Credit Market Freezes*

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Abstract

Credit market freezes in which debt issuance declines dramatically and market liquidity evaporates are typically observed during financial crises. In the financial crisis of 2008-09, the structured credit market froze, issuance of corporate bonds declined, and secondary credit markets became highly illiquid. In this paper we analyze liquidity in bond markets during financial crises and compare two main theories of liquidity in markets: (1) asymmetric information and adverse selection, and (2) heterogenous beliefs. Analyzing the 1873 financial crisis as well as the 2008-09 crisis, we find that when bond value deteriorates, bond illiquidity increases, consistent with an adverse selection model of the information sensitivity of debt contracts. While we show that the adverse-selection model of debt liquidity explains a large portion of the rise in illiquidity, we find little support for the hypothesis that opinion dispersion explains illiquidity in financial crises.

*We thank Bengt Holmström for numerous conversations. We also thank Marty Eichanbaum, Ravi Jaganathan, Dimitris Papanikolaou, Jonathan Parker, Sergio Rebelo, Steve Strongin and seminar participants in Goldman Sachs Global Markets Institute Academic Fellowship Conference for many comments that have improved the paper. We are grateful to Jack Bao and Kewei Hou for sharing their bond liquidity data. Shoham Benmelech, Zach Mikaya, Khizar Qureshi, Jeremy Trubnick and Yupeng Wang provided excellent research assistance.

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Introduction

Financial market freezes – by which we mean large declines in the volume of transactions in both the primary and the secondary markets that occur over a non-trivial period of time – are typically observed during financial crises. For example, issuance of corporate, mostly railroad, bonds collapsed during the financial crisis of 1873 and did not resume until 1879. Likewise, there was a considerable decline in bond issuances in the financial crises of 1884, 1893 and 1907. Similar patterns can be observed during the Great Depression when issuance of bonds by industrial firms fell dramatically in 1931 and did not recover until 1935.[1] In particular, issuance of real estate bonds, which accounted for 23% of the total corporate bond issuance in the 1920s, came to a halt in 1929 when the market for such bonds dried-up. Junk bond issuances that boomed in the first half of the 1980s collapsed in 1990 with the market remaining frozen until 1993. The IT revolution led to a boom in issuance of bonds by telecommunication companies which were in-turn purchased and securitized into Collateralized Bond Obligations (CBO). The massive defaults by telecom companies in 2001 and 2002 led to a collapse of the bond securitization market and CBOs have since disappeared. A more recent example of a market freeze took place during the financial crisis of 2008-09 with the collapse of the structured finance market – the largest and fastest growing financial market in the years leading to the crisis. In particular, not only did the market for mortgage-backed securities such as RMBS and CDOs collapse, but also, other, non-housing segments of the structured finance markets – ranging from commercial loans securitizations to asset-backed securities – came to a halt, and even the issuance of corporate bonds declined significantly.

Credit freezes and liquidity dry-ups during financial crises affect secondary markets as well. During the financial crisis of 2008-09 illiquidity in the bond market rose dramatically. For example, according to Bao, Pan and Wang (2011), aggregate illiquidity doubled from its pre-crisis levels in August 2007, and tripled in March 2008, during the collapse of Bear Stearns. By September 2008, during the Lehman Brothers default and the bailout of AIG, bond illiquidity was five times its pre-crisis level. As we show in our analysis below, illiquidity in the bond market also rose sharply in the panic of 1873 – one of the worst financial crises during the National-Bank era. For example, bid-ask spreads doubled from their pre-crisis levels in August 1873 and remained elevated for more than a year.

This paper analyzes liquidity in bond markets during financial crises with an emphasis on the most recent crisis of 2008-09. In doing so, we compare two main theories of liquidity in markets: (1) asymmetric information and adverse selection, and (2) heterogenous beliefs.

[1] See Benmelech, Frydman and Papanikolaou (2017).

The classic literature explaining liquidity and frictions in trade between economic agents relies on fundamental insights developed in the information economics literature. As first shown in Akerlof (1970) and Spence (1973), private information held by economic agents generates adverse selection in which buyers demand discounts reflecting their concern about the negative information held by sellers. Dang, Gorton and Holmström (2012, 2013) and Holmström (2015) apply these insights to develop an asymmetric-information theory of liquidity in bond markets. This is the first theory we test to understand the determinants of liquidity in bond markets during financial crises.

The fundamental insight of Dang, Gorton and Holmström is that the payoff structure of debt contracts generates two regions in which bonds will trade. When bond default risk is relatively low, bond payoffs will be comparatively insensitive to underlying firm value. The value of private information, and hence adverse selection between economic agents, will be relatively low. As a result, when default risk is low, debt is informationally insensitive, and liquidity will be high. In contrast, when default risk rises, the sensitivity of bond value to underlying firm value increases as the firm is nearing its default boundary. Private information in this region is valuable, adverse selection is therefore high, and debt liquidity will decline. The main prediction of the Dang, Gorton and Holmström model is thus that bond illiquidity will rise as bond value declines, with the bond moving from the informationally insensitive to the informationally sensitive regions.

The second theory of bond liquidity we analyze stems from the literature on heterogeneous beliefs (see, e.g., Harrison and Kreps (1978), Varian (1989), and Harris and Raviv (1993)). By assuming that agents hold different fundamental opinions about underlying asset values – some agents are optimistic while others are pessimistic – the literature on heterogeneous beliefs evades the classic no-trade results in the information economics literature (e.g. Rubinstein (1975), Hakansson et al. (1982), and Milgrom and Stokey (1982)). Adverse selection is thus mitigated – indeed, dissipated – by agents' high certainty in the correctness of their own opinion of asset value: agents engage in trade for their own *perceived* mutual benefit. Differences of opinion can thus promote trade and increase liquidity. Indeed, if agent A values an asset more than agent B, and believes B's valuation to be simply wrong, then agent A does not fear adverse selection in purchasing the asset from B, nor will she require a discount in doing so. Our empirical tests are aimed, therefore, at analyzing to what extent differences of opinion are positively related to liquidity in debt markets during the financial crisis of 2008-09.

One caveat about the theoretical prediction that differences of opinion lead to higher liquidity, is that the theory relies on assumptions regarding the *joint* distribution of beliefs and endowments. To the extent that opinion dispersion rises in a manner perfectly correlated with the distribution of endowments, it need not be the case that trade and liquidity will rise with the degree of the dispersion. Consider for example a scenario with two agents differentiated by their beliefs about asset value – an optimist and a pessimist – where the optimist owns the asset. If, now, opinion dispersion rises in such a way as to make the optimist even more optimistic and the pessimist more pessimistic, there should be no associated increase in trade or market liquidity.[2] Still, if there are numerous agents, and the changes in agents' opinions are not perfectly aligned with current asset holdings, increased dispersion will facilitate trade.

Before turning to testing the ability of the models to explain liquidity of credit markets during financial crises, we begin by providing descriptive evidence on credit issuance dry-ups. We collect data on bond issuance during the period surrounding the 1873, 1929 and 2008-09 financial crises. The results show that in all three crises there is a substantial decline in bond issuance during and after the onset of the crisis. While the evidence is consistent with liquidity dry-ups and market freezes during downturns in the spirit of Myers and Majluf (1984) and Lucas and McDonald (1990), we cannot rule out that the reduction in issuances is driven by lack of corporate demand for credit stemming from a reduction in investment opportunities. Hence, in our main analysis we focus on liquidity in secondary markets – i.e., market liquidity – as opposed to liquidity in primary markets – i.e., funding liquidity.[3]

We begin by empirically testing the main prediction of the Dang, Gorton and Holmström model – namely that during financial crises bond illiquidity rises as bond value declines. To operationalize the empirical tests we use standard measures of bond illiquidity for the 1873 and 2008-09 crises. Specifically, we use bid-ask spreads as a measure for bond illiquidity during the 1873 crisis. For the 2008-09 financial crisis we use γ – the negative covariance of log-price changes in two consecutive periods – that has been proposed by Roll (1984) and has been recently used by Bao, Pan, and Wang (2011) as a measure of bond illiquidity.[4]

Using our hand-collected data from the 19th century as well as TRACE data for the 2007-2009 period, we provide graphical evidence that bond illiquidity rises when bond values deteriorates. For example, the correlation between bid-ask spreads and bond prices during the 1873-1876 period is -0.909. Likewise, the correlation between γ and bond prices during the 2007-2009 period is -0.858. Both correlations are statistically significant at the 1 percent level. We next test the prediction that bond illiquidity rises as bond price declines in financial crises more formally by estimating a regression model in which the dependent variable is

[2] In fact, the opposite may hold, as if forced to trade, the optimist will have to sell to the pessimistic agent.

[3] For a discussion of the relation between funding liquidity and market liquidity see Brunnermeier and Pedersen (2009).

[4] Our results also hold with alternative measures of illiquidity such as the one proposed in Amihud (2002).

bond illiquidity and the main explanatory variable is lagged bond price. Our results confirm the negative association between illiquidity and bond prices in both the 1873 and 2008-09 financial crises even after we control for bond and year-by-month fixed-effects. Our evidence confirms the fundamental prediction of the asymmetric-information theory of bond liquidity in Dang, Gorton, and Holmström (2012): bond illiquidity rises as bond price declines during financial crises.

We continue by analyzing the main prediction of the heterogeneous beliefs theory – i.e., that differences of opinion between economic agents should promote liquidity. Measuring differences of opinion is not trivial as this requires gauging the subjective beliefs of agents engaged in trade. We employ two proxies of differences of opinions in our analysis. The first proxy for differences opinion in debt markets is the absolute value of the difference between the credit rating of Moody's and S&P in notches.[5] Our second measure of opinion heterogeneity is analyst earnings forecast dispersion. Following the literature on analyst forecast dispersion (see, e.g., Diether, Malloy and Scherbina (2002)) we calculate for each bond-month in our sample, the ratio of its firm's standard deviation of analysts' current-fiscal-year annual earnings per share forecasts to the absolute value of the mean analyst forecast.

There are two important caveats to these proxies for opinion dispersion. First, even if the measures accurately capture differences of opinion regarding firm value amongst rating agencies and amongst equity analysts, these measures may not accurately reflect differences of opinion amongst the relevant market participants who are actually trading in the bond markets. Second, it could very well be that incentive structures, career concerns, institutional reputational concerns and the like are influencing earnings forecasts and credit ratings, implying that the actual beliefs of the analysts and rating agencies are different from those announced to the market. We employ these measures because of their availability, and while they have been used extensively in the literature, we proceed with the analysis with these caveats in mind.

First, we show that the difference of opinion measures rise substantially during the crisis. The S&P-Moody's credit rating difference, as well as analyst earnings forecast dispersion, spike up post Lehman collapse – both attaining a maximum in March 2009 – before declining. Taken together with the rise in illiquidity during the crisis described above, the fact that mean opinion dispersion *increased* post-Lehman serves as prima facie evidence against the main prediction of the heterogeneous beliefs prediction of a positive relation between opinion dispersion and liquidity. A simple means comparison analysis confirms the time-series

[5] A one-to-one correspondence exists in the rating system of the two credit rating agencies, and so this measure is well defined.

evidence. Sorting bonds into bins by their degree of bond rating difference results in a positive and monotonic relation between opinion dispersion and illiquidity. Similarly, sorting bonds by deciles of analyst earnings forecast dispersion uncovers a qualitatively similar result: higher dispersion is associated with increased illiquidity, with the effect being particularly pronounced in the top two deciles of analyst forecast dispersion.

More formally, we estimate a regression model relating bond illiquidity to differences of beliefs using our two measures of opinion dispersion. Regressions are run with year-by-month fixed effects – soaking up common time series variation – and bond fixed effects which control for non-time varying bond characteristics. The results show that the Moody's-S&P bond rating difference is positively related to bond illiquidity. Similarly, the opinion dispersion measure based on analyst forecast dispersion is also positively related to illiquidity, with the effect concentrated in high levels of forecast dispersion. In contrast to the heterogeneous beliefs theory, increased opinion dispersion does not seem, therefore, to contribute to increased liquidity.

We then run a "horse-race" between the Dang, Gorton, and Holmström asymmetric-information theory of bond liquidity and the heterogeneous beliefs theory. Estimating regression models relating bond liquidity to bond price as well as the two measures of opinion dispersion, we show that while the relation between illiquidity and price during the 2008-09 financial crisis remains negative and statistically significant, the relation between bond illiquidity and opinion dispersion is not statistically significant once bond price is added as a covariate.[6]

We continue by estimating the portion of the aggregate increase in bond illiquidity during the financial crisis that can be explained simply by the reduction in bond prices, i.e., by the main prediction of the Dang, Gorton, and Holmström asymmetric information theory of bond liquidity. Using the estimated coefficients from the regression of illiquidity on lagged bond price, and integrating over the full distribution of changes in bond price, we conclude that between a quarter and a third of the increase in bond illiquidity after the collapse of Lehman Brothers in September 2008 can be attributed solely to the concurrent reduction in bond prices.

To summarize, our empirical results are consistent with the information asymmetry theory of liquidity as in Dang, Gorton and Holmström (2012). When bond value deteriorates, bond

[6]The fact that the bond rating difference is no longer positively related to illiquidity once bond price is added as a covariate in the regression analysis likely stems from the fact that price and rating difference are negatively related: decreases in bond price are associated with increases in the Moody's-S&P rating difference. Thus, the positive relation between illiquidity and rating difference may simply be reflecting the negative relation between bond price and illiquidity combined with the negative relation between bond price and rating dispersion.

illiquidity increases, as would be predicted by adverse selection stemming from the bond entering a region in which its value is informationally sensitive. The negative relation between bond illiquidity and price explains a large fraction of the rise in illiquidity during the financial crisis, although a sizeable fraction remains unexplained.

In contrast, using two proxies for belief dispersion – the Moody's-S&P difference in bond rating and analyst forecast dispersion – we find little support for the hypothesis that liquidity is enhanced as differences of opinion rise. At the aggregate level, as well as using panel data analysis at the individual bond-level, opinion dispersion did not increase liquidity during the crisis period. If anything, the opposite seems to hold, with illiquidity and dispersion positively related, particularly when using the bond rating difference measure of belief dispersion.

Our results points to a strong link between crises and the dry-ups of market liquidity. We find that asset prices play a crucial role in determining liquidity in debt markets during financial crises. It is precisely when prices decline market-wide, that liquidity dries-up and issuance of new liabilities becomes difficult, reducing the supply of capital for firms already pushed into distress due to the crisis. Illiquidity in credit markets can have dire consequences for households as well. Precautionary savings in the form of fixed-income securities become hard to sell and households in need of liquid funds may find liquidity difficult to obtain precisely when they need it most.

These results have implications for the efficacy of monetary interventions meant to strengthen the economy during downturns through increased lending by the financial sector. In particular, the asymmetric information theory of liquidity suggests that if these interventions occur when borrower balance sheets are weak, liquidity will not easily flow from the financial sector into the economy. Weak borrower balance sheets will imply that issued liabilities will be informationally sensitive, limiting borrowers' ability to raise debt capital. Monetary interventions meant to inject liquidity from the financial sector into the real economy can thus arrive "too late". In contrast, monetary interventions that occur at an earlier stage – when balance sheets are still sufficiently strong that liabilities issued by borrowers are relatively informationally insensitive – will have a larger effect. As a corollary, if monetary interventions are rendered ineffective because they arrive too late in the cycle, the asymmetric information theory of liquidity suggests that fiscal policy may be effective in complementing monetary policy. In particular, strengthening borrower balance sheets directly through fiscal policy shifts corporate liabilities into a less informationally sensitive region in which monetary interventions meant to increase lending become effective.[7]

[7] For a model along these lines that relies on an endogenous collateral constraint – rather than on frictions driven by asymmetric information – see Benmelech and Bergman (2012).

The rest of the paper is organized as follows. Section 1 presents evidence on credit issuance freezes in three financial crises. Section 2 provides evidence on liquidity and informational sensitivity in financial crises. Section 3 evaluates the explanatory power of belief dispersion for liquidity in financial crises. Section 4 studies the explanatory power of bond prices in explaining illiquidity during the 2008-09 crisis. Section 5 concludes.

1 Funding Illiquidity During Financial Crises

We define credit market freezes as large declines in the volume of transactions in both primary and secondary credit markets that occur over a non-trivial period of time. This section provides descriptive evidence on credit market issuance freezes during the financial crises of 1873, 1929, and 2008-09.

1.1 Credit Issuance Freezes in Three Financial Crises

The most recent example of a credit market freeze took place during the financial crisis of 2008-09 with the collapse of the structured finance market – the largest and fastest growing credit market in the years leading to the crisis. Issuance of structured finance securities and especially collateralized debt obligations (CDO) grew dramatically between 2003 and 2006. While the year 2007 was on track to surpass the record numbers of 2006, the credit crisis that began in summer 2007 brought the market for structured finance to a halt.[8] The collapse of the securitzation market is well illustrated in Figure 1 which uses issuance data to illustrate the dramatic decline in issuance of non-agency mortgage securities from 2005 to 2010.[9] Not only did the market for Mortgage-Backed Securities such as RMBS and CDOs collapse, but also other, non-housing segments of the structured finance markets ranging from commercial loans securitizations (CLO) to asset-backed securities (ABS) came to a halt and even the issuance of corporate bonds declined significantly. Figure 2 demonstrates that issuance of non-mortgage asset-backed securities collapsed during the crisis and stayed at a low level in the following years. The decline in the volume of bond issuance was not confined only to securitized assets. Figure 3 shows that issuance of corporate bonds also declined considerably in 2008 and returned to its pre-crisis level only in 2010.

We now turn to another credit market freeze that took place during the financial crisis of 1873. The crisis of 1873 is one of the classic international crises according to Kindleberger (1990). It is also one of Sprague's (1910) four crises of the U.S. National Banking era that

[8] See Benmelech and Dlugosz (2010).

[9] The data used to construct Figures 1-3 were obtained from the Securities Industry and Financial Markets Association (SIFMA).

eventually led to the creation of the Federal Reserve in 1914. The 1873 crisis is traditionally viewed as a classic banking panic triggered by the failure of commercial banks linked to the railroad industry. In turn, the crisis heralded a six year recession according to the NBER business cycle reference dates. We collect information on issuance of bonds, mostly by railroad companies, for the years 1869-1874 from the Commercial and Financial Chronicle (CFC) – a weekly business publication that was first published in 1865 and reported detailed business news as well as detailed prices of bonds and stocks. Figure 4 displays the volume of corporate bonds issuance from 1869 to 1874. As Figure 4 demonstrates, bond issuances declined dramatically in 1873 and 1874 compared to their level in 1870 and 1871. While we do not have detailed information on bond issuance after 1874, contemporary observers of the 1873 financial crisis have argued that bond issuance collapsed during the financial crisis of 1873 and did not resume until 1879.

We provide additional evidence on credit issuance freezes from the financial crisis of 1929. The crisis began on October 1929 with a crash of the stock market that marked the beginning of the Great Depression. According to Mishkin (1991):

> *The outcome of the panic period starting October 23 and culminating in the crash on October 29 was a negative return for the month of October of close to 20%. This was the largest monthly negative return in the stock market up to that time.*[10]

Figure 5 plots the volume of corporate bond issuance of all industrial firms from 1920 to 1940 in millions of current dollars.[11] As Figure 5 demonstrates, issuance of bonds by industrial firms declined in 1929 and then fell dramatically in 1931. The corporate bond market remained frozen until 1935. Benmelech, Frydman and Papanikolaou (2017) use the collapse of the corporate bond market to identify the effects of funding shortage on firms' employment. They show that bonds were the primary source of debt financing for large firms in the 1920s and that the collapse of the bond market during the Great Depression led firms to layoff many of their employees. Figure 6 provides additional information on credit market freezes during the Great Depression. The figure presents data on issuance of real estate bonds from 1925 to 1934 in millions of current dollars.[12] According to Goetzmann and Newman (2010) total issuance of real estate bonds grew from $57.7 million in 1919 to $695.8 million in 1925. By 1928 new issues of real estate bonds surpassed railroad bond issuance and accounted for 23% of the total corporate bond issuance. As Figure 6 illustrates, and consistent with evidence in Figure 1 for the 2008-09 financial crisis, real estate bond issuance collapsed during the crisis with the market for these bonds all but disappearing.

[10] Mishkin (1991) p. 93.

[11] The data is based on Table 52 in Hickman (1960).

[12] The data is based on Johnson (1936a and 1936b).

Our results show that in all three crises there is a substantial decline in bond issuance during and after the onset of the crisis. The evidence is consistent with liquidity dry-ups and market freezes during downturns in the spirit of Myers and Majluf (1984) and Lucas and McDonald (1990). Still, we cannot rule out that the reduction in issuances is driven by a lack of corporate demand for credit stemming from a reduction in investment opportunities.

We next turn to provide suggestive evidence on credit market freezes in secondary markets in which market liquidity dries-up. Providing such evidence requires information on prices of bonds in secondary markets which we have collected for two notable financial crises: the 1873 financial crisis and the more recent 2008-09 crisis.

2 Liquidity and Informational Sensitivity

Liquidity is a notoriously ambiguous concept. By liquidity in secondary markets, we are referring to what is commonly known as "market liquidity" – i.e., the ease with which assets are traded (see, e.g., Brunnermeier and Pedersen (2009)). In our analysis we employ two measures of market liquidity common in the literature – γ and Bid-Ask spreads which we define below. In particular, we do not focus on volume of trade as a measure of liquidity, since exogenous variation in the demand for funds is likely to play an important role in determining agents' need to sell their asset holdings – particularly during financial crises – irrespective of the ease with which assets are traded. Put differently, trading volume may be high not because markets are liquid, but because investors require funding.

2.1 The Financial Crisis of 1873

We collect weekly information from the CFC on prices of corporate – mostly railroad – bonds from January 1873 up to the end of June 1876. The data include the name of the security, the issuing firm, and the bid and ask prices that prevailed for each security during the week. There are 69,444 bond-week observations in our dataset. The CFC reports bid or ask prices for 56,717 bond-week observations, and 12,727 bond-week observations do not have pricing information, suggesting that these bonds were not traded during the week in which the information is not reported. We begin our analysis by calculating an index of bid-ask spreads for bonds that have information on both bid and ask prices. We define the relative bid-ask spread for bond i in week w as:

$$Spread_{i,w} = \frac{Ask_{i,w} - Bid_{i,w}}{Mid\ price_{i,w}}, \tag{1}$$

where $Mid\,price_{i,w}$ is defined as $(Ask_{i,w} + Bid_{i,w})/2$. Next we calculate $Spread_t$ as an equal-weighed time-series average of $Spread_{i,w}$ across bonds and within a month t.

Figure 7 presents the monthly evolution of the bid-ask spread from January 1873 to June 1876. As the figure shows clearly, bid-ask spread increased from 0.052 in August 1873 to 0.060 in September 1873 when the crisis started and 0.063 in October 1873. As the financial crisis intensified with more failures of banks and railroad companies, the bid-ask spread reached 0.099 – almost twice as high as its level before the crisis. Figure 7 also displays the evolution of the mean bond mid-price using the data we have collected from the CFC. As Figure 7 shows, the decline in bond prices is associated with higher bid-ask spreads – indicating that the bond market became less liquid as bonds' prices declined. The correlation between the bid-ask spread and mean bond price is -0.909 and is statistically significant at the 1 percent level.

We argue that the evidence from the 1873 financial crisis is consistent with Dang, Gorton and Holmström model of the effect of the information-sensitivity of debt on liquidity and liquidity dry-ups in debt markets. The main prediction of the model is that that when underlying values deteriorates, debt shifts from being informationally insensitive and becomes informational sensitive, adverse selection problems rise, and liquidity drops. We now turn to conduct similar analysis of the relation between bond prices and market liquidity during the financial crisis of 2008-09.

2.2 The Financial Crisis of 2008-09

We use bond-pricing data from FINRA's TRACE (Transaction Reporting and Compliance Engine). Our initial sample is similar to the one we use in Benmelech and Bergman (2017) and includes all corporate bonds traded in TRACE. We keep bonds with a time-to-maturity of at least six months and standard coupon intervals (including zero-coupon bonds). Our sample is comprised of 'plain-vanilla' corporate bonds – we do not include securitized assets in the sample and exclude bonds that are issued by financial firms, as well as convertible, putable, and fixed-price callable bonds.

As a measure of illiquidity we use, γ, which is defined as the negative covariance of log-price changes in two consecutive periods:[13]

$$\gamma = -Cov(\Delta p_t, \Delta p_{t-1}). \tag{2}$$

[13] See Bao, Pan, and Wang (2011) and Benmelech and Bergman (2017) for details about the intuition and the construction of the γ measure.

Figure 8 presents the evolution of the γ measure of illiquidity over time from January 2006 to December 2010 as well as an index of bond prices that is constructed based on actual bond transactions from TRACE. As the figure demonstrates, and consistent with our findings for the financial crisis of 1873, bond prices and bond illiquidity are negatively correlated. Figure 8 illustrates very clearly the spike in bond illiquidity that coincides exactly with the dramatic decline in corporate bond prices: γ increases from 0.680 in January 2007 to 3.434 in September 2008 the month in which Lehman Brothers filed for bankruptcy and to 7.312 in October 2008. The correlation between γ and bond prices during the 2007-2009 period is -0.858 and is statistically significant at the 1 percent level. Consistent with our findings for the 1873 crisis, we find support for Dang, Gorton and Holmström (2013) that when underlying values deteriorates liquidity drops.

Figure 9 refines the analysis in Figure 8 by stratifying the time-series evolution of the γ by credit rating. For the ease of graphical representation we classify bonds into four categories of bond credit ratings where Rating Category 1 includes the highest quality bonds and Category 4 includes the lowest credit quality bonds. As Figure 9 clearly demonstrates, and consistent with Dang, Gorton and Holmström (2012), lower credit rating bonds exhibits higher levels of illiquidity.[14] Moreover, lower quality bonds – especially those in categories 3 and 4 – become particularly illiquid during the height of the financial crisis of 2008-09.

2.3 Regression Analysis of Bond Prices and Liquidity During Financial Crises

Our graphical evidence for the financial crisis of 1873 and 2008-09 suggests that bond prices and bond liquidity are negatively correlated during financial crises. We next test the prediction that bond illiquidity rises as bond price declines in financial crises more formally by estimating the following baseline specification:

$$Illiquidity_{i,t} = \beta_0 + \beta_1 \times Price_{i,t-1} + \mathbf{b}_i\theta + \mathbf{c}_t\delta + \epsilon_{i,t}, \tag{3}$$

where *Illiquidity* is either γ for the 2007-2009 period or the normalized bid-ask spread $Spread_{i,t}$ for the 1873-1876 period, subscripts indicate bond (i) and either month (for 2007-2009) or week (for 1873-1876) (t), $Price_{i,t-1}$ is bond price, δ_t is a vector of either year or year×month fixed effects, θ_i is a vector of bond fixed effects – and $\epsilon_{i,t}$ is the regression residual. We report the results from estimating variants of regression 3 in Table 1. Tables throughout this paper report regression coefficients and standard errors clustered at the bond level (in

[14] Benmelech and Bergman (2017) provide in-depth analysis of the relation between credit rating and bond liquidity.

parentheses). The main explanatory variable in the table is lagged bond price. Columns 1-2 report results for the 2007-2009 period while Columns 3-4 report results for the 1873-1876 period.

The results reported in Column 1 are based on regression 3, which is estimated with year and bond fixed effects. There is a negative association between illiquidity and bond prices, suggesting that bonds with lower prices are more illiquid (high γ). We obtain very similar results when we include year$\times$month – instead of just year – and bond fixed effects (Column 2). The association between γ and bond price remains negative and significant at the 1% level when we control for bond fixed effects. Likewise, Column 3 shows that bid-ask spreads are negatively correlated with bond prices during the 1873-1876 period after controlling for bond and year fixed-effects. Column 4 repeats the analysis presented in Column 3 and adds year$\times$month fixed-effects. The results are statistically significant at the 1 percent level, suggesting that bonds that experienced lower prices during the 1873 financial crisis also became less liquid. An important concern regarding the negative relation between bond illiquidity and bond price is one of reverse causality. Rather than declines in bond values causing illiquidity to rise, it could be that bond prices are declining due to an expected (future) reduction in bond liquidity. In Benmelech and Bergman (2017) we conduct detailed analysis to address this endogeneity concern, using instrumental variables and non-linearities around the default boundary.

3 Liquidity and Belief Dispersion During the Financial Crisis

A large literature discusses how heterogeneous beliefs can promote trade and liquidity in financial markets (see, e.g., Harrison and Kreps (1978), Varian (1989), and Harris and Raviv, (1993)). This literature provides an alternative theory to trade than that provided by classic asymmetric information and adverse selection theories (Akerlof (1970) and Spence (1973)). By assuming that agents hold different fundamental opinions about underlying asset values – some agents are optimistic while others are pessimistic – the literature on heterogeneous beliefs evades the classic no-trade results in the information economics literature (e.g. Rubinstein (1975), Hakansson et al. (1982), and Milgrom and Stokey (1982)). Agents engage in trade for their own perceived mutual benefit. In this section we analyze the relation between differences of opinion and liquidity in the bond market.

Measuring heterogeneous beliefs among market participants is clearly challenging. To test the heterogeneous beliefs theory we use two imperfect measures to proxy for differences of opinion in market participants' assessment of the future value of bonds during the financial crisis. The first measure is the difference between the S&P and Moody's bond credit rating, and is defined as:

$$Rating\ difference_{i,t} = \Big| S\&P_{i,t} - Moody's_{i,t} \Big|.$$

Since there is a direct correspondence between the Moody's and S&P rating systems, we simply calculate for each bond and month the (absolute value) notch difference between the Moody's credit rating and the S&P credit rating. Credit rating data are taken from Mergent FISD.

The second measure of differences of opinion employed in our analysis is analyst earnings forecast dispersion. To calculate this dispersion, we match each bond issue to the relevant firm's equity using the 6-digit CUSIP. For each month, following Diether, Malloy and Scherbina (2002), we then calculate the ratio of the standard deviation of analysts' current-fiscal-year annual earnings per share forecasts to the absolute value of the mean forecast.[15] This analyst earnings forecast dispersion measure proxies for differences of opinion regarding firm equity, and so is expected to be a better measure of differences of opinion on bond values the lower is the bond rating.[16]

$$Forecast\ dispersion_{i,t} = \frac{\sigma(EPS\ forecast_{i,j,t})}{\Big| Mean(EPS\ forecast_{i,j,t}) \Big|},$$

where i indicates stock, j indicates analyst, and t indicates month. EPS forecast is the analyst' forecast at each month for current fiscal year annual earning per share.

3.1 Liquidity and Belief Dispersion: Descriptive Evidence

Table 2 provides summary statistics on the distribution of the Moody's-S&P bond rating difference over the sample period, 2007-2010. As can be seen, just over 50% of observations exhibit no rating difference. Over a third of bonds exhibit a rating difference of one notch, approximately nine percent of bond-months exhibit a rating difference of two notches, and two percent of the sample exhibits a difference of three notches or more. Table 3 provides the distribution of analyst earnings forecast dispersion. As can be seen, the median ratio of earnings forecast dispersion – i.e. the ratio of standard deviation to mean analyst forecasts – is 0.03, with a 75th percentile of 0.084.

[15] Data on earnings forecasts are taken from I/B/E/S.

[16] For example, consider a firm that has issued a very safe bond trading with a low spread to the maturity-matched Treasury. Even if there exist large differences of opinion regarding firm earnings, these should not be expected to translate into differences of opinion regarding the firm's bond value, which all market participants may agree is very safe, regardless of their position on the firm's equity value.

Figures 10 and 11 protray the evolution of dispersion of opinion over the crisis using the two differences of opinion variables. As can be seen in Figure 10, analyst earnings forecast dispersion increased greatly following the collapse of Lehman Brothers, with median forecast dispersion more than doubling from 0.024 in September 2008 to its peak of 0.077 in March 2009. The figure clearly shows that earnings forecast dispersion is seasonal, with a yearly frequency. This seasonality arises due to the fact that dispersion is calculated each month with respect to the (fiscal) year end earnings forecasts. This dispersion will naturally decline towards the latter part of the year, as the time until the earnings report shortens. The fact that the dispersion measure is calculated with respect to the end of year forecast also explains why the large rise in the measure occurs not immediately after Lehman's collapse in September 2008, but rather early in 2009.

Figure 11 depicts the evolution of the Moody's-S&P bond rating difference over the crisis. Here we see a spike in the bond rating difference at the end of 2007, and another larger spike post-Lehman (with a lag as bond ratings take time to adjust). The Moody's-S&P rating difference rises from a mean value of 0.54 in September 2008, to a peak of 0.78 in March 2009.[17] Bond rating differences decline by August 2009 and remain relatively constant thereafter, but at a level higher than that of early 2007. Indeed, in January 2010, the mean credit rating difference is 0.67.

Figures 10 and 11 also present the evolution of monthly (par-value-weighted) mean bond illiquidity, as proxied by the γ illiquidity measure. As discussed above, illiquidity sharply rose during the crisis. We note that the concurrent rise of illiquidity and rise of our proxies for differences of opinions during the crisis provides prima facie evidence against the hypothesis that heterogeneous beliefs promote liquidity.

3.2 An Empirical Analysis of the Relation between Liquidity and Belief Dispersion

Figure 12 displays average illiquidity calculated over different levels of Moody's-S&P credit rating difference, while Figure 13 depicts average bond illiquidity over the 10 deciles of (lagged) analyst forecast dispersion.[18] Illiquidity in both figures, and throughout the analysis below, is measured by γ. Consistent with the co-movement of illiquidity and opinion dispersion depicted in Figures 10 and 11, Figure 12 shows that illiquidity rises with credit

[17] It is interesting to note that the two measures of opinion dispersion, calculated from two different markets (equity and debt) and two differing sets of market participants (rating agencies and equity analysts), attain their maximum value during the crisis in the same month – March 2009. The time-series correlation between the mean forecast dispersion and the mean rating difference is 0.47.

[18] Recall that only approximately 1% of the sample has a bond rating of 4 or more.

rating dispersion and particularly so for bond rating differences of three notches or more. Similarly, Figure 13 shows that illiquidity rises with higher analyst forecast dispersion. Similar to Figure 12, the increase in illiquidity is most pronounced for the top two deciles of forecast dispersion.

Moving to regression analysis, Table 4 regresses γ on indicator variables defined over the Moody's-S&P bond rating differences.[19] Importantly, the regression is run with bond and year-by-month fixed effects to absorb non-time varying bond determinants of illiquidity, as well as market-wide variation in illiquidity during the crisis. Identification is thus obtained by comparing the illiquidity of two bonds with different measures of the Moody's-S&P spread in the same month and year (as compared to each bond's mean illiquidity).

As can be seen in Table 4, increased credit rating differences between Moody's and S&P is associated with higher bond illiquidity. Difference of opinion, as captured by bond rating divergence, does not seem to promote liquidity, as would be predicted by the heterogeneous beliefs literature. The economic effect is substantial: Controlling for year and month-by-bond fixed effects, as compared to bonds with no disagreement between Moody's and S&P rating, bonds where the respective ratings differ by three notches exhibit a γ illiquidity measure that is higher by 1.26 units, representing approximately 70% of the mean during the crisis. Bonds with a four notch divergence in ratings exhibit a γ illiquidity measure that is higher by 3.03 units, or 165% of mean γ.

Table 5 runs the analogous regression using indicator variables defined over the quintiles of analyst forecast dispersion. As can be seen, the relation between analyst forecast dispersion and bond illiquidity is generally weak, but the highest quintile of forecast dispersion exhibits substantially larger illiquidity than the lowest quintile of earnings forecast dispersion: with bond and year-by-month fixed effects, the difference between the two quintiles is 0.318, or approximately 250% of the mean level of illiquidity.

Although the positive relation between analyst forecast dispersion and bond illiquidity is not supportive of the heterogeneous beliefs theory, we cannot rule out that endogeneity, and in particular omitted variables, are biasing our results. Indeed, one potential explanation for the positive relation between belief dispersion and illiquidity is that dispersion in beliefs increase when underlying bond values deteriorate. Such a negative relation between belief dispersion and bond price would occur if, for example, heterogeneous beliefs are more likely to arise when bonds become riskier.[20] The positive relation between bond illiquidity and higher bond opinion dispersion in Tables 4 and 5 may then simply be reflecting the negative

[19] The omitted variable in the regression is a Moody's-S&P credit rating difference of zero.

[20] Thus, one might expect lower belief dispersion regarding the default probability of a AAA rated bond than for a BB rated corporate bond.

relation between bond price and illiquidity combined with the negative relation between bond price and rating dispersion.

Figures 14 and 15 provide initial evidence on the relation between bond risk and opinion dispersion, showing the evolution of the two measures of opinion dispersion during the crisis calculated over four categories of bond credit ratings.[21] Figure 15, which depicts the evolution of average bond rating differences by bond credit rating groups, sorts the bonds based on the higher between the Moody's and S&P credit rating. The figures depict the monthly par-value weighted average opinion dispersion measure. As can be seen, lower rated bonds (rating category 4) exhibit the sharpest rise in opinion dispersion during the crisis. In addition, Figure 15 shows a substantial increase in the rating dispersion for the highest credit rating. This is a result of Moody's, but not S&P, downgrading Aaa rated bonds.

To further understand the relation between bond prices and opinion dispersion, Table 6 regresses the change in opinion dispersion – either Moody's-S&P credit rating difference or analyst forecast dispersion – on the change in bond price. As can be seen, difference of opinion, as proxied by bond rating differences, rise when bond price declines, although the effect is not economically large: a one standard deviation decline in bond price increases bond rating dispersion by approximately 2.5 percent of the mean rating dispersion (Column 1). However, calculating the effect over bond-month observations where the γ illiquidity measure is not missing – i.e. the sample over which the relation between illiquidity, bond price, and opinion dispersion is analyzed – triples this economic magnitude, to approximately 7.5 percent of the mean rating difference. The last two columns of Table 6 analyze the relation between analyst forecast dispersion and bond price, showing that it is not statistically significant.

3.3 Asymmetric Informational and Belief Dispersion: A Horse Race

Table 7 conducts a "horserace" between the two theories of bond illiquidity: the asymmetric information theory which predicts that illiquidity should decline with bond price and the heterogeneous beliefs theory, which predicts that differences of opinion promote liquidity. Specifically, the specifications in the table relate the γ measure of bond illiquidity to price as well as to indicator variables defined over the different levels of bond rating difference. As usual, all regressions are run with bond and year-by-month fixed effects. As can be seen in Table 7, illiquidity as measured by γ is still negatively related to bond price – consistent with the asymmetric information theory of liquidity of debt (as in Dang, Gorton and Holmström (2012)) and the results above. However, as the second column of the table shows, bond rating

[21] Rating Category 1 includes the highest quality bonds.

dispersion is no longer related to illiquidity in a statistically significant manner once bond price and bond-by-year fixed effects are included.

In a similar manner, Table 8 regresses the γ illiquidity measure on both bond price and analyst forecast dispersion. As in Table 7, bond price is still negatively related to bond illiquidity, but differences of opinion, as proxied by analyst forecast dispersion, is not related to γ in a statistically significant manner.

In sum, our results are consistent with the information asymmetry theory of liquidity as in Dang, Gorton and Holmström (2012). In contrast, using two proxies for belief dispersion – the Moody's-S&P difference in bond rating and analyst forecast dispersion – we find little support for the hypothesis that liquidity is enhanced as differences of opinion rise. At the aggregate level, as well as using panel data analysis at the individual bond-level, opinion dispersion did not increase liquidity during the crisis period. If anything, the opposite seems to hold, with illiquidity and dispersion positively related, particularly when using the bond rating difference measure of belief dispersion. However, once we control for bond price movements, belief dispersion is not related in a statistically significant manner to the γ measure of bond-market illiquidity.

4 To What Extent Can Bond Price Variation Explain the Rise in Illiquidity During the 2008-09 Crisis?

We have shown that deteriorations in bond value are associated with rises in bond illiquidity, consistent with the main prediction of the asymmetric information theory of liquidity in debt markets. To what extent can this relation, combined with the market-wide deterioration in bond prices post-Lehman collapse, explain the rise in bond market illiquidity during the crisis?

To fix ideas, Figure 16 and 17 depict the cumulative distribution function and probability density function of bond prices for August and October 2008, as well as January 2009. The figures show the large changes in the distribution of bond prices – with a sharp leftward movement of mass in the distribution of bond prices in October 2008, i.e. post Lehman – which is partially reversed by January, 2009.

To understand the role of bond price deterioration in explaining the behavior of bond-market liquidity during the crisis, we first regress bond illiquidity (proxied by γ) on twenty indicator variables defined over twenty equal-sized bins of lagged bond price, running the following specification:

$$Illiquidity_{i,t} = \beta_0 + \sum_{k=1}^{20} \beta_k \times PriceBin^k_{i,t-1} + \mathbf{b}_i\gamma + \mathbf{c}_t\delta + \epsilon_{i,t}, \tag{4}$$

where *Illiquidity* is γ, for bond i in month t. *PriceBin* is a set of twenty indicator variables based on (within-year) twenty equal sized bins of bond price – $PriceBin^k_{i,t-1}$ equals one if bond i is in price bin k at month $t-1$.[22] b_i is a vector of bond fixed-effects, and c_t is a vector of either year or year×month fixed-effects.[23] Standard errors are clustered at the bond level.

Using the regression coefficients, we calculate for each bond in each month in our sample the predicted illiquidity of that bond based on the bond's price. We calculate the market-level predicted illiquidity by calculating the par-value weighted average across all bonds. Figure 18 presents for each month t the change in predicted (weighted-average) bond-market illiquidity from January 2007 to month t, together with the actual change in the weighted average bond-market illiquidity. The figure uses a regression specification which does not include bond fixed effects. Figure 19 displays the analogous predicted change in bond-market illiquidity but uses the regression specification which includes bond fixed effects.

As can be seen, predicted and actual changes in illiquidity track each other closely up to late 2007 (i.e. pre-crisis) and from the first quarter of 2010 and on. In the interim period, the increase in actual illiquidity is higher than the predicted increase stemming solely from the decline in bond prices. Still, the leftward shift in the distribution of bond prices, in and of itself, can explain between a quarter and a third of the increase of the rise in actual bond market illiquidity during the crisis.

5 Conclusion

This paper analyzes illiquidity in bond markets during financial crises and compares two main theories of liquidity in markets: (1) asymmetric information and adverse selection, and (2) heterogenous beliefs. We find that when bond value deteriorates, bond illiquidity increases, consistent with an adverse selection model of the information sensitivity of debt contracts as in Dang, Gorton and Holmström (2012, 2013) and Holmström (2015). In contrast, we find little support for the hypothesis that opinion dispersion explains illiquidity in financial crises. Our results point to a strong link between crises and the dry-ups of market liquidity and have implications for the efficacy of monetary interventions that are designed to boost lending by the financial sector.

[22]The first price bin represents bonds with the lowest price.

[23]Note that with the inclusion of bond fixed effects, the regression is identified off of changes over time in the level of illiquidity and bond price for each bond.

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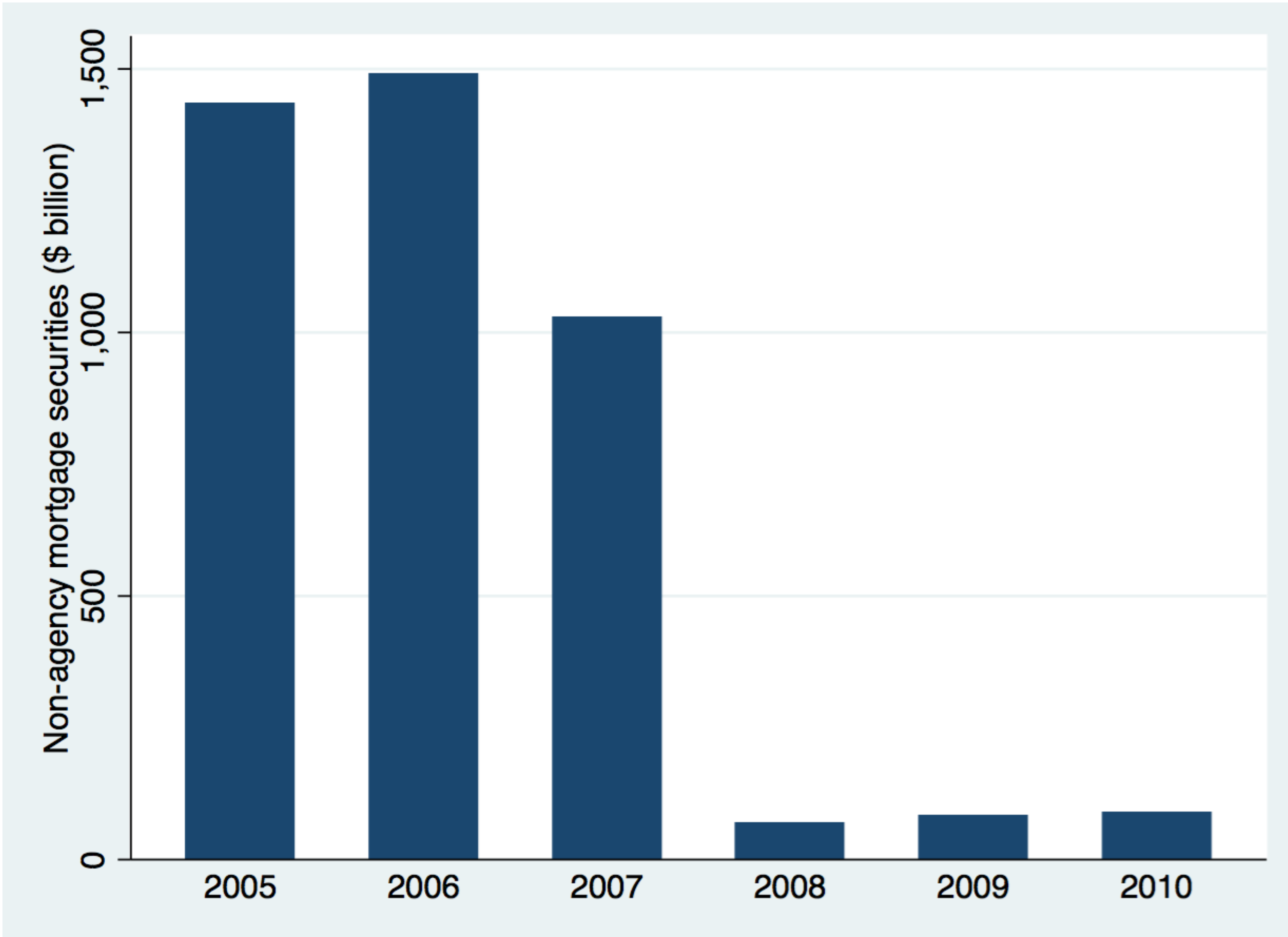

Figure 1: Non-agency mortgage securities issuance: 2005-2010.

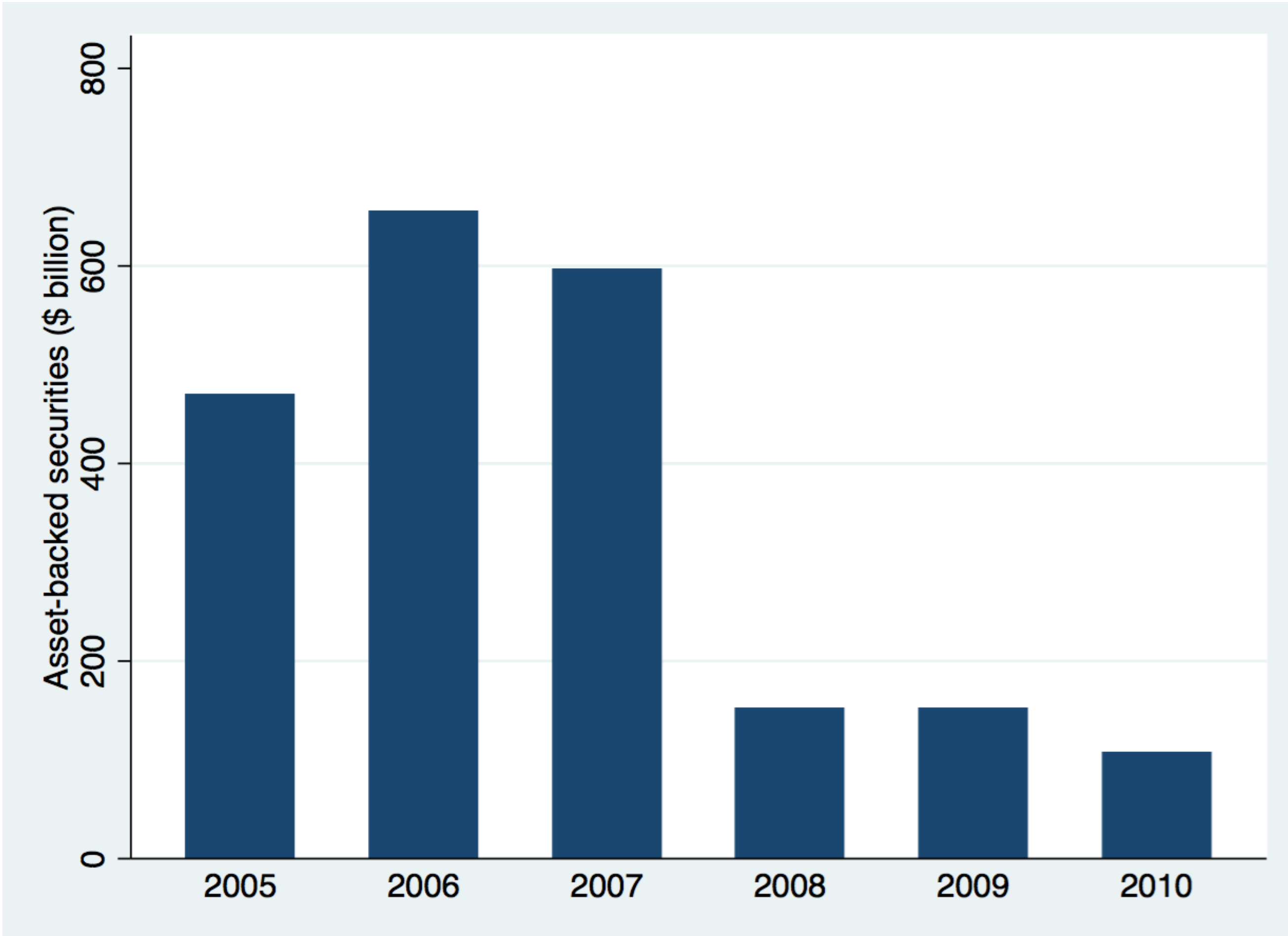

Figure 2: Asset-backed securities issuance: 2005-2010.

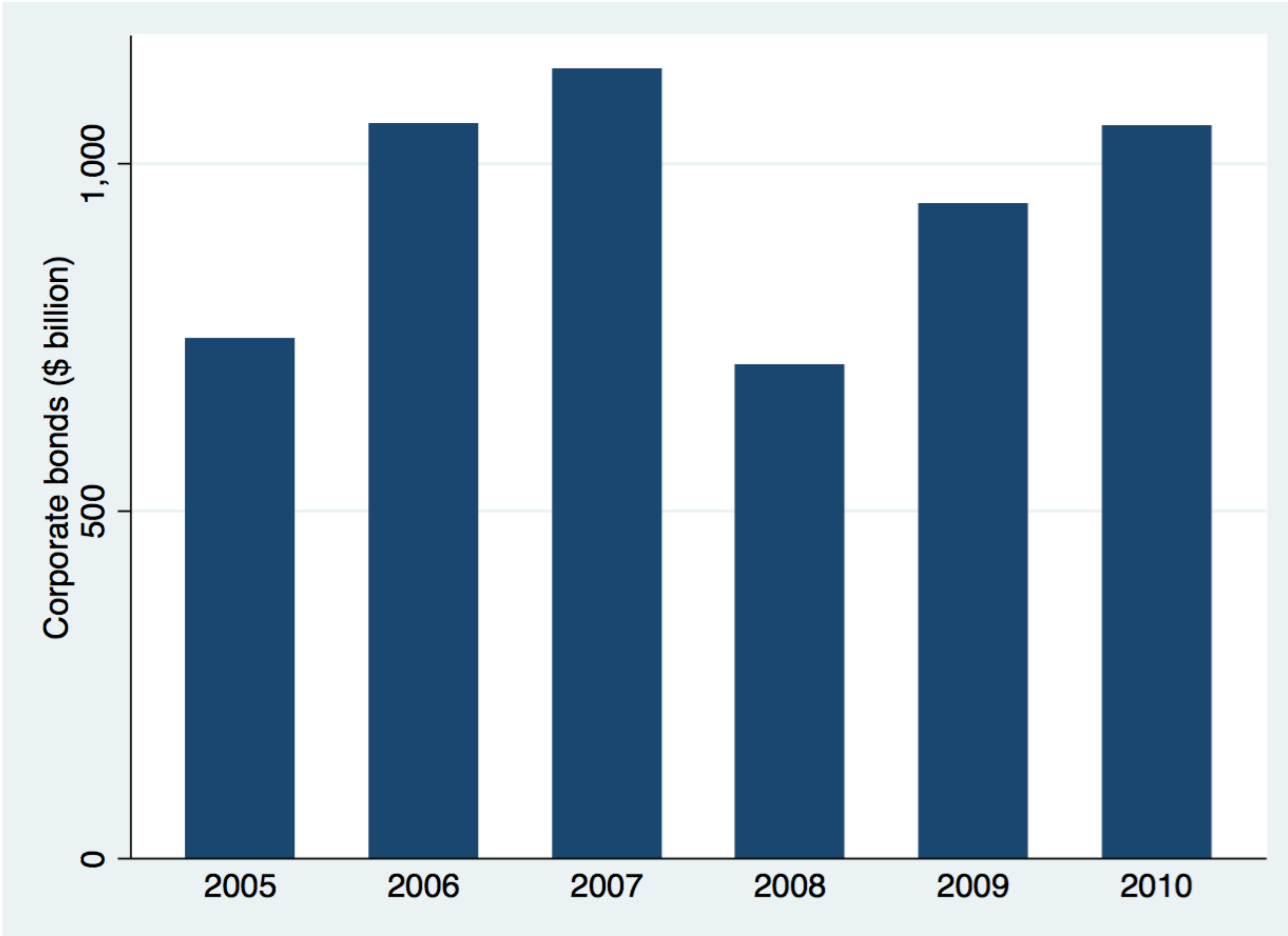

Figure 3: Corporate bonds issuance: 2005-2010.

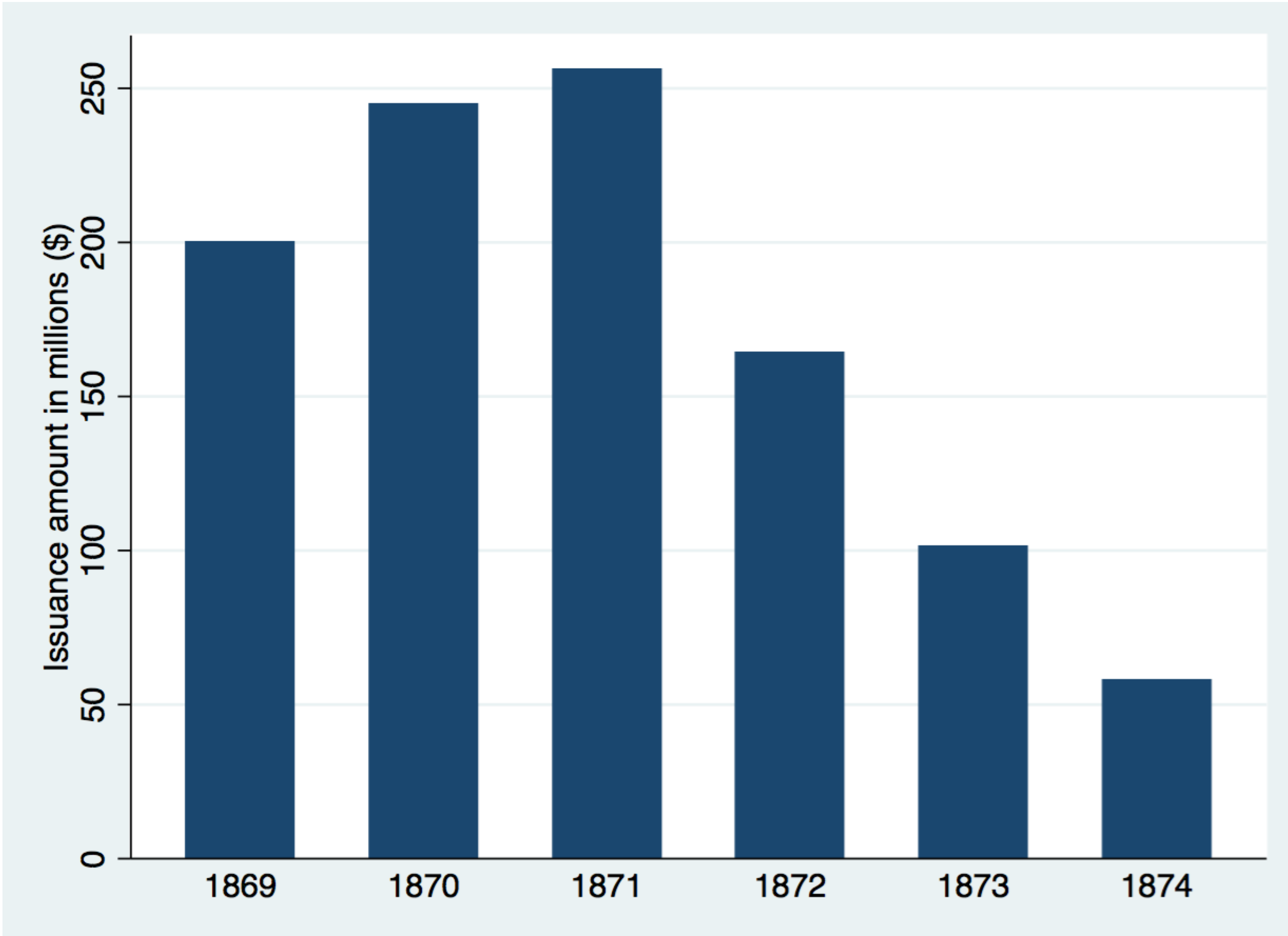

Figure 4: Corporate bonds issuance: 1869-1874.

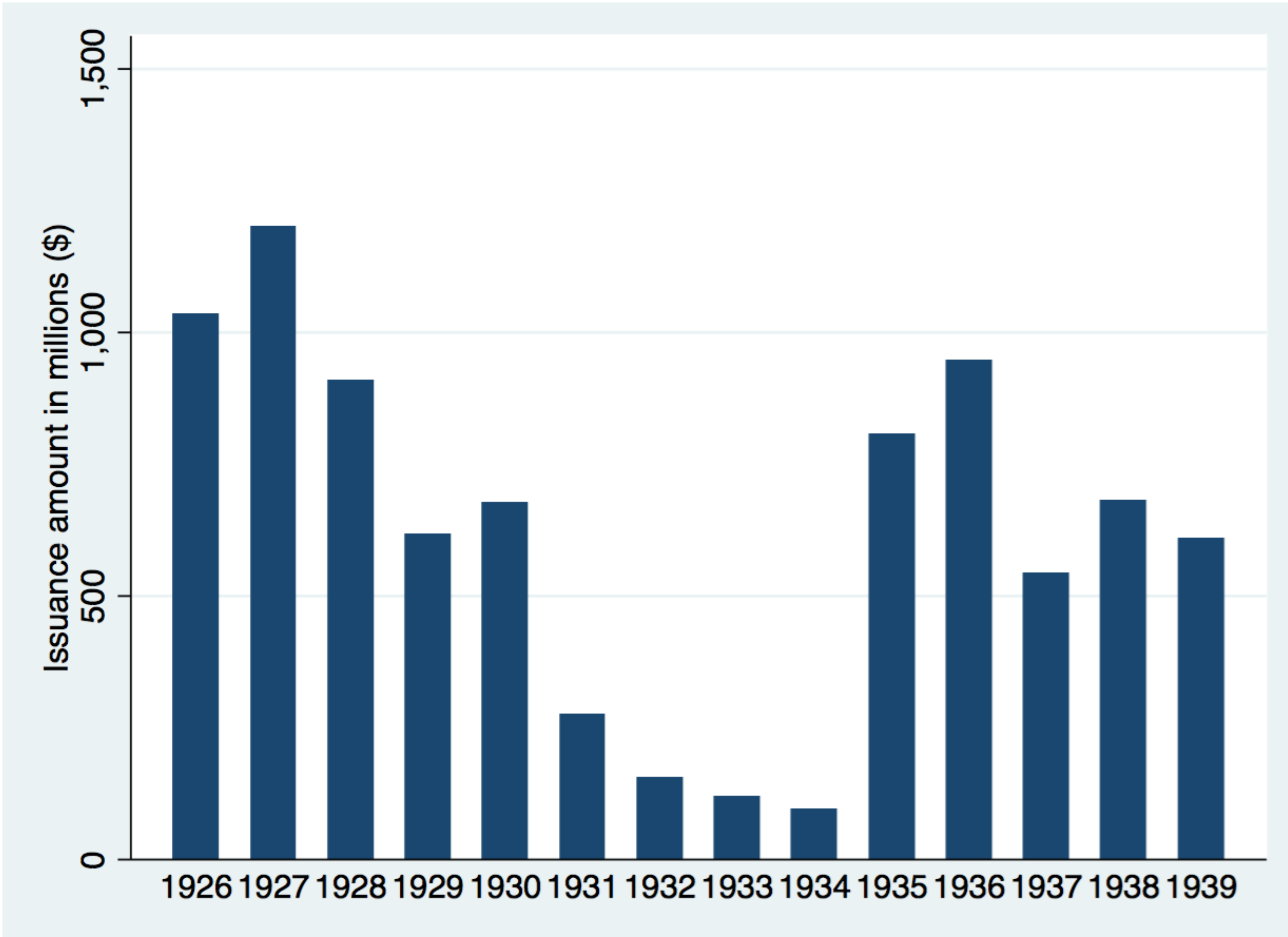

Figure 5: Industrial bonds issuance: 1926-1939.

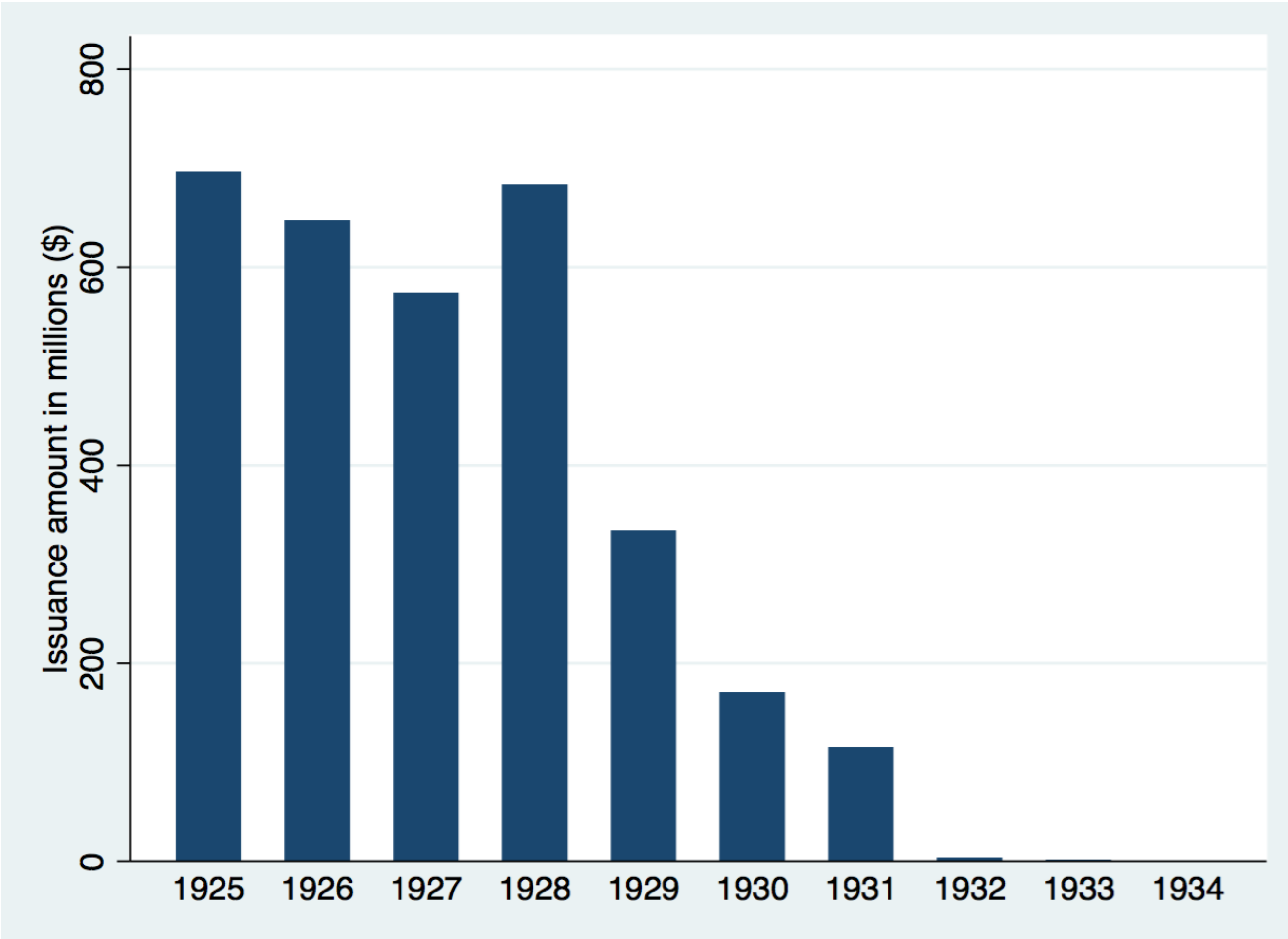

Figure 6: Real estate bonds issuance: 1925-1939.

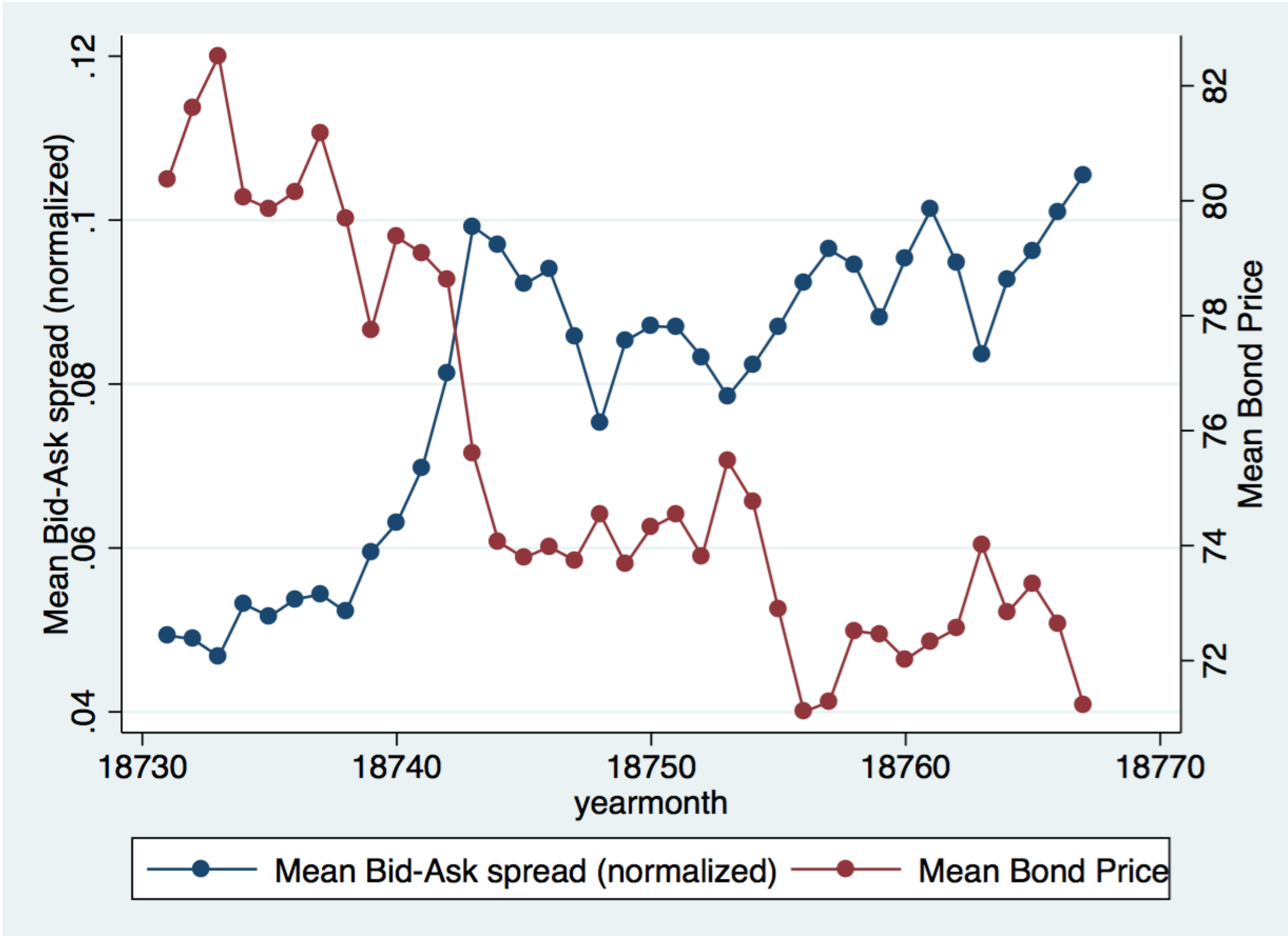

Figure 7: Bid-ask spreads and bond prices: 1873-1876.

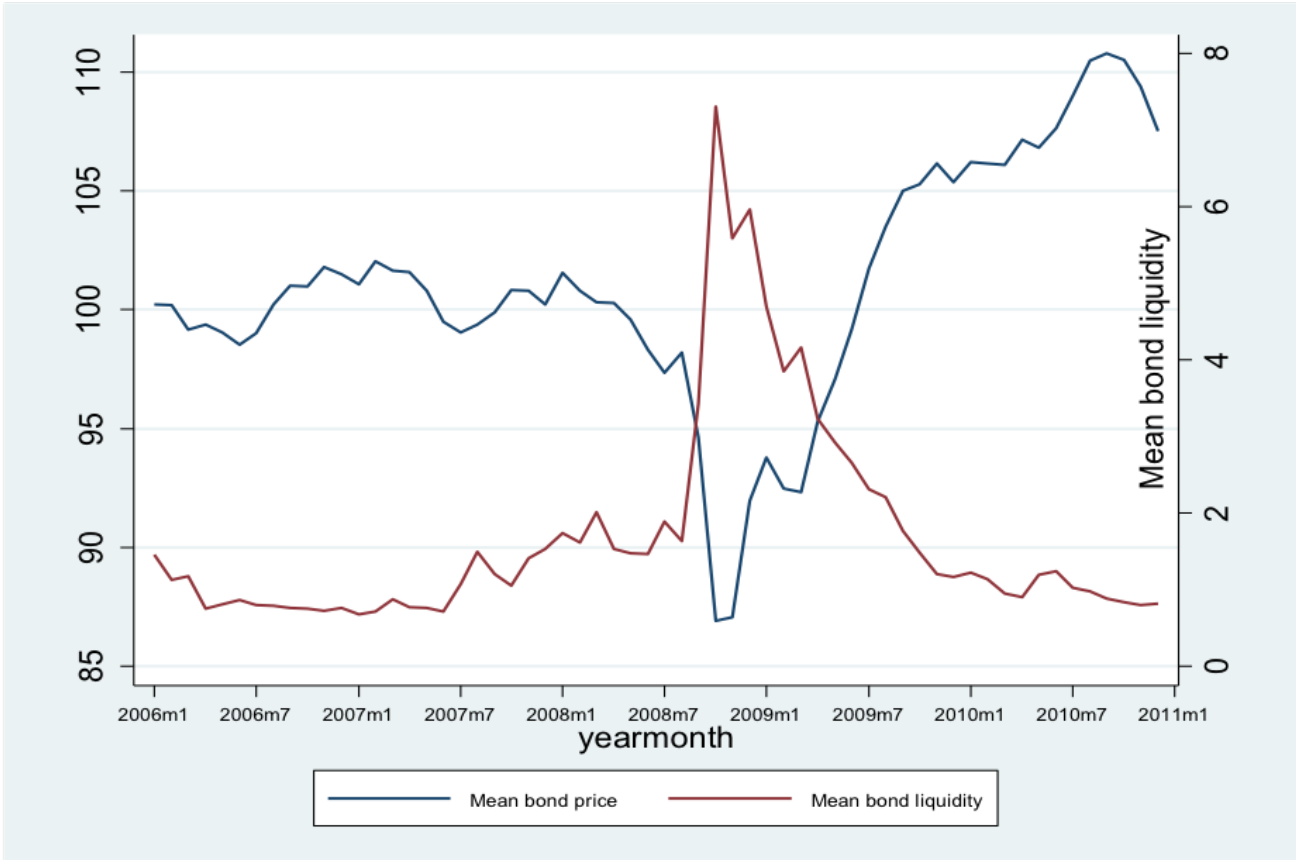

Figure 8: Illiquidity and bond price: 2007-2009.

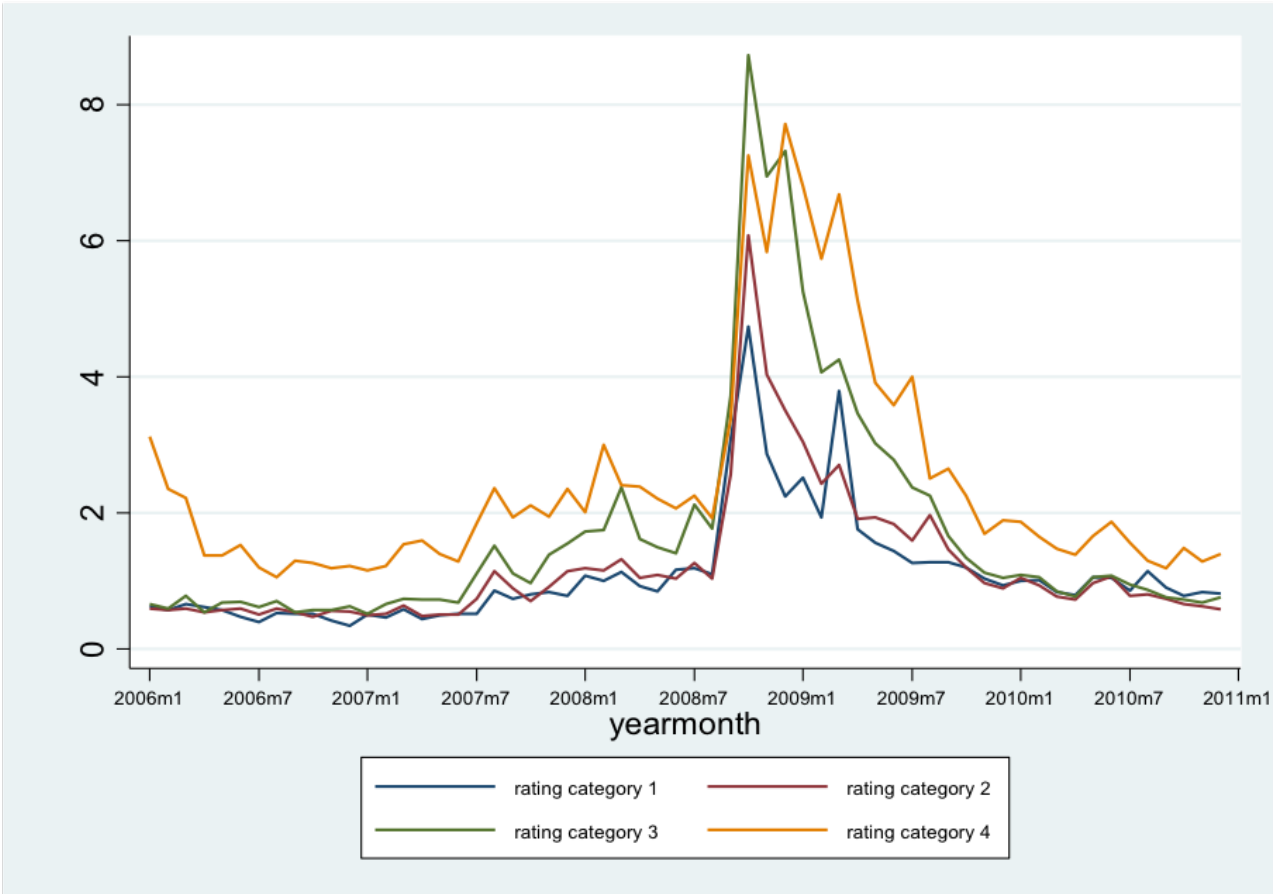

Figure 9: Average illiquidity by credit rating: 2007-2009.

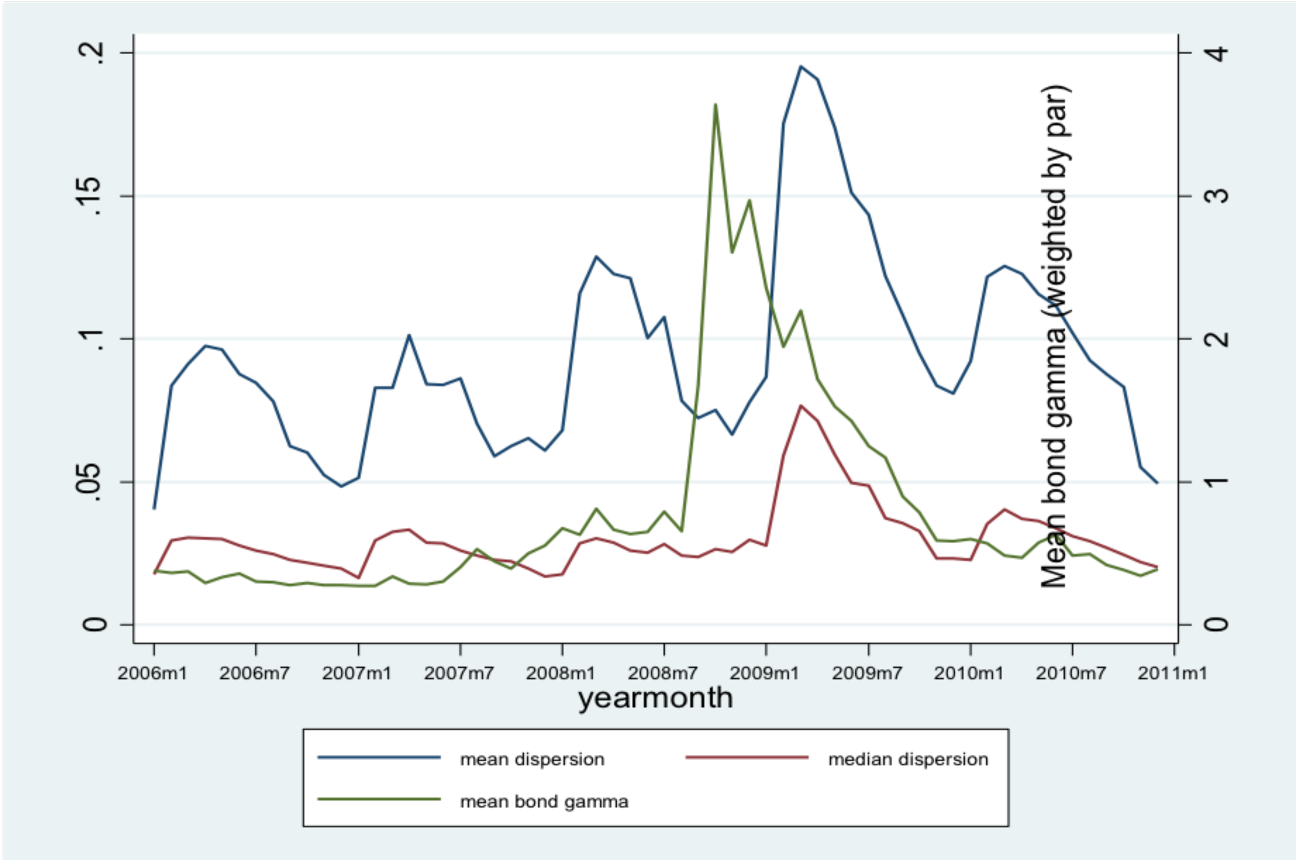

Figure 10: Mean and median analyst forecast dispersion and bond illiquidity: 2007-2009.

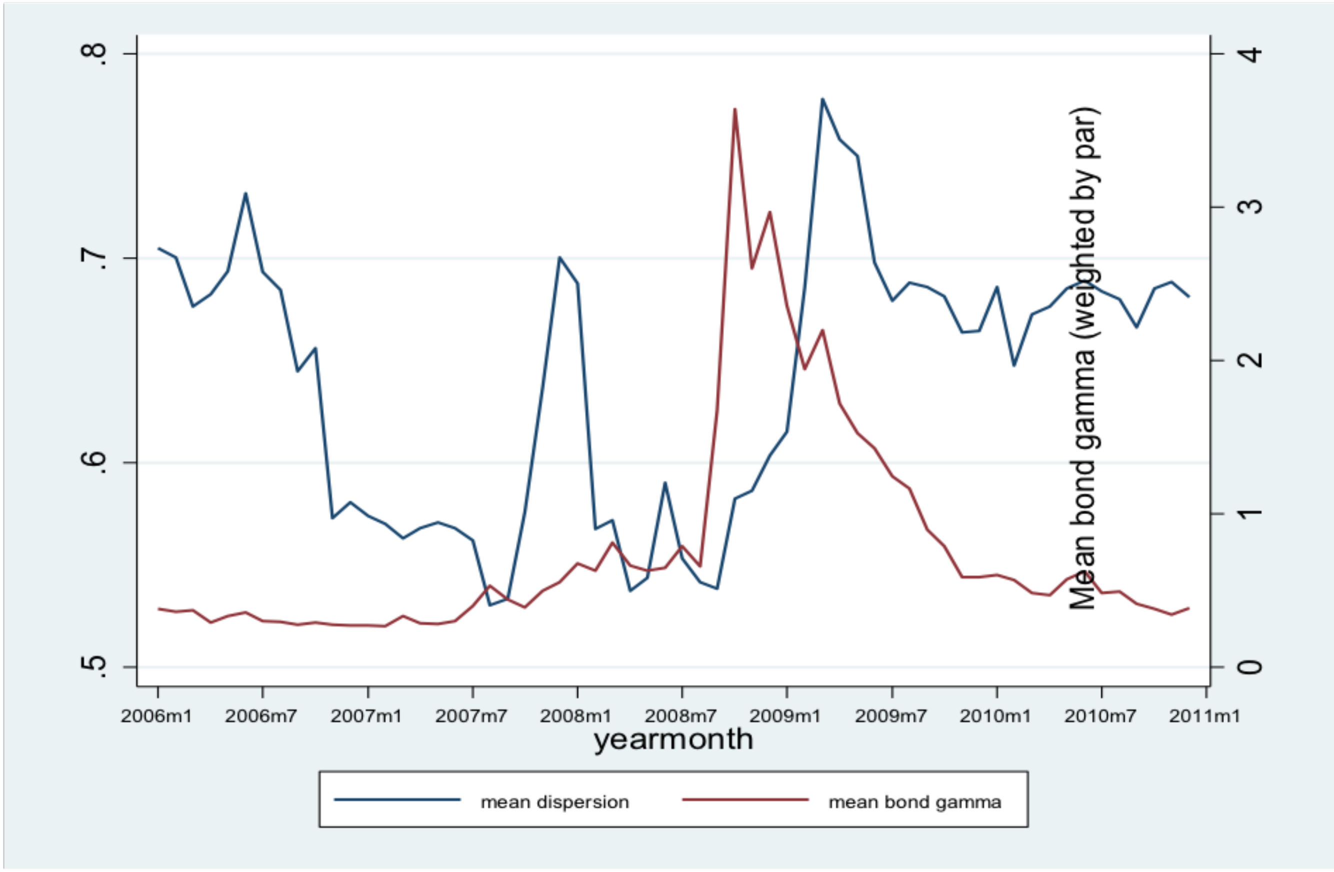

Figure 11: Mean rating dispersion and bond illiquidity: 2007-2009.

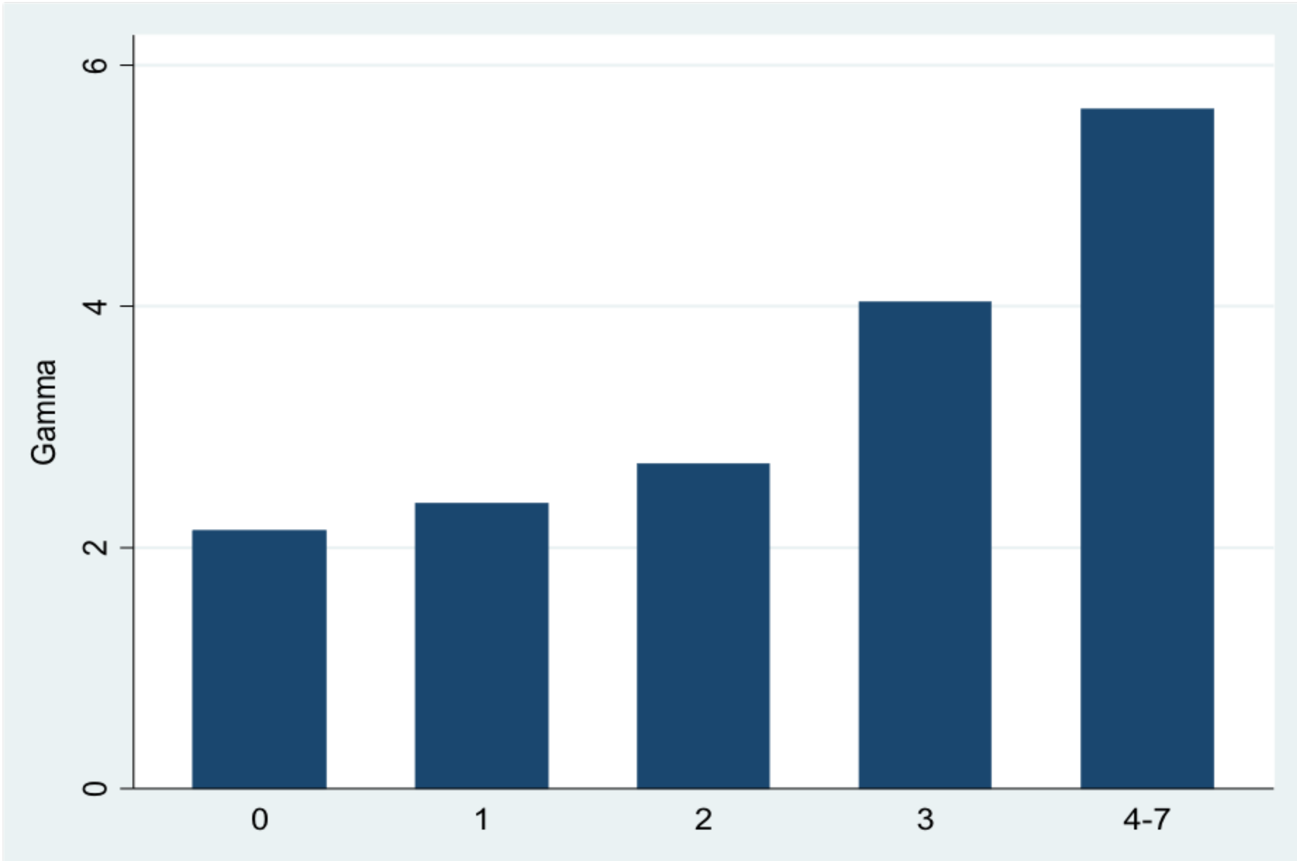

Figure 12: Average illiquidity by lagged bond rating difference: 2007-2009.

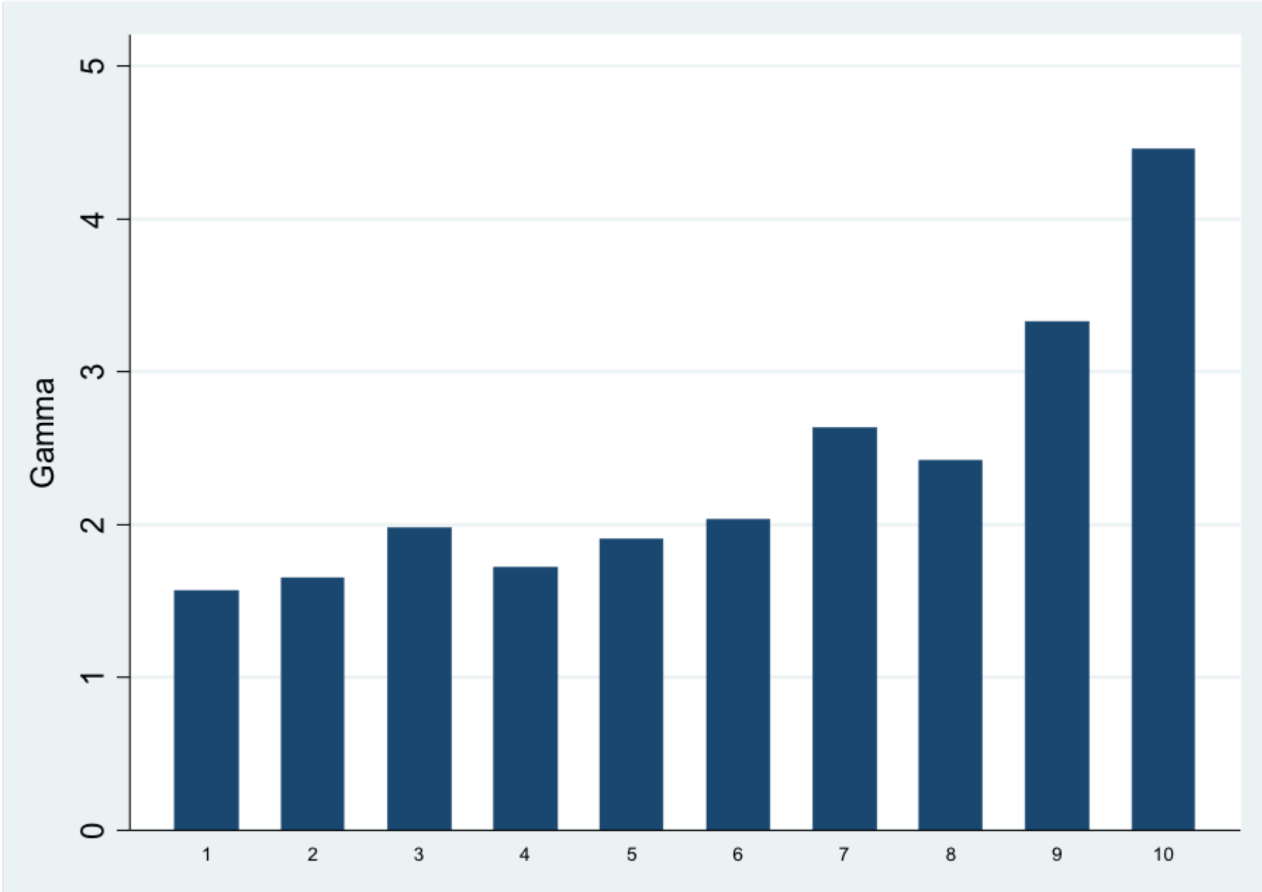

Figure 13: Average illiquidity by lagged dispersion of analysts forecast: 2007-2009.

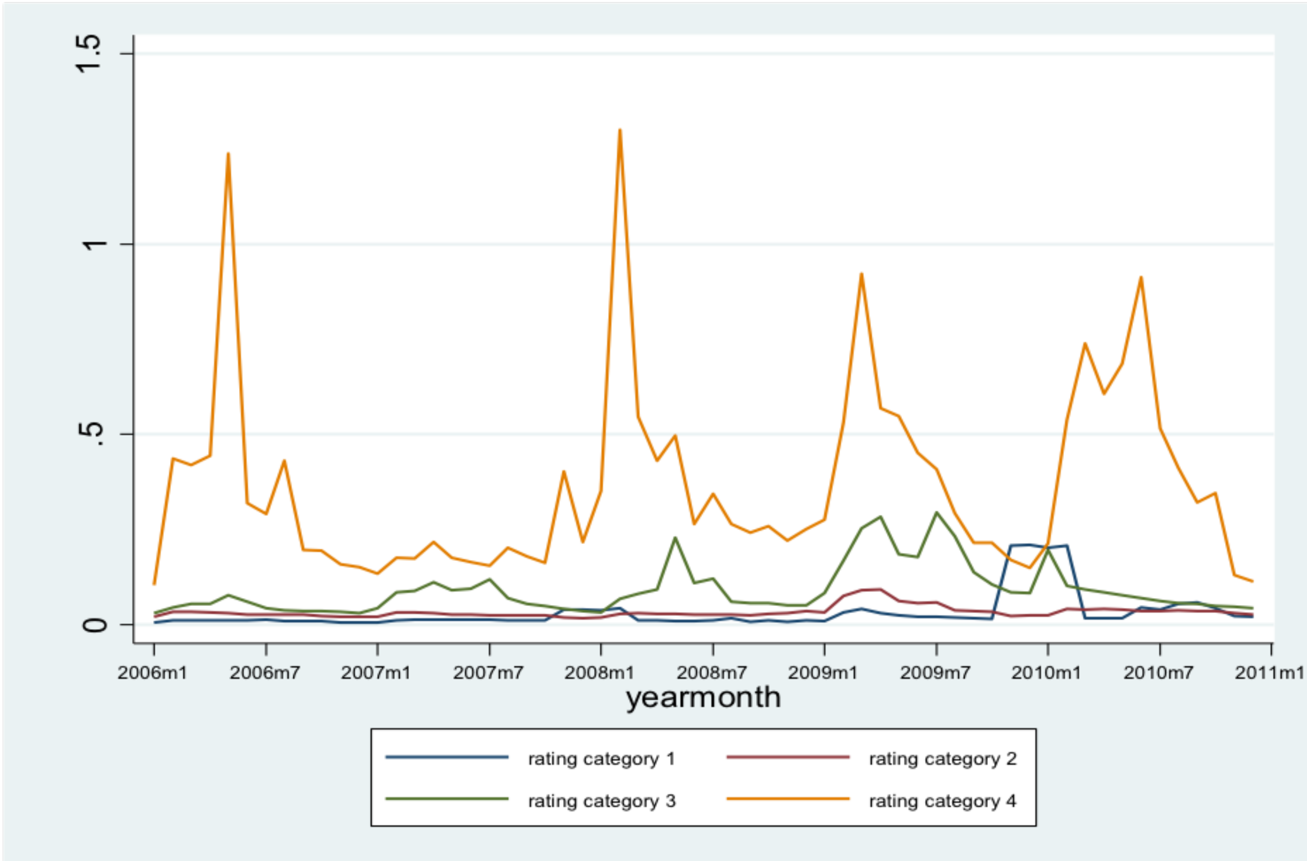

Figure 14: Analysts forecast dispersion by Moody's credit rating: 2007-2009.

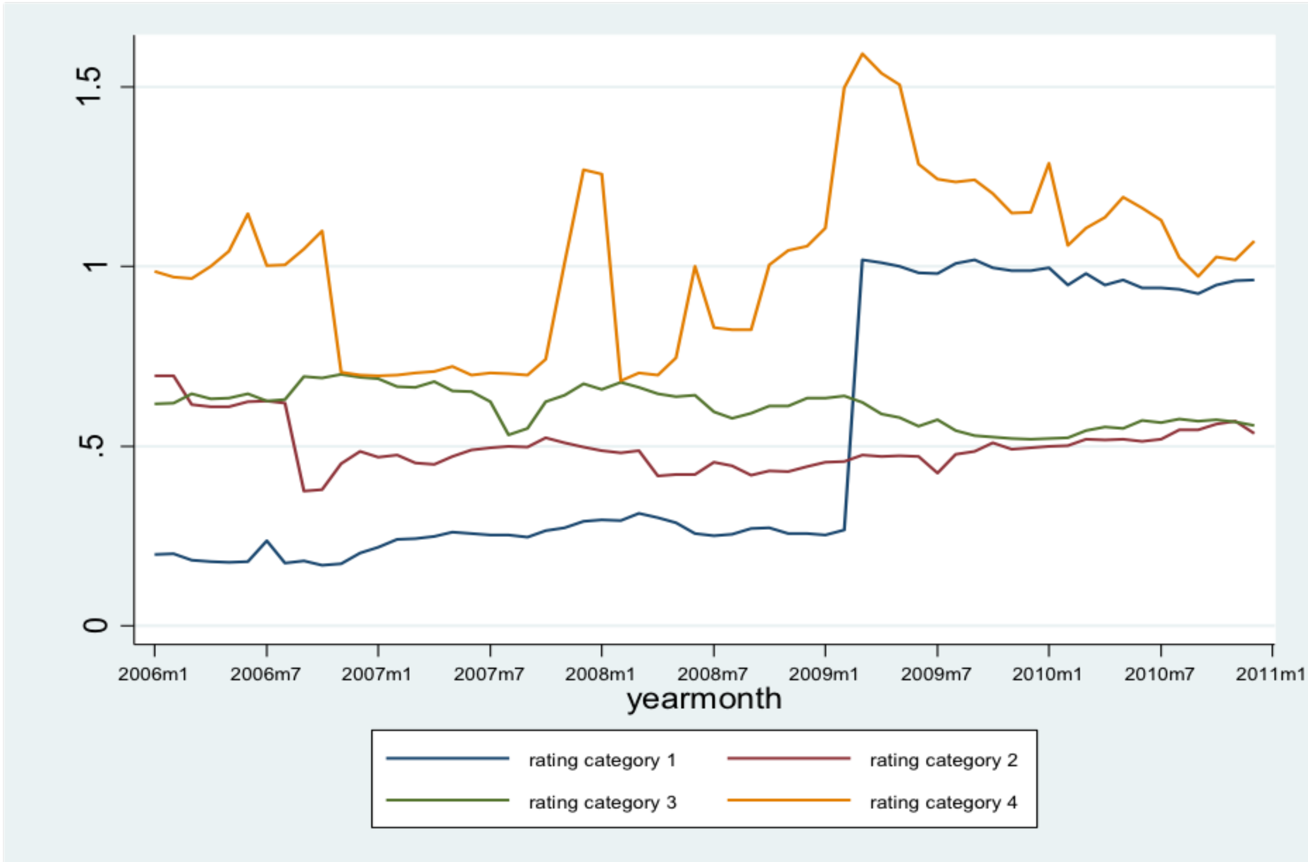

Figure 15: Mean bond rating difference by credit rating: 2007-2009.

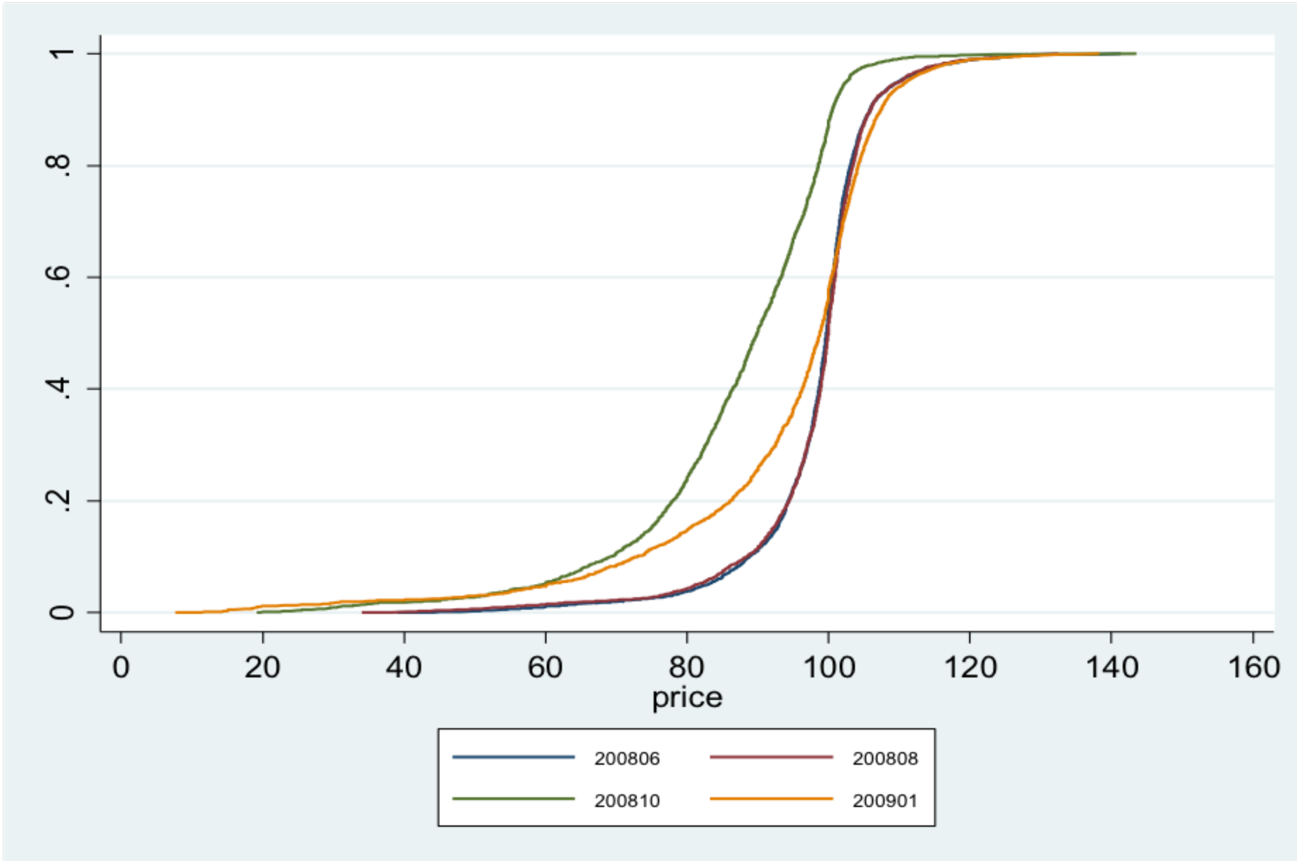

Figure 16: Bond price cumulative distribution function: 2007-2009.

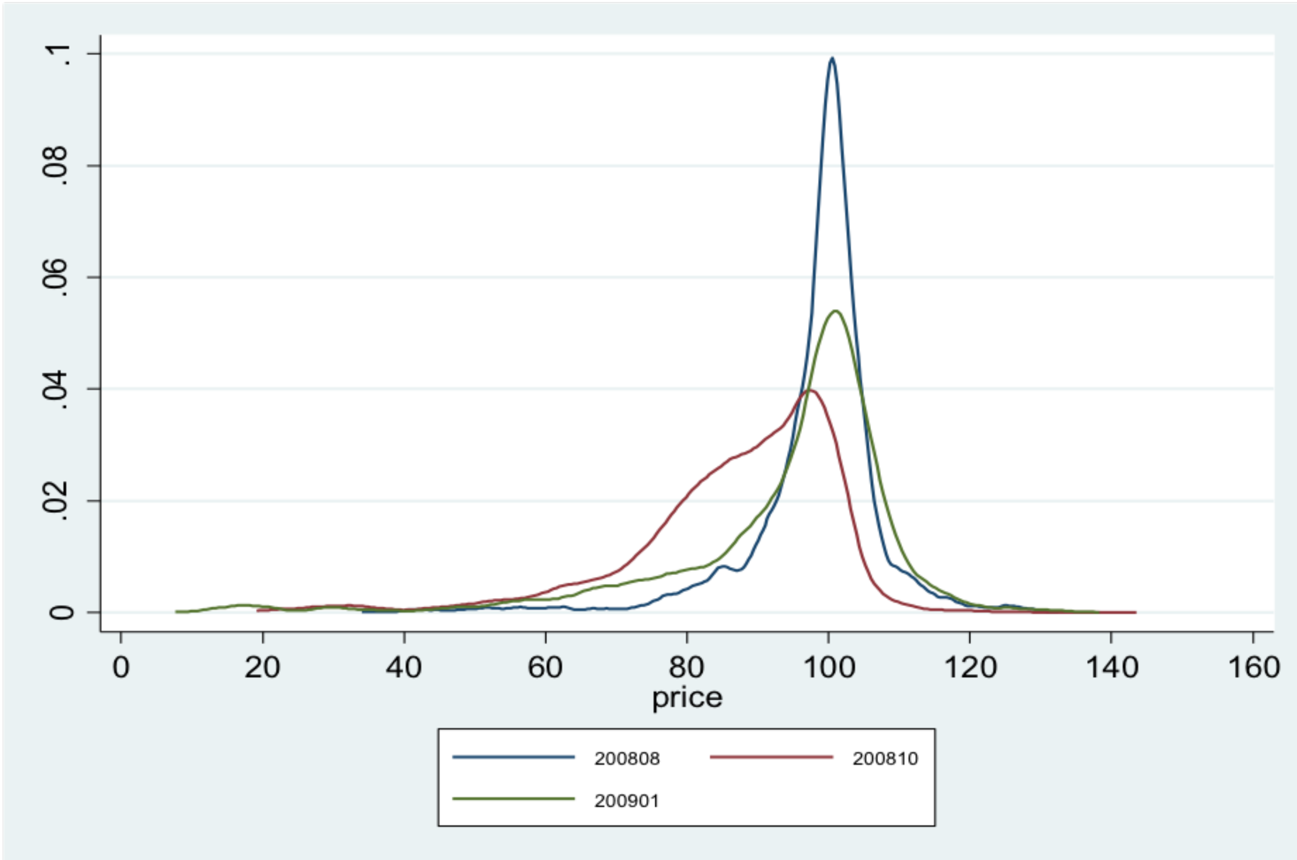

Figure 17: Bond price probability density function: 2007-2009.

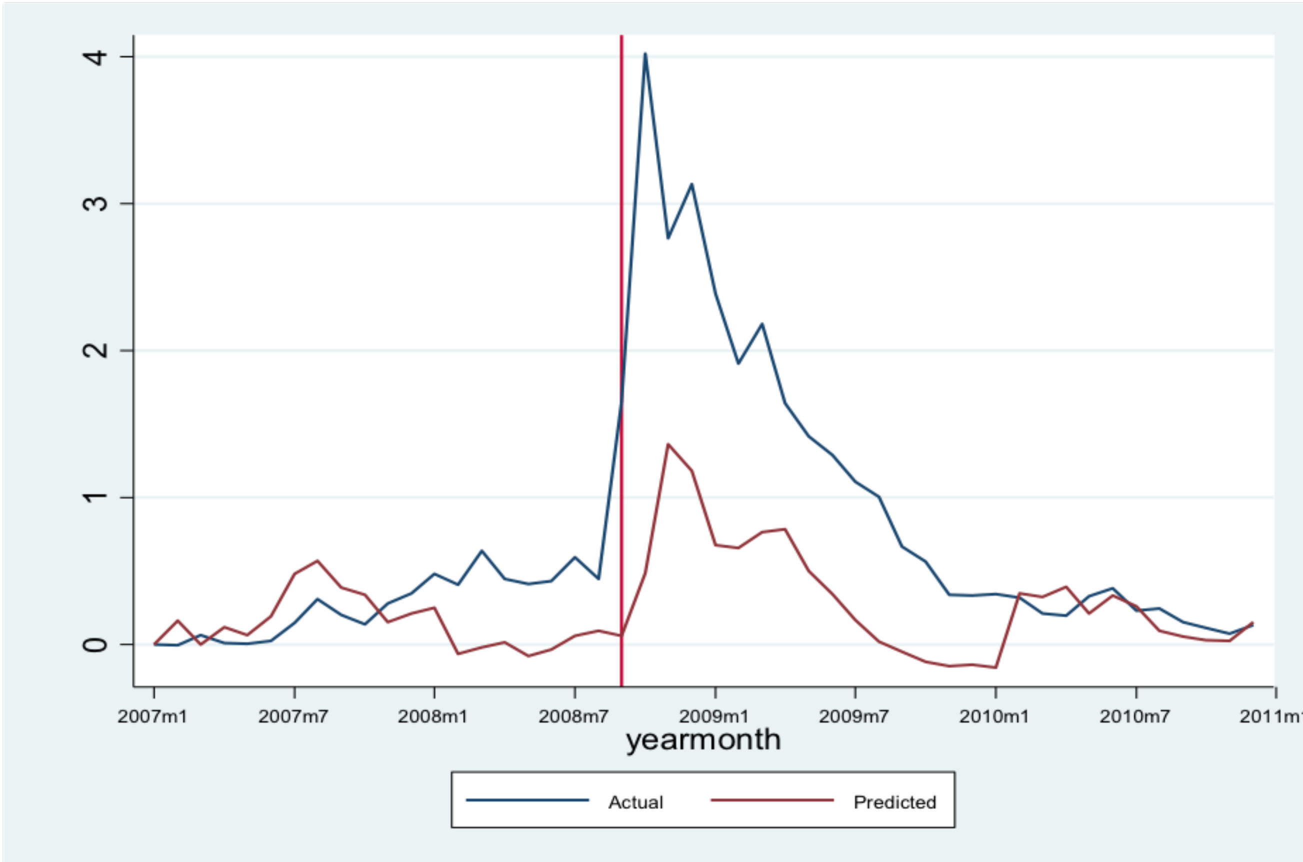

Figure 18: Predicted Illiquidity: 2007-2009 (without bond fixed-effects).

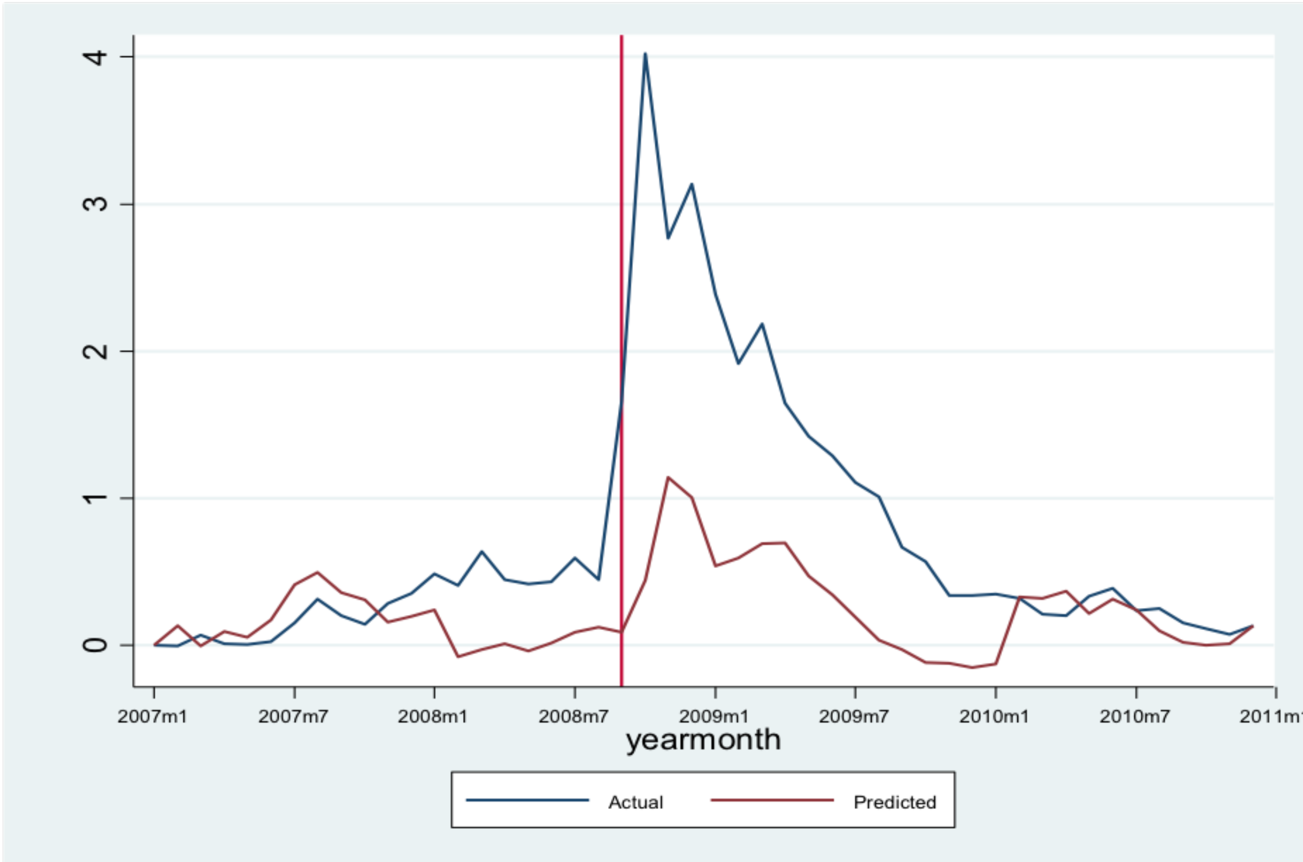

Figure 19: Predicted Illiquidity: 2007-2009 (with bond fixed-effects).

Table 1: Bond illiquidity and lagged prices

	(1) Gamma	(2) Gamma	(3) Bid-Ask spread	(4) Bid-Ask spread
Price_{t-1}	-0.204***	-0.169***	-0.0033***	-0.0032***
	(0.005)	(0.006)	(0.0005)	(0.0006)
Constant	21.592***	17.768***	0.299***	0.296***
	(0.523)	(0.611)	(0.037)	(0.037)
Bond FE	Yes	Yes	Yes	Yes
Year FE	Yes	No	Yes	No
Year * Month FE	No	Yes	No	Yes
Period	2007-09	2007-09	1873-1876	1873-1876
Observations	41,672	41,672	27,170	27,170
$Adj - R^2$	0.417	0.458	0.745	0.747

Table 2: Bond rating differences: Summary Statistics

Rating diff	Frequency	Percent
0	57,117	52.62
1	39,815	36.68
2	9,465	8.72
3	1,298	1.2
4	532	0.49
5	114	0.11
6	163	0.15
7	30	0.03
8	2	0
9	1	0
10	8	0.01
11	1	0
12	1	0
13	2	0
Total	114,572	100%

Table 3: Analysts' forecast dispersion: Summary Statistics

Mean	0.134
Median	0.030
Std	0.642
p25	0.013
p75	0.084
Min	0
Max	33.3
Observations	46,635

Table 4: Bond illiquidity and bond rating differences

	(1) Gamma	(2) Gamma
Rating Diff 1	0.024	0.014
	(0.104)	(0.092)
Rating Diff 2	0.977***	0.658***
	(0.215)	(0.202)
Rating Diff 3	1.615**	1.263**
	(0.705)	(0.636)
Rating Diff 4	3.562***	3.030***
	(0.932)	(0.868)
Constant	0.696***	0.336***
	(0.080)	(0.095)
Bond FE	Yes	Yes
Year FE	Yes	No
Year * Month FE	No	Yes
Observations	41,148	41,148
$Adj-R^2$	0.274	0.393

Table 5: Bond illiquidity and analysts' forecast dispersion

	(1) Gamma	(2) Gamma
Forecast dispersion 2	-0.010	0.099
	(0.082)	(0.078)
Forecast dispersion 3	-0.146*	0.030
	(0.089)	(0.092)
Forecast dispersion 4	0.132	0.066
	(0.122)	(0.125)
Forecast dispersion 5	0.382**	0.318*
	(0.174)	(0.174)
Constant	0.650***	0.174
	(0.105)	(0.125)
Bond FE	Yes	Yes
Year FE	Yes	No
Year * Month FE	No	Yes
Observations	22,571	22,571
$Adj-R^2$	0.277	0.402

Table 6: Changes in rating differences and analyst dispersion and price changes

	Δ Rating difference	Δ Rating difference	Δ Analysts dispersion	Δ Analysts dispersion
ΔPrice	-0.001***	-0.003***	-0.000	0.004
	(0.000)	(0.001)	(0.001)	(0.002)
Constant	0.004***	0.005***	0.002***	0.000
	(0.001)	(0.001)	(0.000)	(0.002)
Year * Month FE	Yes	Yes	Yes	Yes
Gamma not missing	No	Yes	No	Yes
Observations	108,518	41,267	46,363	22,475
$Adj - R^2$	0.00595	0.00593	0.00642	0.00869

Table 7: The effects of bond rating differences and bond price on bond illiquidity

	(1) Gamma	(2) Gamma
Rating Diff 1	-0.079	-0.062
	(0.083)	(0.079)
Rating Diff 2	-0.009	0.034
	(0.146)	(0.146)
Rating Diff 3	-0.902**	-0.694
	(0.442)	(0.438)
Rating Diff 4	-0.940*	-0.450
	(0.504)	(0.483)
Price_{t-1}	-0.210***	-0.174***
	(0.005)	(0.006)
Constant	22.159***	18.314***
	(0.523)	(0.611)
Bond FE	Yes	Yes
Year FE	Yes	No
Year * Month FE	No	Yes
Observations	41,148	41,148
$Adj - R^2$	0.421	0.461

Table 8: The effects of analyst dispersion and bond price on bond illiquidity

	(1) Gamma	(2) Gamma
Forecast dispersion 2	-0.041	0.073
	(0.070)	(0.070)
Forecast dispersion 3	-0.090	0.141*
	(0.077)	(0.080)
Forecast dispersion 4	-0.114	0.176
	(0.106)	(0.110)
Forecast dispersion 5	-0.370**	0.186
	(0.149)	(0.155)
Price_{t-1}	-0.207***	-0.174***
	(0.007)	(0.007)
Constant	21.817***	17.967***
	(0.642)	(0.737)
Bond FE	Yes	Yes
Year FE	Yes	No
Year * Month FE	No	Yes
Observations	22,571	22,571
$Adj - R^2$	0.436	0.479