that the exchange premia in the treatment rating group (AA+ and AA) react differently to the policy shock than the control groups (AAA and AA−). However, Figure 5 does not control for the potential changes in the composition of the simultaneous-trading sample before and after the event. These concerns will be formally addressed based on a formal regression-based Diff-in-Diff approach with various fixed effects, to which we turn next.

4 Empirical Analysis

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

4.1 Research Design

To identify the effects of changes in pledgeability on bond pricing, ideally we would like to compare how the price of the same bond behaves with and without an exogenous shock to the haircut. As is evident from Figure 3, the policy shock brought drastic changes to the haircuts of AA+ and AA bonds (the treatment group) while leaving those of AAA and AA− bonds (the control group) largely unaffected. But the bonds in the treatment group are not randomly selected. Besides the differences in the observable characteristics, it is possible that the exchange's new policy specifically targeted AA+ and AA bonds for reasons that are not controlled for. In particular, the policy makers might have private information about the rising risks of the treated enterprise bonds, which are signaled to the market through the policy action. If so, the policy shock would be correlated with unobserved changes in investors' beliefs about asset fundamentals and hence would violate the exclusion restriction; in this case, we may not be able to attribute the relative changes in credit spreads of the treated bonds to the changes in haircuts.

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

4.1.1 Exchange premia based on dual-listed bonds

We explain our main identification strategy through the following economic framework. Consider an investor with access to both the exchange and interbank market. A one-period defaultable bond i with rating j is traded on both markets. The bond's payoff at time $t+1$ (maturity) is $\widetilde{Y}_{i,t+1}$. The market-specific haircut at time t is h^m_{ijt}, with $m \in \{EX, IB\}$. Let p^m_{ijt} be the price of the bond at time t in market m. The first-order condition for the investor's optimal portfolio decision yields the Euler equation:[27]

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

The first term on the right-hand side of (3) is standard: $\widetilde{M}_{t+1}$ is the pricing kernel for this agent (as determined by the ratio of marginal utility of consumption between $t+1$ and t); the second term is the pledgeability premium due to borrowing constraint. Notice that λ is the Lagrange multiplier associated with the collateral constraint scaled by the marginal utility at time t, which represents the shadow value of relaxing the collateral constraint. It is related to the "specialness" in Duffie (1996) and can be microfounded by the wedge between the collateralized and uncollateralized borrowing (see, e.g. Gârleanu and Pedersen, 2011; Chen, Cui, He, and Milbradt, 2018).

A key assumption behind Eq. (3) is that agents in our model are marginal on both markets. It follows that the exchange premium in terms of price differential can be expressed as:

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

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

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

context of Chinese corporate bond markets, mutual funds, insurance companies, and securities firms are active on both markets (see Section 2.3). We offer empirical evidence in Appendix B that these three groups of financial institutions were actively trading, and hence were marginal, in both markets around the 2014 policy shock.

Eq. (4) shows that one can identify λ based on how the exchange premium changes in response to relative changes in haircuts across the two markets. As shown earlier, the 2014 policy shock significantly increased the haircuts for AA+ and AA enterprise bonds on the exchange. This explains the basis of our first set of estimates based on AA+ and AA bonds, implicitly assuming that their haircuts on the interbank market remain unchanged during the shock.

Besides the collateral constraints, there could be additional factors (such as market liquidity) that affect bond pricing. More specifically, these market liquidity factors may have affected the haircuts on the interbank market as well, which may introduce certain biases in estimating Eq. (4). While the simple model above does not consider these factors, we can summarize them with a residual term ϵ_{ijt}^{m}. The exchange premium then becomes:

$$p_{ijt}^{EX} - p_{ijt}^{IB} = \lambda \left(h_{ijt}^{IB} - h_{ijt}^{EX} \right) + \epsilon_{ijt}^{EX} - \epsilon_{ijt}^{IB}. \tag{5}$$

We are interested in identifying λ in the above equation.

Since we do not directly observe the haircuts on the interbank market or the residual terms, two additional identification assumptions are needed. First, we assume the interbank haircuts satisfy

$$h_{ijt}^{IB} = h_{i}^{IB} + h_{j}^{IB} + h_{t}^{IB}. \tag{6}$$

According to Table 3, which reports the interbank market haircuts of a major bank before and after the policy shock, bonds in the four rating groups seemed to experience a parallel shift in their haircuts, suggesting that this assumption largely holds in the data.

Second, we similarly assume the residual, which captures liquidity effects other than pledgeability-related reasons, satisfies

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

The key point of this assumption here is that we can rule out rating-time variations in the residual. One leading economic mechanism that potentially violates this assumption is the standard "flight-to-quality" effect, a concern that we will discuss later in Section 4.2.2, where we present various estimation results based on different control groups (i.e., whether AAA or AA− rated bonds).

Denoting $\Delta\epsilon_u \equiv \epsilon_u^{EX} - \epsilon_u^{IB}$, where $u \in \{i, j, t\}$, and assuming that the shadow cost of capital λ remains constant during the event window, the price differential can be expressed as:

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

In other words, the shadow cost of capital, λ, can be identified from the responses of exchange premia to the rating-time dependent haircuts in the exchange market (the first term), as all other terms can be absorbed by bond, rating, or time fixed effects. This forms the basis of our 2SLS regression, which uses the policy shock as an instrument for the haircut change in the exchange market.

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

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

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

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

The second stage of the 2SLS is:

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

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

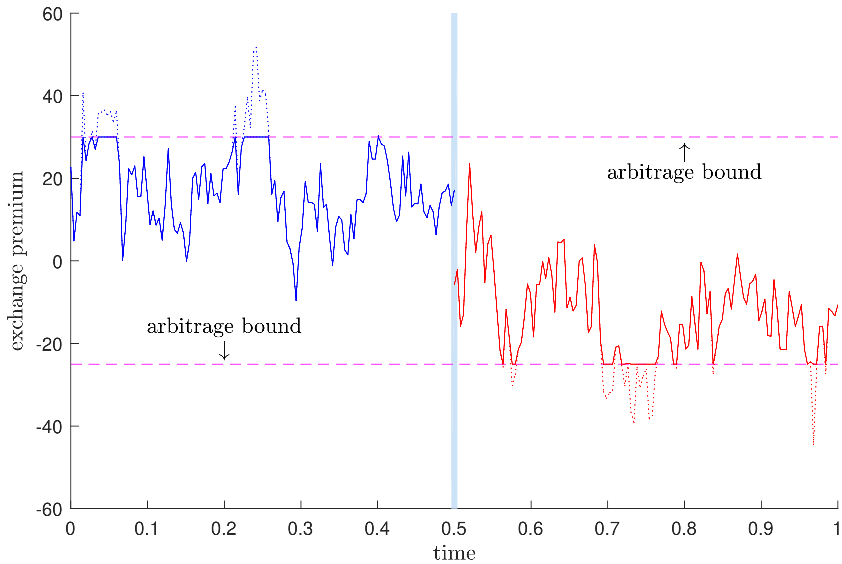


Figure 6: **The impact of arbitrage on the estimate of pledgeability premium.** With simulated data, this figure illustrates how cross-market arbitrage forces can lead to a reduction in the exchange premium, which in turn leads to a downward-biased estimate of $\hat{\delta}$.

noting that rating fixed effects should be included in the presence of bond fixed effects because a bond's rating can change over time.

Cross-market arbitrage: potential downward biases of $\hat{\delta}$ The exchange premium–based estimate of $\hat{\delta}$ in Eq. (11) from the above empirical design is likely downward biased, due to the (limited) cross-market arbitrage activities. We have discussed in great detail the significant trading frictions—in particular the delays caused by transfer of custody across two markets—in the second half of 2.3, and as well as footnote 24. However, as illustrated in Figure 6, in general, market forces will prevent the exchange premium from drifting too far away from zero.[28] In the data, indeed, although there were no significant reactions on the interbank market for AA+ and AA rated bonds on the day of the policy shock, the credit spreads of these rating classes rose slowly in the days that followed, potentially due to arbitrage activities between these two markets. In other words, the interbank-market credit spreads could also be adversely affected by the policy shock on the exchange.

Consequently, the changes in exchange premia would tend to understate the effect of the pledgeability changes on bond prices. With the possible downward bias of the 2SLS estimator in mind, we consider the following alternative approach that is designed to deliver an upward-biased estimate.

[28]The presence of arbitrage forces will also likely alter the equilibrium dynamics of the exchange premium, a factor that is ignored in our illustration.

4.1.2 Premia over matching AAA exchange-market bonds

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

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

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

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

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

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

1. First, suppose that the policy maker has some private information that AA+/AA rated bonds are lower quality than the market believes, and hence releases the liquidity-tightening rules on these bonds. The market views the policy shock as the negative signal of the treated AA+/AA bonds, leading to a negative shock to the "fundamental residual" term.

2. Second, suppose that the matched AAA bonds with better fundamentals have a smaller beta than those of treated AA/AA+ bonds, so that the "fundamental residual" term has a positive beta. Because the liquidity-tightening policy shock is likely to represent a negative aggregate market shock, this again implies a negative shock to the "fundamental residual" term.

3. Finally, suppose that the policy shock represents a liquidity-tightening event, and the resulting flight-to-liquidity effect raises the price of matched AAA bonds, perhaps due to better uncontrolled fundamentals (i.e., beyond the observable controls we add in the regressions). This effect also leads to a negative shock to the "liquidity residual" term.

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

4.2 Pledgeability and Asset Prices: Exchange Premia

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

4.2.1 Diff-in-Diff analysis

We have showed some preliminary evidence in Figure 4 and Figure 5 that exchange premia across ratings react differently to the policy shock. Overall, they are consistent with the interpretation that the drop in pledgeability on the exchange adversely affects its bond prices. These results, however, have potentially severe limitations, as they do not control for the potential changes in the composition of the sample before and after the event. To have a higher chance of being included in the simultaneous trading sample (i.e., being traded on both markets within a three-day window), a bond needs to be traded relatively frequently on the two markets. Trading frequencies are endogenous and could change with market conditions, including the policy shock. For example, the trading of enterprise 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.

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

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

As Figure 7 shows, the average exchange premia for the treated AA+/AA bonds and the control AAA/AA− bonds share a common trend before the policy shock. The Diff-in-Diff coefficients up to 100 days before the event are insignificantly different from the one immediately before the event. After the event, the exchange premia for the treated group became significantly lower relative to the control group. Consistent with the results in Figure 4, the gap ranges between −30 to −50 bps and remained significant in the 6 months after.

4.2.2 IV estimation

Now we conduct the IV estimation following the procedure outlined in Section 4.1. The results are shown in Table 5. Results are reported 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 that excludes AA− bonds (i.e., using only AAA bonds as the control group). By comparing the results across the three samples, we can learn about the sensitivity of the IV estimates to the assumption regarding how the exchange premia of the treated group and that of the two control

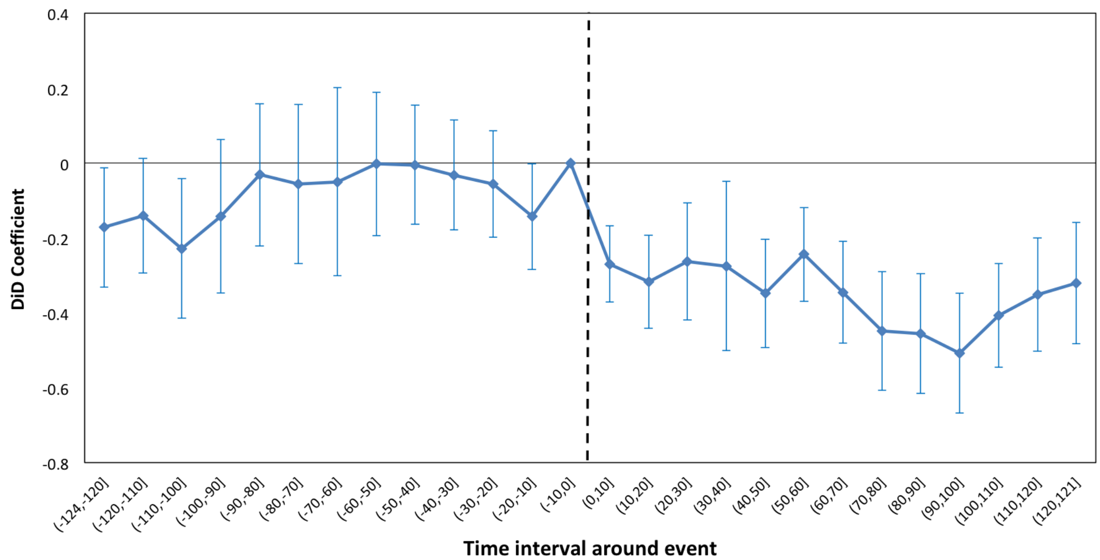


Figure 7: **Difference-in-Difference estimation of exchange premia.** This figure plots the estimated coefficients $\hat{d}_k$ along with their confidence intervals in the difference-in-difference specification of (13). The point estimate immediately before the event date is normalized to zero (hence a zero standard error). The dotted line indicates the event on 12/08/2014. The sample is from 2014/6/9 to 2015/6/8, which is divided into 26 10-day sub-periods.

groups share common variations over time.

[Insert Table 5]

In all regressions we always include rating fixed effects and time fixed effects at the weekly level. 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-day–level characteristics (time to maturity, turnover ratio, market price, and volatility) and various macro factors (term spread, CDB yield, 1-day exchange market repo rate over SHIBOR spread, and stock market return). The t-statstics in parentheses are based on standard errors clustered by week. For robustness, we also report the t-statistics based on standard errors clustered by rating and week (in brackets).

To simplify the interpretation of estimation magnitude, the exchange premium is quoted as percentage while explanatory variables are quoted as raw values, and the estimated coefficients in the first stage are reported as percentage.

The first stage, which regresses exchange market haircuts on the policy shock dummies and other controls (see Eq. (10)), is quite strong. This result, is expected given the sharp dependence of bond-level haircuts on credit ratings (see Table 4) and the nature of the policy shock (which specifically targeted ratings). The magnitude of the coefficient on the policy shock dummy is consistent across all three samples. Without bond fixed effects and regular controls, the value of the estimated coefficients around 70% reflects the average rise in haircut for AA+ and AA bonds (see Figure 3). The magnitude of the coefficient drops slightly after bond level controls are included, likely reflecting changes in the composition of the sample due to the "simultaneous trading" requirement. The standard errors are indeed higher when clustering by rating and week than when clustering by week, consistent with persistent variations in haircuts within each rating.

In the second stage, we regress the exchange premia on the fitted haircuts, $\widehat{haircut}$, from the first-stage regression (see Eq. (11)), with the coefficient δ measuring the effect of changes in haircut on exchange premia. The coefficient estimate is highly statistically significant across different samples and specifications, although the economic magnitude varies depending on the control group (more on this point later). In the full sample, the estimated $\hat{\delta}$ of -0.40 implies that an increase in the haircut from 0 to 100% would raise the bond yields on the exchange by 40 bps.

Flight to quality Using different control groups yields somewhat different estimates for $\hat{\delta}$. Dropping the AAA bonds from the sample raises the magnitude of the estimated $\hat{\delta}$ to -0.53. This is consistent with the results in Figure 5, where we saw the average exchange premium of AA− bonds rising more than that of the AAA bonds after the event. In contrast, when restricting the sample to the one without the AA− bonds—so that only the AAA bonds are used as the control group—the estimated $\hat{\delta}$ is -0.21. 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 21 bps.

The reason that the estimated pledgeability premium is significantly smaller with AAA bonds as the control is likely due to a "flight-to-quality" effect, as upon the policy shock it is quite plausible that institutional investors started selling their lower-rated (AA+ and below) enterprise bonds and increasing the holdings of AAA bonds on both markets. As we argue below, the effect of the "flight-to-quality" is likely to be stronger on the interbank market. As a result, the exchange premium of AAA bonds would decline after the event (as the prices of AAA bonds rise on the interbank market relative to the exchange) while that of the AA− bonds would rise. This would make AAA bonds a poor control group, biasing the estimate of δ downward.

What drove a stronger "flight-to-quality" effect in the interbank market in this episode? As we explained in the introduction, this December 2014 policy event hit institutional investors hard, which triggered many non-bank financial institutions and even commercial banks to scramble for liquidity. Since the exchange market is more "retail" oriented while the interbank market is a "wholesale" market (recall Section 2.2 and Figure 2), financial institutions turned to the interbank market as the primary source of funding to cover any large-scale liquidity shortage following the 2014 policy shock. While we do not have detailed enterprise bond holdings data in the two markets, we are able to obtain data on the enterprise bond holdings from an anonymous institutional investor during that event. Their average daily holdings of AAA enterprise bonds on the interbank market increased by 61.6% from the month before to the month after the policy shock, while the increase was only 16.8% on the exchange market. In contrast, their AA+ and AA enterprise bond holdings declined by around 10% on the interbank market and by up to 40% on the exchange. These statistics are consistent with our interpretation of the "flight-to-quality" effect above.

Other robustness tests As robustness test, we repeat the analysis for a half-year event window (three months before and after the policy shock; see Table A4 in Appendix) and using the same-day trading sample (Table A5 in Appendix). The findings are quantitatively similar. We also report the results of OLS regressions of exchange premium on the haircut in Table A6 in the appendix. The OLS estimate of $\hat{\delta}$ has smaller magnitude of -0.23 compared to the IV estimate. The upward bias in the OLS estimate is likely due to omitted variables.[29]

Another factor that could potentially affect our estimate is that post-event market liquidity could change differentially across ratings and markets. As a robustness test, we add controls that measure the liquidity of the two markets separately, including the rating-level turnover by market as of the day of trade. The economic and statistical magnitudes for the estimates of pledgeability premia are similar (see Table A7 for the simultaneous trading sample and Table A8 for the same-day sample in the appendix). Notice that controlling for rating-level turnover (or similarly bid-ask spreads) may lead to underestimation of the pledgeability premium due to over-controlling. The reason is that the policy shock is likely to have heterogeneous effects on liquidity for different ratings and markets, which cannot be separated from the effects on exchange premia.

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

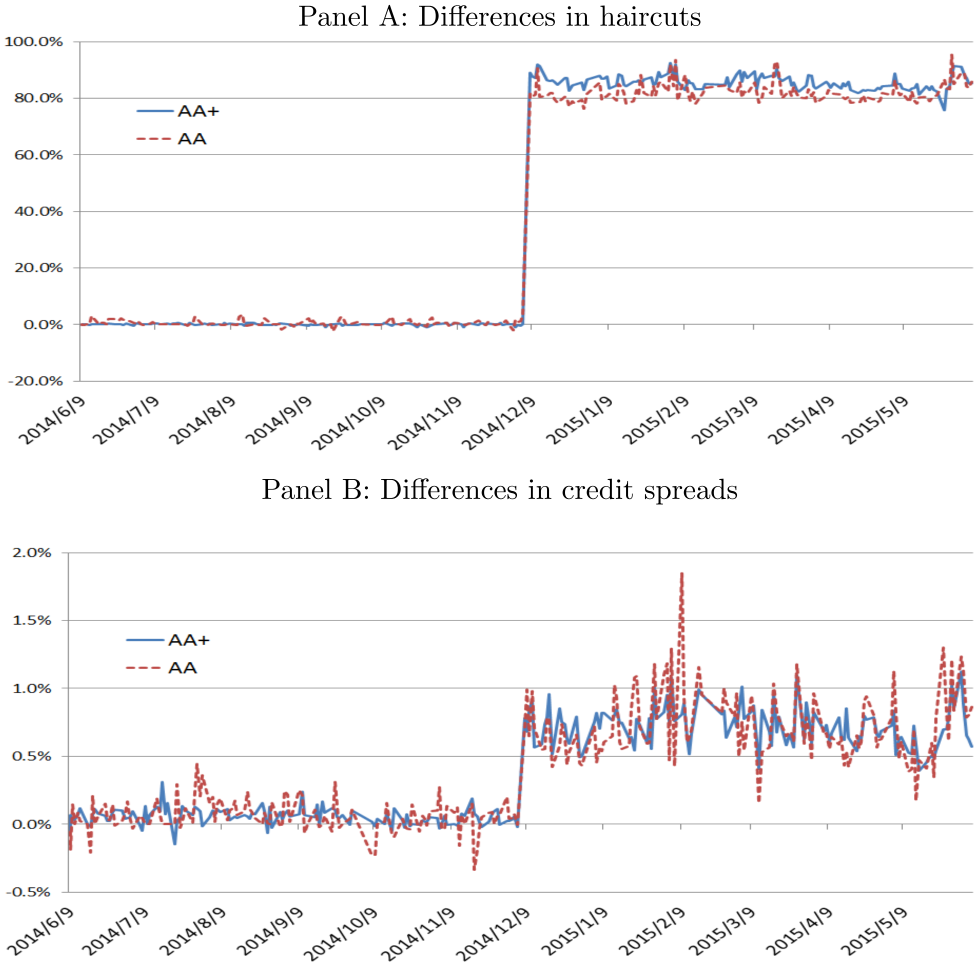


Figure 8: **Differences in haircuts and exchange credit spreads between the AA+/AA and matched AAA bonds.** This figure plots differences of AA+/AA dual-listed enterprise bonds' haircut and exchange market credit spread with respect to matched AAA bonds. Panels A and B plot the differences in haircut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

4.3 Pledgeability and Asset Prices: Matching AAA Bonds

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

We match each bond-day observation of AA+ and AA enterprise bonds on the exchange market with AAA bond-day observations that have the same haircut and credit spread during the pre-event window. Our matching procedure, which is detailed in Appendix A.3, results in very similar pre-event haircuts and credit spreads for the treatment group (AA+ and AA) and the matched AAA benchmarks. Figure 8 shows the differences in haircuts and credit spreads of the bonds in the treatment group and those of the matched AAA bonds. The average haircuts are 13.0% and 12.8% for treatment and control bonds, respectively; the 10th percentile haircuts are 5.3% and 5.4%; and the 90th percentile haircuts are 29.7% and 27.8%. The average credit spreads are 1.31% and 1.26% for treatment and control bonds; the 10th percentile credit spreads are 0.78% and 0.75%; and the 90th percentile credit spreads are 1.80% and 1.75%. The pledgeability premium is thus the difference between a treatment bond's exchange market credit spread and the average credit spread of all matched AAA bonds on the same day of trade.

Table 6 reports the results of the two-stage IV estimation using the matched AAA bonds as a benchmark.[30] The first-stage is reported in Panel A and confirms that the policy shock is a strong instrument variable. The estimated coefficients of the second-stage regressions are consistent with our conjecture (Panel B of Table 6): a 100% increase in the haircut of AA+/AA bonds transfers to a 83 bps decrease in the pledgeability premium, the effect of which is larger than the estimate of 40 bps when the interbank credit spread of the simultaneous trading sample is used as the benchmark (Column 2 of Table 5).[31] Overall, our IV estimation provides a lower bound of 40 bps and an upper bound of 83 bps on bond yields when the haircut increases from 0 to 100%. Taking the two numbers together, the average impact on credit spread for a 100% increase in the haircut is around 61 bp, which translates to 3.41% price change for an average dual-listed enterprise bond as we will discuss with more detail in the next section.

4.4 Economic Effects

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

First, we can re-express the impact of changes in the haircut on bond yield in dollar terms. Consider a bond with face value of 100 RMB. The average enterprise bond in our sample has a coupon rate of 6.62% and a maturity of 7.58 years. The yield to maturity is 6.45%. When the haircut increases from 0 to 100%, the yield to maturity would increase by 40 bps based on the exchange premium estimate, and the price would drop from 103.7

[30]For the sample of only treated AA+ and AA bonds, we do not include the weekly time fixed effects as our treatment dummy only reflects the time series variation coming from before and after the event.

[31]To be consistent with the definition of exchange premium and the interpretation of the economic magnitude, the premium in question is defined as the yields of matched AAA enterprise bonds minus those of AA+/AA enterprise bonds.

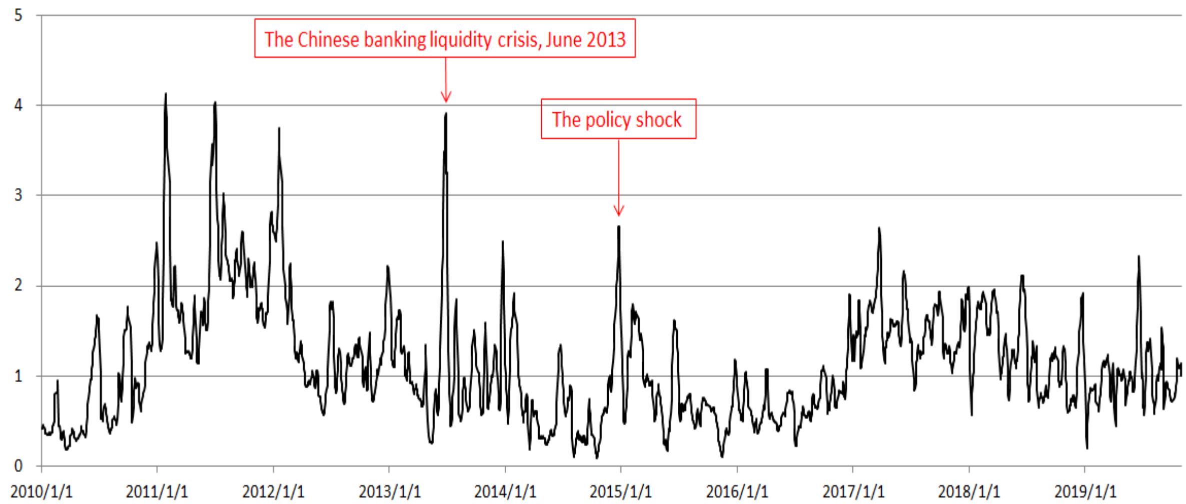


Figure 9: **Spread between the interbank market repo rate and the CDB bond yield, as percentages.** This figure plots the daily spread between the one-month interbank market repo rate for all financial institutions ("R1m") and the CDB bond yield calculated from CDB bonds with one-month maturity. Two events, the CDSC policy shock on 12/8/2014 studied by this paper and the Chinese banking liquidity crisis during 06/2013 analyzed in Hachem and Song (2017), are indicated. The sample period is from 1/1/2010 to 10/31/2019.

to 101.4 RMB, which is 2.3 RMB or 2.2%. Based on the estimate of premia over matched AAA bonds, the yield increase would be 83 bps, and the price drop would be 4.8 RMB or 4.6%.

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

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

The pledgeability premium will be higher when the marginal investor is more frequently in a liquidity-constrained state, and/or when she faces higher shadow cost of capital in the constrained state. The shadow cost of capital is the gap between the interest-rate spread of collateralized and uncollateralized financing—that is, a form of financing risk premium (n.b., uncollateralized financing is default adjusted as in, for example, Gilchrist and Zakrajsek, 2012). Finally, the premium is higher for assets with smaller haircuts.

Through the lens of the formula above, we can infer the shadow cost of capital for investors on the exchange market. Before the policy shock, about 35% of the enterprise bonds on the exchange were used as repo collateral on a typical day. If we interpret this number as the frequency of a typical bond investor being liquidity constrained, then the pledgeability premium estimates of 40 to 83 bps, which are for a bond with a 0% haircut, imply a shadow cost of capital of 1.1% to 2.4% per annum.

Finally, to put into perspective our estimate of the pledgeability premium and shadow cost of capital during the historical episode around the end of 2014, we plot the time series of the spread between the interbank market repo rate for all financial institutions and the risk-free CDB yield in Figure 9; this spread is a widely used indicator of funding constraints in the Chinese bond markets. Consistent with the policy shock tightening the funding constraints faced by financial institutions, the spread did spike up on the day of policy shock as indicated in Figure 9. In the longer sample, we also see other periods (e.g., the Chinese banking liquidity crisis during June 2013 indicated in the figure) with even higher repo spreads. The pledgeability premium is likely to be significantly higher during these crisis episodes.

5 Conclusion

The equilibrium price of an asset not only depends on its fundamentals but also its pledgeability. The Chinese corporate bond markets provide an ideal laboratory to study the effect of pledgeability empirically thanks to the fact that some bonds with identical fundamentals are simultaneously traded in two parallel markets—centralized exchange market and decentralized OTC interbank market. The differences in pledgeability lead to identical corporate bonds having different prices on the two markets. By exploiting a policy shock that dramatically reduced the pledgeability of bonds rated below AAA and above AA− on the exchange market, we are able to establish a causal effect of asset pledgeability on prices. Estimates based on instrumental variables imply that a 100% increase in the haircut increases credit spreads by 40–83 bps.

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Table 1: Definition of variables

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

Table 2: Summary statistics

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

Panel A: All variables

	N	Mean	STD	P10	Median	P90
EX premium	9976	-0.03	0.45	-0.62	-0.02	0.50
EX premium_{pre}	4882	0.08	0.40	-0.38	0.05	0.56
EX premium_{post}	5094	-0.14	0.47	-0.73	-0.11	0.41
Haircut	9976	63.79	38.50	14.41	100.00	100.00
Haircut_{pre}	4882	32.35	23.50	7.42	30.51	44.63
Haircut_{post}	5094	93.93	22.75	100.00	100.00	100.00
Conversion	9976	38.34	40.85	0.00	0.00	90.00
Conversion_{pre}	4882	71.68	25.19	58.00	74.00	98.00
Conversion_{post}	5094	6.39	23.95	0.00	0.00	0.00
IB spread	9976	2.40	0.80	1.40	2.41	3.41
EX spread	9976	2.44	0.85	1.31	2.49	3.46
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	9976	5.11	1.62	2.96	5.29	6.74
Turnover	9976	0.08	0.08	0.01	0.05	0.17
Market price	9976	105.06	5.64	100.46	105.37	110.81
Volatility	9976	0.02	0.02	0.00	0.01	0.04
CDB_{spot}	9976	4.36	0.51	3.80	4.15	5.18
Term spread	9976	0.54	0.31	0.27	0.44	0.95
GC001-SHIBOR	9976	1.89	3.86	-0.46	0.61	5.46
Ret_{stock}	9976	0.40	1.59	-1.13	0.32	2.31

Panel B: Exchange premia by rating (%)

AAA	538	0.16	0.45	-0.34	0.07	0.72
AA+	3082	0.02	0.42	-0.53	0.01	0.55
AA	5181	-0.08	0.45	-0.69	-0.04	0.45
AA−	1175	-0.05	0.45	-0.61	-0.05	0.48

Panel C: Haircuts by rating (%)

AAA	538	10.62	8.82	5.21	6.74	26.00
AA+	3082	60.56	40.65	7.14	100.00	100.00
AA	5181	63.02	35.57	26.39	43.20	100.00
AA−	1175	100.00	0.00	100.00	100.00	100.00

Table 3: Haircuts on the interbank market

This table reports average haircuts on the interbank market one and six months prior to and after 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	7.41 (0.85)	11.44 (1.87)	28.85 (3.12)	33.64 (14.11)
12/09/14–01/08/15	17.24 (1.10)	16.53 (2.24)	32.14 (2.88)	37.18 (22.37)
06/09/14–12/08/14	8.38 (0.56)	12.93 (0.96)	32.03 (1.53)	35.66 (7.01)
12/09/14–06/08/15	13.76 (0.44)	14.38 (1.25)	31.23 (1.28)	37.20 (8.89)

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. The symbols *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively. The sample period is 6/9/2014 to 12/8/2014.

	Full			Simultaneous		
	(1)	(2)	(3)	(4)	(5)	(6)
Dummy_{AAA}	91.41***		36.13***	93.20***		−95.80***
	(125.22)		(3.13)	(25.37)		(−3.49)
Dummy_{AA+}	80.83***		26.67**	82.26***		−105.66***
	(89.78)		(2.26)	(47.72)		(−4.00)
Dummy_{AA}	72.53***		18.85	72.00***		−113.19***
	(178.62)		(1.60)	(67.93)		(−4.29)
Dummy_{AA-}	1.89		−49.74***	3.84		−177.49***
	(1.10)		(−4.32)	(1.01)		(−7.06)
Market price		0.71***	0.57***		0.70***	1.50***
		(98.04)	(4.94)		(42.08)	(6.16)
Volatility		−26.31	−48.56**		−110.66**	−64.46**
		(−0.88)	(−2.36)		(−2.27)	(−2.11)
MCB			−2.03**			−2.96
			(−2.27)			(−1.37)
Coupon			−0.93			−2.61*
			(−1.34)			(−1.92)
Maturity			0.28			1.07
			(1.17)			(1.40)
Turnover			386.22***			3.88
			(5.67)			(0.85)
$\text{Yield}^{CDB}_{matching}$			53.23			1180.65**
			(0.25)			(2.13)
Size			1.21***			1.00
			(2.85)			(1.25)
Leverage			−8.75***			−6.34
			(−3.42)			(−0.95)
CDB_{spot}			−2.47			−9.31*
			(−1.23)			(−1.69)
Term spread			−2.95**			−2.64
			(−2.55)			(−0.63)
SHIBOR			4.17***			12.19***
			(6.84)			(4.13)
Ret_{stock}			0.12***			0.18
			(4.65)			(0.75)
Industry FE	–	–	✓	–	–	✓
R-square	0.97	0.92	0.97	0.95	0.90	0.96
N	117780	117780	117780	4882	4882	4882

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

Panel A: First stage

Dependent: Haircut	Full		exclude AAA		exclude AA−	
	(1)	(2)	(3)	(4)	(5)	(6)
Shock	72.89	67.80	72.12	64.96	74.35	72.31
	(113.42)***	(28.92)***	(109.08)***	(17.18)***	(93.15)***	(104.14)***
	[19.99]***	[11.23]***	[19.57]***	[8.07]***	[18.97]***	[14.46]***
Controls	−	✓	−	✓	−	✓
Rating FE	✓	✓	✓	✓	✓	✓
Week FE	✓	✓	✓	✓	✓	✓
Bond FE	−	✓	−	✓	−	✓
R-square	0.93	0.97	0.92	0.96	0.92	0.97
N	9976	9799	9438	9282	8801	8631

Table 5 (cont.): IV estimation

Panel B: Second stage

Dependent: Exchange premia	Full		exclude AAA		exclude AA−	
	(1)	(2)	(3)	(4)	(5)	(6)
$\widehat{Haircut}$	−0.50	−0.40	−0.64	−0.53	−0.24	−0.21
	(−8.64)***	(−5.40)***	(−8.68)***	(−5.50)***	(−3.55)***	(−2.84)***
	[−3.04]***	[−3.07]***	[−8.78]***	[−11.31]***	[−6.89]***	[−4.10]***
Maturity		1.97		2.10		2.41
		(2.70)***		(2.71)***		(3.08)***
		[2.41]**		[2.32]**		[2.88]***
Turnover		0.07		0.05		0.10
		(0.89)		(0.68)		(1.11)
		[1.15]		[0.80]		[1.51]
Market price		0.01		0.01		0.01
		(3.75)***		(2.95)***		(4.87)***
		[3.11]***		[2.62]***		[5.25]***
Volatility		0.08		−0.03		0.01
		(0.31)		(−0.11)		(0.03)
		[0.62]		[−0.08]		[0.08]
CDB_{spot}		−8.47		−4.95		−13.36
		(−0.89)		(−0.51)		(−1.16)
		[−1.52]		[−0.47]		[−1.84]*
Term spread		5.48		1.37		10.80
		(1.10)		(0.23)		(2.12)**
		[1.60]		[0.09]		[3.04]***
GC001-SHIBOR		−0.25		−0.25		−0.23
		(−2.28)**		(−2.53)**		(−2.03)**
		[−1.88]*		[−1.42]		[−1.47]
Ret_{stock}		−0.14		−0.26		0.09
		(−0.47)		(−0.71)		(0.27)
		[−0.66]		[−0.96]		[0.51]
Rating FE	✓	✓	✓	✓	✓	✓
Week FE	✓	✓	✓	✓	✓	✓
Bond FE	–	✓	–	✓	–	✓
R-square	0.15	0.50	0.14	0.48	0.17	0.52
N	9976	9799	9438	9282	8801	8631

Table 6: IV estimation using matched AAA bonds as benchmark

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

Panel A: First stage

Dependent: Haircut	(1)	(2)
Shock	86.89***	85.77***
	(89.77)	(85.77)
Controls	–	✓
Rating FE	✓	✓
Bond FE	–	✓
R-square	0.98	0.99
N	9961	9916

Panel B: Second stage

Dependent: Pledgeability premium	(1)	(2)
$\widehat{Haircut}$	−0.74***	−0.83***
	(−30.87)	(−17.72)
Maturity		−0.03
		(−0.34)
Turnover		2.18***
		(2.94)
Market price		0.02***
		(4.78)
Volatility		0.39
		(0.93)
CDB_{spot}		−3.53
		(−0.93)
Term spread		4.40
		(0.90)
GC001-SHIBOR		−0.19
		(−0.70)
Ret_{stock}		0.32
		(0.70)
Rating FE	✓	✓
Bond FE	–	✓
R-square	0.15	0.63
N	9961	9916

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.[32] 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 2.5, 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.[33] 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

[32] These five rating agencies are Chengxin (Chengxin Securities Rating and Chengxin International Rating), Lianhe (China United Rating and China Lianhe Rating) and Dagong Global Credit Rating; for a comprehensive review of the rating agency, see Amstad and He (2018).

[33] AA− bonds are included in the control group as few AA− bonds are pledgeable even before the policy shock.

times just in 2014. Before June 27, 2014, bonds with both the issuer rating and bond 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.[34]

A.2 Construction of exchange premium

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

The pairing procedure for "simultaneous trading" is as following:

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

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

[34]Since 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.

market trading on day t. Otherwise, the exchange premium is the difference between trading day t-1 (t-2) interbank market credit spread and trading day t exchange market credit spread.

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

We match exchange market listed AA+ and AA-rated enterprise bonds with AAA-rated enterprise bonds as benchmark in two dimensions: haircut and matching CDB credit spread. The matching is conducted at bond-day level in the six-month window before the event date, i.e., from June 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 credit spread of all non-zero trading AAA bonds that belong to the set of pre-event matched AAA bonds w.r.t. the AA+/AA bond is used as the benchmark. The following steps describe the detailed pre-event matching procedure and how we benchmark AA+/AA bonds with matched AAA bonds.

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

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

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

4. To ensure that an AA+ or AA bond's matching CDB credit spread is close enough to those of the candidate AAA bonds, an AA+ or AA bond's bond-day observation is dropped if the fifth smallest absolute credit spread difference between an AA+ or AA bond and the candidate AAA bond is larger than the median value of all

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

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

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

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

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

B Spot and Repo Transactions of Marginal Investors

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

Figure A2 Panel A plots the share of enterprise bonds held by the marginal investors over deposited enterprise bonds on each market. Over the one-year window from 2014/6/30 to 2015/6/30, enterprise bonds held by those marginal investors account for more than 50% of interbank market deposited enterprise bonds, and the number is higher than 70% on the exchange market. Figure A2 Panel B plots the share of enterprise bond spot transaction by marginal investors over the four quarters around the policy shock. Marginal investors' spot transactions account for 30% to 50% of all interbank market enterprise bond trades, and these numbers are around 80% for the exchange market. Overall, mutual funds, insurance companies, and securities firms are important traders of enterprise bonds on both markets, not just before the policy shock, but also after the policy shock.

In Figure A3, we plot the monthly repo and reverse repo transaction shares by participant type over the period of 2014:6 to 2015:5. Those marginal investors also actively participate in the repo transactions on the interbank market: around 20% of repo and 7% of reverse-repo transactions were conducted by them. We do not have detailed repo transaction data by participant type for the exchange market. But according to a research report issued by Shanghai Stock Exchange,[35] those three groups of marginal investors account for 58.9% of repo transactions in 2014, while natural persons are the single largest lenders on the reverse-repo market (44.5%), followed by general legal entities (17.4%), and trusts (10.4%). Therefore, those three groups of institutions are important net borrowers, i.e., leverage users, in both interbank and exchange repo markets.

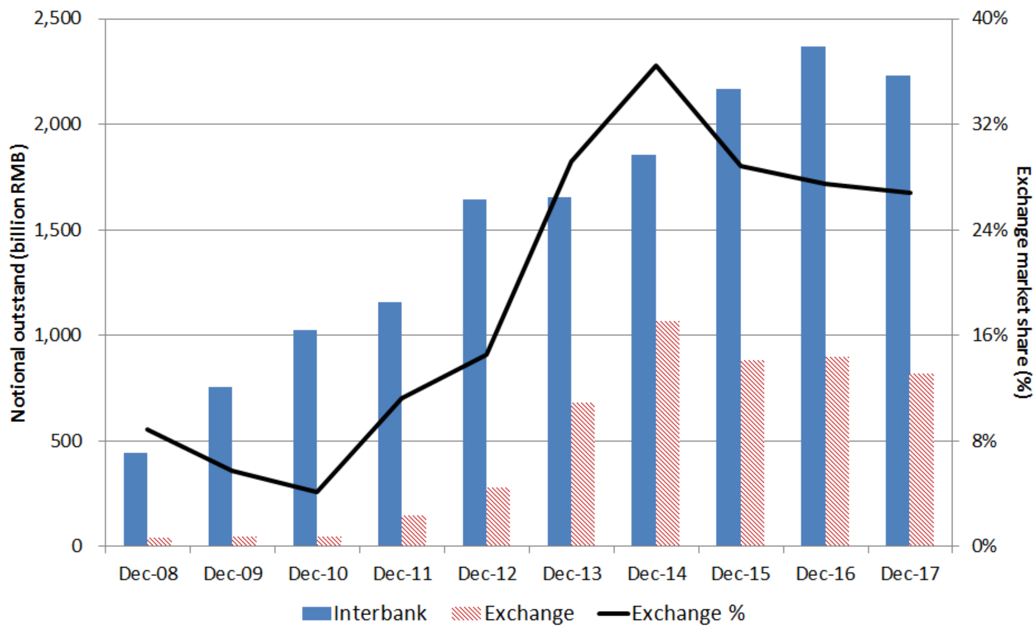
C Additional Results

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

Figure A1: Dual-listed enterprise bonds

This figure plots the notional outstanding and the issuance of dual-listed enterprise bonds in China from 2008 to 2017. Panel A plots enterprise bond outstanding in the interbank and exchange markets. Panel B plots the issuance amount for all enterprise bonds and dual-listed enterprise bonds.

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



Panel B: Enterprise bond issuance (billion RMB)

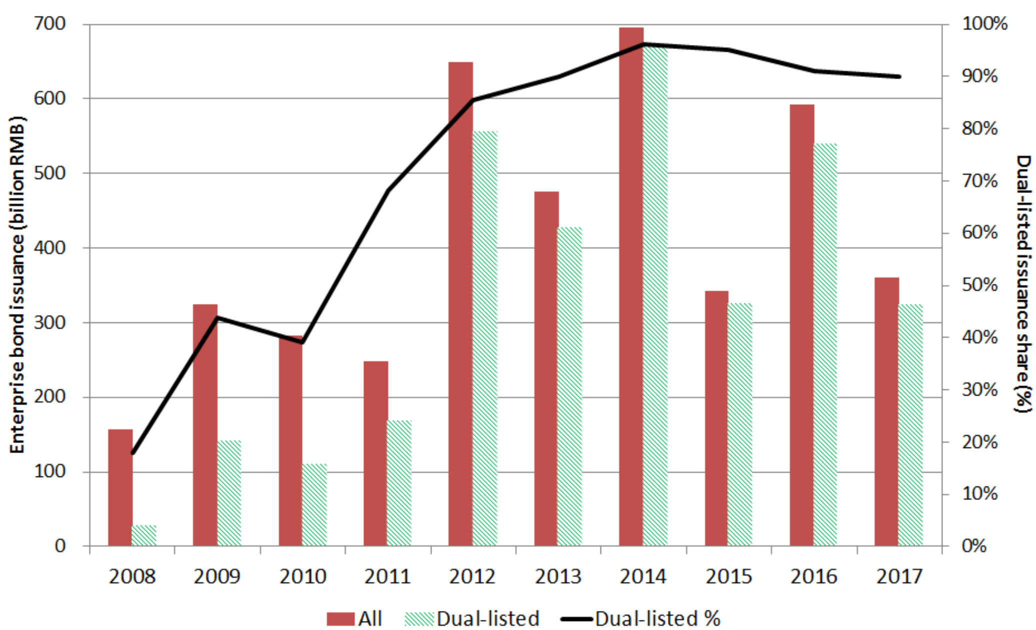
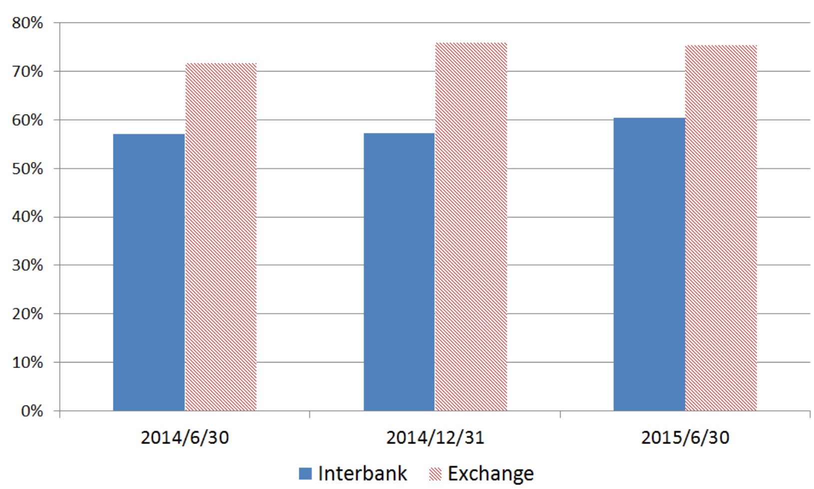


Figure A2: Marginal investors' holding and spot transaction shares on the two markets

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

Panel A: Marginal investors' holding share of enterprise bonds



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

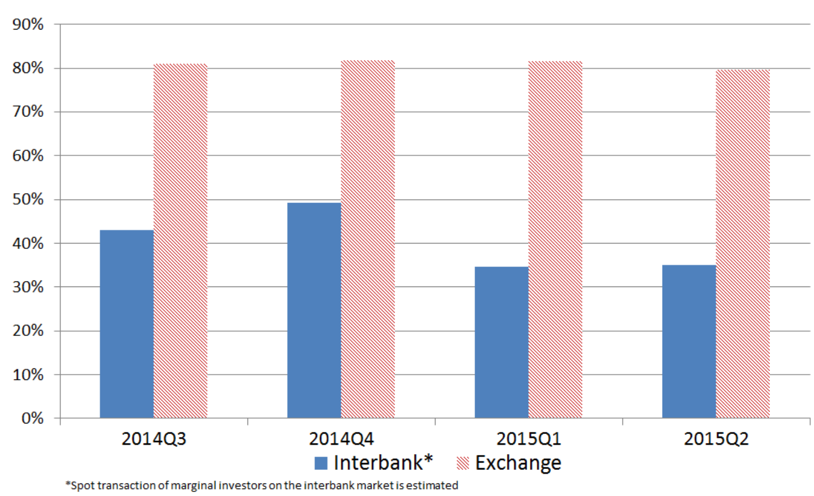
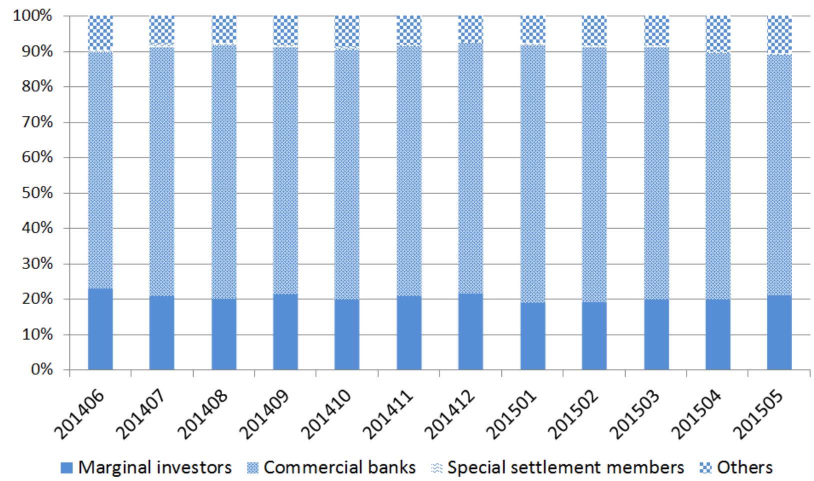


Figure A3: Repo and reverse-repo transaction shares on the interbank market

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

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



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

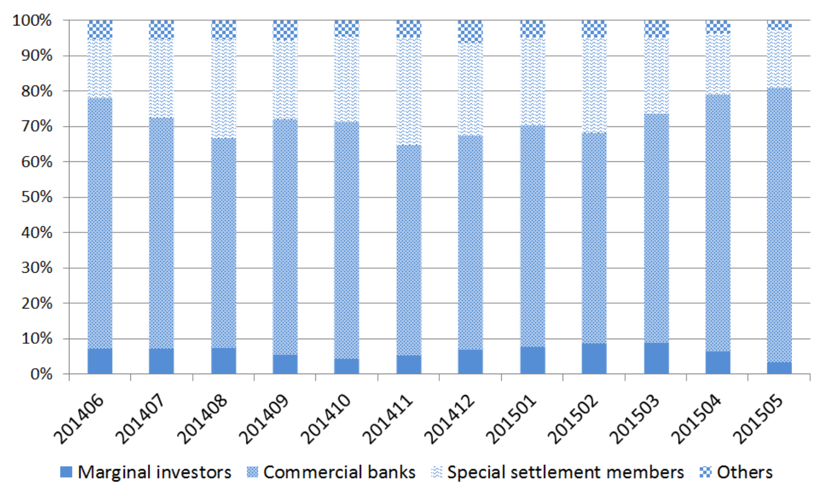


Table A1: China's bond market liquidity

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

Panel A: China and U.S. comparison

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

Panel B: China's exchange bond market liquidity

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

Panel C: China's interbank bond market liquidity

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

Table A2: Sample coverage

This table reports the sample coverage by rating. Panel A presents the number of bonds for the simultaneous trading sample and the dual-listed enterprise bond sample.[36] 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 and dual-listed sample

	All	AAA	AA+	AA	AA−
$N_{simultaneous}$	1072	85	316	553	118
$N_{dual-listed}$	2493	378	755	1058	302
Coverage (%)	43.0%	22.5%	41.9%	52.3%	39.1%

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%

[36] Since our observations are at bond-rating level, we treat the same bond with different ratings at two points in time as different bonds for the purpose of reporting the summary statistics in this table. The number of unique dual-listed enterprise bonds is 1800 and the simultaneous sample covers 55% of all these dual-listed enterprise bonds.

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. The table presents number of observations, the mean, the standard deviation, the 10th percentile, the median, and the 90th percentile. Panel A presents the summary statistics of key variables. Panel B presents the summary statistics of exchange premia by rating. Panel C presents the summary statistics of haircuts by rating.

Panel A: All variables

	N	Mean	STD	P10	Median	P90
EX premium	3410	-0.06	0.44	-0.64	-0.03	0.50
EX $premium_{pre}$	1655	0.06	0.39	-0.39	0.03	0.56
EX $premium_{post}$	1755	-0.17	0.46	-0.76	-0.13	0.40
Haircut	3410	64.69	38.54	14.72	100.00	100.00
$Haircut_{pre}$	1655	32.70	24.47	7.40	30.44	72.08
$Haircut_{post}$	1755	94.85	21.13	100.00	100.00	100.00
Conversion	3410	37.33	40.86	0.00	0.00	90.00
$Conversion_{pre}$	1655	71.18	26.24	28.00	74.00	98.00
$Conversion_{post}$	1755	5.42	22.24	0.00	0.00	0.00
IB spread	3410	2.46	0.80	1.44	2.47	3.47
EX spread	3410	2.51	0.85	1.37	2.58	3.49
Maturity	3410	5.12	1.58	3.05	5.25	6.75
Turnover	3410	0.08	0.09	0.02	0.06	0.18
Market price	3410	105.50	3.96	100.82	105.26	110.70
Volatility	3410	0.01	0.02	0.00	0.01	0.03
CDB_{spot}	3410	4.37	0.52	3.80	4.15	5.19
Term spread	3410	0.55	0.31	0.28	0.45	0.97
GC001-SHIBOR	3410	1.78	3.72	-0.46	0.53	5.46
Ret_{stock}	3410	0.42	1.59	-1.13	0.29	2.44

Panel B: Exchange premia by rating

	N	Mean	STD	P10	Median	P90
AAA	160	0.15	0.43	-0.38	0.07	0.64
AA+	1046	-0.01	0.43	-0.57	0.00	0.54
AA	1783	-0.10	0.44	-0.69	-0.06	0.45
AA−	421	-0.06	0.46	-0.63	-0.05	0.50

Panel C: Haircuts by rating

	N	Mean	STD	P10	Median	P90
AAA	160	10.18	7.68	5.07	6.67	25.60
AA+	1046	62.06	40.74	7.01	100.00	100.00
AA	1783	62.78	35.97	18.50	43.65	100.00
AA−	421	100.00	0.00	100.00	100.00	100.00

Table A4: IV estimation: [−3,3]-month event window

This table reports the results of IV regressions using the simultaneous trading sample in the [−3,3]-month window around the event day. Panels A and B present the results for the first and second stage regressions. Columns (1) and (2) present the results using full sample. 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+, AA, and AAA bonds. The sample period is 9/9/2014 to 3/8/2015. Heteroscedasticity consistent t-statistics clustered by week are reported in parentheses. The symbols *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: First stage

Dependent:	Full		AA+ & AA & AA−		AA+ & AA & AAA	
Haircut	(1)	(2)	(3)	(4)	(5)	(6)
Shock	72.10***	71.95***	71.19***	72.03***	73.99***	72.38***
	(95.62)	(82.31)	(83.28)	(72.78)	(89.99)	(75.66)
Controls	No	Yes	No	Yes	No	Yes
Rating FE	Yes	Yes	Yes	Yes	Yes	Yes
Week FE	Yes	Yes	Yes	Yes	Yes	Yes
Bond FE	No	Yes	No	Yes	No	Yes
N	4391	4208	4107	3948	3830	3658
R-square	0.93	0.98	0.92	0.98	0.91	0.97

Panel B: Second stage

Dependent:	Full		AA+ & AA & AA−		AA+ & AA & AAA	
Exchange premia	(1)	(2)	(3)	(4)	(5)	(6)
$\widehat{Haircut}$	-0.37***	-0.21***	-0.47***	-0.30***	-0.21***	-0.10
	(-5.50)	(-3.45)	(-5.32)	(-3.15)	(-2.89)	(-1.39)
Maturity		3.46***		3.62***		3.71***
		(2.68)		(2.73)		(2.74)
Turnover		0.01		-0.00		0.08
		(0.11)		(-0.00)		(0.66)
Market price		0.01**		0.01		0.01***
		(2.08)		(1.25)		(2.70)
Volatility		0.08		-0.01		-0.08
		(0.12)		(-0.02)		(-0.12)
CDB_{spot}		-12.66		-9.76		-14.51
		(-1.10)		(-0.85)		(-1.08)
Term spread		41.10**		34.69*		49.36**
		(2.20)		(1.78)		(2.47)
GC001-SHIBOR		-0.02		0.02		-0.11
		(-0.17)		(0.19)		(-0.91)
Ret_{stock}		-0.40		-0.47		-0.12
		(-0.81)		(-0.76)		(-0.24)
Rating FE	Yes	Yes	Yes	Yes	Yes	Yes
Week FE	Yes	Yes	Yes	Yes	Yes	Yes
Bond FE	No	Yes	No	Yes	No	Yes
N	4391	4208	4107	3948	3830	3658
R-square	0.10	0.49	0.09	0.48	0.10	0.50

Table A5: 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+, AA, and AAA bonds. The sample period is 6/9/2014 to 6/8/2015. Heteroscedasticity consistent t-statistics clustered by week are reported in parentheses. The symbols *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: First stage

Dependent:	Full		AA+ & AA & AA−		AA+ & AA & AAA	
Haircut	(1)	(2)	(3)	(4)	(5)	(6)
Shock	72.84***	67.16***	71.93***	64.02***	74.70***	71.73***
	(100.85)	(22.46)	(92.48)	(14.24)	(75.17)	(84.52)
Controls	No	Yes	No	Yes	No	Yes
Rating FE	Yes	Yes	Yes	Yes	Yes	Yes
Week FE	Yes	Yes	Yes	Yes	Yes	Yes
Bond FE	No	Yes	No	Yes	No	Yes
N	3410	3145	3250	3004	2989	2737
R-square	0.93	0.97	0.92	0.97	0.92	0.97

Panel B: Second stage

Dependent:	Full		AA+ & AA & AA−		AA+ & AA & AAA	
EX premia	(1)	(2)	(3)	(4)	(5)	(6)
$\widehat{Haircut}$	-0.54***	-0.46***	-0.65***	-0.62***	-0.25***	-0.17**
	(-7.64)	(-4.95)	(-7.21)	(-5.13)	(-3.81)	(-2.01)
Maturity		-0.15		-0.12		0.41
		(-0.14)		(-0.11)		(0.34)
Turnover		0.09		0.07		0.15
		(0.82)		(0.67)		(1.26)
Market price		0.01		0.00		0.01***
		(1.47)		(1.03)		(2.72)
Volatility		0.24		0.10		0.40
		(0.55)		(0.23)		(0.54)
CDB_{spot}		-18.60		-14.34		-25.88
		(-1.37)		(-1.02)		(-1.55)
Term spread		-3.08		-6.54		1.53
		(-0.37)		(-0.65)		(0.22)
GC001-SHIBOR		-0.23		-0.21		-0.40**
		(-0.86)		(-0.80)		(-2.29)
Ret_{stock}		-0.63		-0.77		-0.52
		(-1.56)		(-1.78)		(-1.32)
Rating FE	Yes	Yes	Yes	Yes	Yes	Yes
Week FE	Yes	Yes	Yes	Yes	Yes	Yes
Bond FE	No	Yes	No	Yes	No	Yes
N	3410	3145	3250	3004	2829	2596
R-square	0.17	0.55	0.16	0.54	0.13	0.53

Table A6: OLS estimation

This table reports the results of OLS regressions using the simultaneous trading sample. Columns (1) and (2) present the results using full sample. 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+, AA, and AAA bonds. The sample period is 6/9/2014 to 6/8/2015. Heteroscedasticity consistent t-statistics clustered by week are reported in parentheses. The symbols *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

Dependent:	Full		AA+ & AA & AA−		AA+ & AA & AAA	
Exchange premia	(1)	(2)	(3)	(4)	(5)	(6)
Haircut	-0.38***	-0.23***	-0.43***	-0.26***	-0.22***	-0.10*
	(-9.14)	(-4.94)	(-9.22)	(-4.78)	(-5.08)	(-1.88)
Maturity		2.19***		2.41***		2.56***
		(3.00)		(3.20)		(3.17)
Turnover		0.07		0.05		0.10
		(0.89)		(0.64)		(1.15)
Market price		0.012***		0.01**		0.02***
		(3.98)		(3.28)		(5.05)
Volatility		0.06		-0.02		-0.01
		(0.25)		(-0.08)		(-0.03)
CDB_{spot}		-12.71		-11.78		-16.38
		(-1.29)		(-1.21)		(-1.39)
Term spread		9.27**		7.39*		13.18**
		(2.16)		(1.83)		(2.41)
GC001-SHIBOR		-0.25**		-0.26***		-0.22**
		(-2.33)		(-2.62)		(-2.00)
Ret_{stock}		-0.04		-0.09		0.18
		(-0.14)		(-0.28)		(0.53)
Rating FE	Yes	Yes	Yes	Yes	Yes	Yes
Week FE	Yes	Yes	Yes	Yes	Yes	Yes
Bond FE	No	Yes	No	Yes	No	Yes
N	9976	9799	9438	9282	8801	8631
R-square	0.15	0.50	0.15	0.49	0.17	0.52

Table A7: IV estimation: Robustness with alternative controls

This table reports the results of IV regressions using the simultaneous trading sample with alternative control variables. $\text{Turnover}^{ex}/\text{Turnover}^{ib}$ is the bond-day-market level turnover. $\text{Turnover}^{ex}_{rating}/\text{Turnover}^{ib}_{rating}$ is the rating-day-market level turnover. Panels A and B present the results for the first and second stage regressions. Columns (1) and (2) present the results using full sample. 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+, AA, and AAA bonds. The sample period is 6/9/2014 to 6/8/2015. Heteroscedasticity consistent t-statistics clustered by week are reported in parentheses. The symbols *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: First stage

Dependent:	Full		AA+ & AA & AA−		AA+ & AA & AAA	
Haircut	(1)	(2)	(3)	(4)	(5)	(6)
Shock	72.89***	68.17***	72.12***	65.41***	74.35***	72.32***
	(113.42)	(29.78)	(109.08)	(17.33)	(93.15)	(105.62)
Controls	No	Yes	No	Yes	No	Yes
Rating FE	Yes	Yes	Yes	Yes	Yes	Yes
Week FE	Yes	Yes	Yes	Yes	Yes	Yes
Bond FE	No	Yes	No	Yes	No	Yes
N	9976	9799	9438	9282	8801	8631
R-square	0.93	0.97	0.92	0.96	0.92	0.97

Panel B: Second stage

Dependent:	Full		AA+ & AA & AA−		AA+ & AA & AAA	
Exchange premia	(1)	(2)	(3)	(4)	(5)	(6)
$\widehat{Haircut}$	-0.50***	-0.40***	-0.64***	-0.52***	-0.24**	-0.21***
	(-8.64)	(-5.68)	(-8.68)	(-5.72)	(-3.55)	(-2.97)
Maturity		1.99***		2.13***		2.40***
		(2.77)		(2.79)		(3.08)
Turnover^{ex}		0.52		0.44		0.33
		(1.34)		(1.16)		(0.83)
Turnover^{ib}		0.06		0.05		0.09
		(0.78)		(0.60)		(1.01)
Market price		0.01***		0.01***		0.01***
		(3.75)		(2.97)		(4.86)
Volatility		0.08		-0.03		0.02
		(0.31)		(-0.11)		(0.04)
$\text{Turnover}^{ex}_{rating}$		-2.15		-3.53		-17.36
		(-0.11)		(-0.16)		(-0.91)
$\text{Turnover}^{ib}_{rating}$		-1.77		-1.94		0.62
		(-1.10)		(-1.21)		(0.38)
CDB_{spot}		-8.51		-5.00		-13.12
		(-0.89)		(-0.52)		(-1.14)
Term spread		5.22		1.20		10.83**
		(1.08)		(0.20)		(2.15)
GC001-SHIBOR		-0.25**		-0.26***		-0.24**
		(-2.35)		(-2.60)		(-2.14)
Ret_{stock}		-0.15		-0.27		0.09
		(-0.48)		(-0.70)		(0.26)
Rating FE	Yes	Yes	Yes	Yes	Yes	Yes
Week FE	Yes	Yes	Yes	Yes	Yes	Yes
Bond FE	No	Yes	No	Yes	No	Yes
N	9976	9799	9438	9282	8801	8631
R-square	0.15	0.50	0.14	0.48	0.17	0.52

Table A8: IV estimation using same-day sample: Robustness with alternative controls

This table reports the results of IV regressions using the same-day trading sample with alternative control variables. $\text{Turnover}^{ex}/\text{Turnover}^{ib}$ is the bond-day-market level turnover. $\text{Turnover}^{ex}_{rating}/\text{Turnover}^{ib}_{rating}$ is the rating-day-market level turnover. Panels A and B present the results for the first and second stage regressions. Columns (1) and (2) present the results using full sample. 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+, AA and AAA bonds. The sample period is 6/9/2014 to 6/8/2015. Heteroscedasticity consistent t-statistics clustered by week are reported in parentheses. The symbols *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

Panel A: First stage

Dependent:	Full		AA+ & AA & AA−		AA+ & AA & AAA	
Haircut	(1)	(2)	(3)	(4)	(5)	(6)
Shock	72.84***	68.08***	71.93***	65.05***	74.70***	71.76***
	(100.85)	(25.69)	(92.48)	(15.57)	(75.17)	(81.39)
Controls	No	Yes	No	Yes	No	Yes
Rating FE	Yes	Yes	Yes	Yes	Yes	Yes
Week FE	Yes	Yes	Yes	Yes	Yes	Yes
Bond FE	No	Yes	No	Yes	No	Yes
N	3410	3145	3250	3004	2889	2737
R-square	0.93	0.97	0.92	0.97	0.92	0.97

Panel B: Second stage

Dependent:	Full		AA+ & AA & AA−		AA+ & AA & AAA	
Exchange premia	(1)	(2)	(3)	(4)	(5)	(6)
$\widehat{Haircut}$	-0.54***	-0.46***	-0.65***	-0.61***	-0.25***	-0.20**
	(-7.64)	(-5.33)	(-7.21)	(-5.09)	(-3.81)	(-2.30)
Maturity		-0.11		-0.07		0.39
		(-0.11)		(-0.07)		(0.34)
Turnover^{ex}		0.62		0.63		0.46
		(1.24)		(1.23)		(0.84)
Turnover^{ib}		0.09		0.07		0.15
		(0.80)		(0.63)		(1.21)
Market price		0.01		0.00		0.01***
		(1.47)		(1.05)		(2.72)
Volatility		0.22		0.08		0.38
		(0.51)		(0.19)		(0.51)
$\text{Turnover}^{ex}_{rating}$		-22.01		-21.44		-64.77
		(-0.71)		(-0.68)		(-1.61)
$\text{Turnover}^{ib}_{rating}$		-6.62***		-6.24***		-4.53
		(-2.85)		(-2.61)		(-1.44)
CDB_{spot}		-17.93		-14.06		-24.50
		(-1.36)		(-1.03)		(-1.52)
Term spread		-4.37		-7.20		0.27
		(-0.52)		(-0.71)		(0.04)
GC001-SHIBOR		-0.27		-0.24		-0.48**
		(-0.96)		(-0.88)		(-2.51)
Ret_{stock}		-0.67		-0.80*		-0.57
		(-1.59)		(-1.75)		(-1.43)
Rating FE	Yes	Yes	Yes	Yes	Yes	Yes
Week FE	Yes	Yes	Yes	Yes	Yes	Yes
Bond FE	No	Yes	No	Yes	No	Yes
N	3410	3145	3250	3004	2989	2737
R-square	0.17	0.55	0.16	0.54	0.20	0.59

Table A9: IV estimation using matched AAA bonds as a benchmark: Robustness with alternative controls

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

Panel A: First stage

Dependent: Haircut	(1)	(2)
Shock	86.89***	85.64***
	(89.77)	(77.58)
Controls	No	Yes
Rating FE	Yes	Yes
Bond FE	No	Yes
N	9961	9916
R-square	0.98	0.99

Table A9 (cont.): IV estimation using matched AAA bonds as benchmark: Robustness with alternative controls

Panel B: Second stage

Dependent: Pledgeability premium	(1)	(2)
$\widehat{Haircut}$	-0.74***	-0.81***
	(-30.87)	(-20.21)
Maturity		-0.07
		(-0.98)
Turnover		1.99***
		(2.73)
Market price		0.02***
		(4.72)
Volatility		0.34
		(0.76)
Maturity_*bmk*		0.02**
		(2.32)
Turnover_*bmk*		-5.36***
		(-2.76)
Market price_*bmk*		0.00
		(1.43)
Volatility_*bmk*		1.48
		(1.27)
$\text{Turnover}^{ex}_{rating}$		45.85
		(1.00)
$\text{Turnover}^{ib}_{rating}$		1.01
		(0.24)
CDB_{spot}		-2.57
		(-0.68)
Term spread		4.96
		(0.92)
GC001-SHIBOR		-0.14
		(-0.52)
Ret_{stock}		0.35
		(0.74)
Rating FE	Yes	Yes
Bond FE	No	Yes
N	9961	9916
R-square	0.15	0.63