Information, Insurance, and Interaction: The Municipal Bond Market after the Monolines

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Abstract

When monoline insurers lost their prime ratings in 2008 and could no longer wrap municipal bonds with their AAA credit ratings, the information environment of municipal financing changed dramatically. Adapting the empirical strategy of Benmelech and Bergman (2018), this paper marshalls a wide variety of evidence for the information sensitivity theory of liquid assets, demonstrating that municipal bonds transitioned from an information insensitive to an information sensitive state with the monolines' downgrades. Using data from municipal Comprehensive Annual Financial Reports, I turn to creditors' and borrowers' interactions under information sensitivity. I show that creditors began to acquire and value information about municipalities' debt service payments to tax revenues relative to those of other municipalities, as well as their absolute pension commitments. In response to investor attention, municipalities then attempt to use their financial disclosures as a venue for costless signalling of borrower quality. These results present implications for post-crisis reforms to the municipal bond market, as well as for the possibility of interpreting municipal spending cuts as strategic behavior in information sensitive environments.

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1 Introduction

"By the time this is over, the lines... may be redrawn when it comes to who, if anyone, can force a community to make good on its promises."

— Mary Williams Walsh for the New York Times*, "In Alabama, a County That Fell Off the Financial Cliff," February 18, 2012.*

The national memory of the 2007-2009 recession's impact on cities, counties, and other municipalities is dominated by the devastating bankruptcies in Jefferson County, Alabama in late 2011 and Detroit, Michigan in 2013, each at the time the largest municipal bankruptcy recorded in U.S. history. However, even local governments that had neither filed for bankruptcy nor defaulted on their debt enacted sharp cuts to critical social services. Before its eventual Chapter 9 filing in 2012, Stockton, California had already eliminated 25 percent of its police officers, 30 percent of its fire department, and over 40 percent of all other city employees in an effort to stave off default and continue to service its debt (Wollan, 2012). After Scranton, Pennsylvania refused to honor a guarantee on revenue bonds issued by its parking authority, the city found itself preemptively locked out credit markets, able to fund its short-term operating expenses with neither new short-term bonds nor access to private bank loans. Scranton then imposed pay cuts on all municipal workers—teachers, firefighters, police officers, sanitation workers—to the minimum wage, $7.25 an hour, as its mayor asked, "What am I going to pay them with?" (Cooper, 2012).

Stockton and Scranton's spending cuts were in part necessitated by balanced-budget requirements, statutory or constitutional rules binding on most states that can force severe cuts in services and increases in taxes during recessions, exactly when most residents are economically vulnerable (Bernanke, 2011). However, capital expenditures—including the typically bond-financed construction of highways, schools, and public transportation—also saw steep cutbacks during and after the recession, even though they are often generally exempted from balanced-budget rules and would have provided much-needed economic and employment benefits. In a speech given as Chairman of the Federal Reserve, Ben Bernanke suggested several possible explanations of municipalities' seemingly irrational reductions in capital expenditures, including the fact that debt service payments on the bonds used to finance capital projects would come out of already-strained operating budgets, and the difficulty as a matter of political optics of increasing spending during "a period of general austerity" (Bernanke, 2011).

However, it is easy to imagine different legal regimes that would not tie municipalities' hands when it comes to running brief operating deficits during recessions. Nor is it implausible to suppose that if creditors were to recognize capital expenditures' salutary effect on municipalities' economic health, increasing revenue streams long before their debt matures and thereby improving municipalities' quality as borrowers, they might not demand debt servicing payments so large as to significantly strain municipal operating budgets (especially once accounting for short-term increases in tax revenues and decreases in social services spending owing to employment effects). At the kernel of these speculations lies the question of how necessary municipal spending cuts really are during downturns: whether the city- and county-level austerity enacted during and after the 2007-2009 recession was merely contingent (on particular legal rules, misguided political ideologies, or conjunctions of credit market conditions), or instead inheres in the structure of municipal debt.

While these counterfactuals are not readily accessible, a rich literature on the information economics of debt markets makes possible an analysis of how different information structures built into the form of securities contracts affect the incentives of municipalities and their creditors. In this paper, I explore one precondition for understanding budgetary choices as in part determined by strategic interactions with creditors—namely, that the post-crisis structure of the municipal bond market created strong incentives for creditors to acquire information about municipal issuers' fiscal condition. The Dang, Gorton, and Holmstrom (2012, 2015) information insensitivity model suggests that this possibility is intrinsic to the contractual form of municipal bonds: of all securities, debt minimizes an agent's incentive to produce private information about its payoffs, but a shock to the fundamentals of the borrower can render information insensitive debt newly information sensitive.

Moreover, the market for municipal bonds—unlike sovereign or corporate debt—provides a unique opportunity for investigating this theory (and its applications to governments' spending choices). Specialized financial institutions, called monolines, began to proliferate in the 1970s and 1980s to insure municipal debt. Since guaranteed or "wrapped" securities take on the rating of their guarantor, municipalities who purchased insurance could issue debt with a monoline's AAA rating rather their own, precluding a transition to information sensitivity even in the event of public bad news about the municipality's underlying credit quality. However, in 2008, the monolines were suddenly, steeply downgraded, losing their ability to prevent municipal bonds from becoming information sensitive. Importantly, the monolines' loss of their AAA ratings had nothing to do with the municipal bonds they insured, but instead to an expanding business line in wrapping mortgage-

backed securities and other structured products.

In this paper, I exploit this exogenous change in information structure to examine the resulting consequences of the information sensitivity theory of bond liquidity for strategic information production between municipalities and their creditors. Using a large panel dataset constructed from Municipal Securities Rulemaking Board (MSRB) municipal bond transaction data, bond characteristic data from SDC Platinum, credit ratings from the three major agencies, and municipal Comprehensive Annual Financial Reports (CAFRs), this paper makes three key contributions to the literature. First, it studies a transition from an information insensitive to an information sensitive state precipitated not by a shock to borrower quality but to the market's overall information structure. Second, it considers government balance sheet data as a determinant of credit market phenomena at a municipal, rather than sovereign or even state level. Third, it situates governments' financial signalling choices not in a general game theoretic setting with exogenous information asymmetry but in the unique informational context of debt markets.

In the first half of the paper, I test a battery of hypotheses concerning bond illiquidity that together provide strong evidence for the claim that municipal bonds transitioned from an information insensitive to an information sensitive regime with the collapse of the monolines. I begin by replicating the empirical strategy Benmelech and Bergman (2018) use to test the Dang, Gorton, Holmstrom (2012) information insensitivity theory of debt. First, I confirm the prediction that the hockey-stick relation in bond payoffs induces a nonlinear dependence of bond illiquidity on bond price only in the subsample of the data after the collapse of the monolines. Second, I show that in the subsample postdating but not predating the collapse of the monolines, bonds with a higher credit rating at issuance are more illiquid, controlling for credit rating. This result is in keeping with Hanson and Sunderam (2013)'s model of information production infrastructure in the presence of information asymmetry.

I depart from Benmelech and Bergman, who considered only persistent information sensitivity in the corporate bond market, by formally causally identifying a transition from information insensitivity to information sensitivity with the monolines' loss of their prime ratings. While a simple difference-in-differences specification suggests that the regime shift to Hanson-Sunderam information asymmetry did not occur until early 2012, introducing interactions with bond insurance more precisely specifies the temporal sequencing of that transition. In particular, I find (with some reservations based on sample size) that not only insured bonds but also uninsured bonds were information insensitive

prior to the downgrade of the monolines. Moreover, while the early 2012 transition to information sensitivity continues to hold for insured bonds, uninsured bonds became information sensitive immediately after the monolines lost their Aaa ratings. While identifying precisely the event that precipitated this change in 2012 is beyond the scope of the paper, two possibilities include municipalities' well-publicized mounting fiscal stress in 2011—described by Moody's Investor Services as "the worst year yet" for municipal issuers (Moody's, 2011)—including Jefferson County's Chapter 9 filing, or the impending downgrade of FSA and Assured Guaranty, the last monolines to retain high investment grade credit ratings.

After having established that municipal bonds became information sensitive after their loss of monoline insurance, I then analyze bondholders' and municipalities' interactions in their new informational setting. I begin with bondholders, testing whether municipal bonds are sensitive to information beyond credit ratings—in particular, to measures of municipal debt burdens, pension obligations, and fiscal capacity made publicly available in municipalities' CAFRs. I find that illiquidity rises rapidly in quartiles of debt service payments to tax revenue, as well as in absolute amounts of both total and unfunded pension/OPEB liabilities.

Turning to municipalities' reaction to this form of creditor attention, I investigate whether municipalities whose bonds are more information sensitive are more likely to attempt to use their budgetary reporting to signal borrower quality to creditors. After constructing municipality/year-level measures of information sensitivity that capture the nonlinearity of the relationship between bond illiquidity and price, I find that after the monolines are downgraded, municipalities with more strongly nonlinear dependencies become more likely to change actuarial methods used to evaluate their pension commitments. In sum, this paper presents three key results: that the municipal bond market broadly transitioned from an information insensitive to an information sensitive regime after the monoline insurers lost their prime ratings; that creditors in the new information sensitive context began paying attention to municipalities' relative debt service burdens and absolute pension commitments; and that municipalities react to creditor attention in the new informational regime by strategically altering their finances.

The paper will proceed as follows. Section 2 provides additional background on the monoline insurers, their role in the 2008 financial crisis, and the structure of the municipal bond market in the wake of their collapse. Section 3 situates this paper in relation to the existing literature on both the particular structure of the municipal bond market and the informational determinants of

liquidity in general debt markets. Section 4 details data sources and variable constructions. Section 5 demonstrates the transition from information insensitivity to sensitivity after the downgrade of the monolines, wherein Sections 5.1-5.2 replicate Benmelech and Bergman (2018) and Sections 5.3-5.4 establish causal identification. Section 6 analyzes the sources of information to which creditors became attuned in the new informational context, and Section 7 explores municipalities' strategic response to creditor behavior. Section 8 concludes with implications for federal and municipal policy.

2 Monoline insurers and the 2007-2008 financial crisis

Even though default rates on municipal bonds, even during the crisis, remained very low compared to comparably rated corporate debt (less than one percent; see GAO, 2012), municipal financing was nonetheless a prime target for liquidity support, maturity transformation, and credit enhancement. A set of similar instruments, variable rate debt obligations (VRDOs) and auction rate securities (ARS), performed the former two functions by combining floating interest rates reset on a periodic basis with (respectively explicit or implicit) liquidity backstops (see FCIC, 2011; Wei and Yue, 2015). The monolines provided additional credit enhancement, in part to make lower- or unrated municipal bonds eligible for purchase by tax-exempt money market mutual funds (MMMFs), which are required under rule 2a-7 of the Investment Company Act to invest only in high-quality, short-term instruments that the funds' advisors determine bear "minimal credit risks." Since the SEC mandates that tax-exempt MMMFs invest at least 80% of their assets in (or derive 80% of their income from) municipal bonds—out of $465 billion under management in 2008—municipalities were strongly incentivized to meet 2a-7 eligibility. Accordingly, by March 2008, the monolines insured as much as 30 percent of the municipal securities held by tax-exempt MMMFs (Sirri, 2008).

Since monolines had AAA credit ratings and operated in the municipalities' realm of long-term credit risk with minimal exposure to short-term volatility, they were not typically required to post margin against changes in the market value of their contracts. As a result, they "kept razor-thin capital" even while branching out from their original business model to insure mortgage-related securities (FCIC, 2011). By the end of 2006, the monolines had collectively entered into $800 billion of guarantee contracts on structured products, an exposure just over 60 percent the size of their $1.3 billion municipal insurance portfolio (Bergstresser, 2010). After CDS rates for MBIA and Ambac, the two largest monolines, rose by over 300 basis points in late 2007 as the MBS market deteriorated,

ratings agencies abandoned monolines' non-mark-to-market evaluation (Moody's, 2007). As a result of reevaluating monolines' capital adequacy based on cumulative losses on the market value of their MBS insurance, in January 2008, Ambac lost its AAA rating from Fitch, and Moody's downgraded two smaller monolines, CIFG and Financial Guaranty, in the two months after. Ambac and MBIA followed for both Moody's and S&P in June, triggering a cascade of downgrades that left all major monolines but FSA and Assured Guaranty (which merged on July 1, 2009) with speculative-grade credit ratings by the end of 2009 (Table 1).

Using data from SDC Platinum (see Section 4.2), we can see that issuance insured by FSA and Assured Guaranty fell precipitously just before and immediately after their first downgrades, but shortly picked up to near-precrisis levels; however, for all other monolines, insured issuance went to zero immediately after their downgrades and never recovered (Figure 3). Accounting for around 60 percent of all municipal bonds prior to the crisis, overall insured issuance plummeted immediately following Moody's rating action placing the first monolines on review for possible downgrade on December 14, 2007, reaching near-negligible levels after the Ambac and MBIA downgrade on June 19, 2008 (Figures 1 and 2).

3 Related literature

This paper exists at the intersection of three bodies of literature, finding its motivation in informational theories of government austerity, theoretical basis and empirical methodology in information insensitivity models of bond liquidity, and subject matter in studies of municipal bond insurance.

Existing research on information and strategic government spending focuses on the sovereign setting. This context presents several substantial disanalogies to municipal governments, including fiscal multipliers on spending, full legal competence to run short- and long-term deficits, and, in paradigmatic cases, independent monetary policy (and hence the ability to control the supply of—and even monetarize—government debt). Morever, the literature analogizes to fairly generic games with exogenous information asymmetry, such as Spence's job market games (Rivas, 2017) or credit rationing in markets with adverse selection (Dellas and Niepelt, 2014). By way of contrast, the information insensitivity literature in which this paper is rooted expressly begins without an assumption of exogenous adverse selection, and moreover particularizes the informational structure of debtor-creditor relations to the specific character of debt securities. The task of agents in these

models is not to mitigate exogenous adverse selection, but instead to minimize potential (endogenous) adverse selection in a setting in which even their choices to acquire information at zero cost are endogenized.

Information insensitivity models of bond liquidity proceed from the observation that unlike stock markets, which exist to allocate risk efficiently by providing a price discovery mechanism, money markets are instead "about obviating the need for price discovery" (Holmstrom, 2015). Functioning money-like assets—for which market participants have "no need to ask questions" about their value, even if information can be acquired for free—are built from over-collateralized debt because, as it turns out, debt is the optimal security for minimizing information sensitivity, i.e. precisely the property that captures incentives for an agent to produce private information about the value of a security (Dang, Gorton, and Holmstrom, 2015). The payoff of debt as a function of the value of the assets that back it is shaped like a hockey-stick, following the 45 degree line from 0 to the face value of the debt and then remaining constant. Accordingly, shocks about the fundamentals of assets that back debt—in this case, municipalities' fiscal capacity or borrower quality—can render information-insensitive debt newly information-sensitive if they shift the distribution of the underlying assets closer to the kink in the hockey-stick. One unique feature of this model's endogenization of adverse selection is that it provides a ready explanation for asset fire-sales: rather than trigger adverse selection, market participants would rather preserve information-insensitivity and respond to such a shock by selling money market securities at prices below their value (Dang, Gorton, and Holmstrom, 2012). In relation to this model, this paper contributes a study of a shift to information sensitivity triggered not by a shock to borrower fundamentals but to the systemic information structure of the market. In this context, while the monolines' downgrade precipitated some initial run behavior, especially in adjacent VRDO and ARS markets (Section 2), idescrminate fire-sale prices in a market that faced no underlying borrower credit deterioration would have been too high of a cost for market participants to bear, even to preserve information insensitivity and minimize adverse selection concerns. Moreover, my lack of a finding of adverse selection prior to the monolines' loss of their Aaa ratings—pace some of the literature on monolines, below—lends some empirical justification for the model's endogenization of such concerns.

Emerging over the past several years, empirical literature testing predictions of the information insensitivity theory is extremely diverse in subject matter and identification strategy. Using the I/B/E/S survey of professional forecasters, Brancati and Macchiavelli (2018) directly study the

dynamics of information production and expectations of default risk in markets for bank debt. Gallagher, Schmidt, Timmermann, and Wermers (2018) exploit detailed MMMF portfolio holdings disclosures to study portfolio rebalancing decisions after public bad news, finding that more sophisticated investors acquired information about risk exposures to Europe during the Eurozone crisis. Perignon, Thesmar, and Vuillemey (2017) focus on the prediction that once a security becomes information sensitive, uninformed lenders may prefer to stop lending altogether, while informed lenders continue to lend to high-quality borrowers, finding that this supply-driven form of adverse selection better reflects the dynamics of wholesale funding dry-ups during the recent crisis than does classical information asymmetry theory's demand-driven account. Lastly, Benmelech and Bergman (2018) test a diverse palette of hypotheses concerning corporate bond liquidity. While Gallagher, Schmidt, Timmermann, and Wermers' empirical strategy would also translate to the municipal bond market in light of 2a-7 MMMF's large holdings in municipal debt (see Section 2), I instead chose to replicate Benmelech and Bergman in order to study a wider array of creditors.

Lastly, a robust literature on the municipal bond market and monoline insurance has existed since the monolines' market penetration in the 1980s, although much of it is complicated by empirical difficulties attending the municipal bond market's lack of liquidity. Spiegel and Starks (2016) outlines a method of constructing return indices for highly illiquid bond markets that applies methods from real estate economics, used by Hund et al. (2018) to control for the municipal bond market's high degree of within-category heterogeneity, as well as representativeness and endogeneity concerns with respect to which bonds trade on a given day. Hund et al. explain their (perhaps surprising) findings that municipal bond investors ignored the steep deterioriation of the monolines in equity and CDS markets (see Section 2) by suggesting that either bond insurance was not particularly valuable to investors or that short-sale constraints on municipal bonds inhibit price discovery. However, another possibility remains, namely the contention of this paper: since municipal bonds were information insensitive prior to monolines' loss of their Aaa ratings, investors had little incentive to acquire more information even at trivial cost. Early research on monolines suggests that bond insurance confers a net benefit over issuing uninsured debt, whether due to tax effects (Nanda and Singh, 2004), information production (Gore et al., 2004), or signalling effects (Thakor, 1982). More recent literature presents more mixed evidence, including yield inversions of insured over uninsured bonds during the crisis (e.g. Bergstresser, 2010; Chirinko, 2018). In my paper, bringing to bear theories of information insensitivity on this topic suggests that the bond insurance conferred a benefit insofar

as it suppressed transitions to information sensitivity, minimizing adverse selection concerns.

Literature related to the second half of this study, which analyzes information procession of municipalities' fiscal condition, includes Boyer (2018). Using U.S. Census State Finances data, that paper shows that states with a higher pension liability-to-GDP ratio are considered closer to default, as measured by CDS spreads. Care must be taken in using self-reported data on local government finances, owing to the relative lack of standardization in municipal reporting requirements (see Section 6); in fact, I exploit precisely this unreliability to explore signalling interactions between municipalities and creditors. To my knowledge, this paper is also the first to perform an analysis like Boyer's at the level of municipalities rather than states. A few disanalogies between municipalities and states makes this setting particularly interesting. First, municipalities, unlike states, are legally authorized to declare bankruptcy. Moreover, while states "increasingly push[ed] down their problems to their local governments" (Moody's, 2011), cutting municipal funding in the wake of the crisis, municipalities have no smaller jurisdictions onto which to offload financial stress—leaving them with fewer avenues to reduce spending short of cutting social services and capital expednitures. In the interests of identification, municipalities necessarily entail a much larger sample size than states, and also make it possible to control for state-level heterogeneity and clustering. Finally, Schwert (2017) shows that default risk, not liquidity, is the main driver of municipal bond yields, giving some loose credibility to this research program.

4 Data and variables

4.1 Bond illiquidity

The sample used in this paper is constructed from a variety of sources that, together, describe the municipal finance environment from 2005 to 2013. First, several measures of bond illiquidity used in Benmelech and Bergman (2018) are constructed using daily municipal market trade data made available by the Municipal Securities Rulemaking Board (MSRB) via WRDS. Since this paper concerns creditor behavior and knowledge, I exclude inter-dealer trades, and additionally filter primary market transactions, bonds with a time-to-maturity of less than one year, and price outliers (bonds with prices less than 50 or more than 150 percent of par value), following Hund et al. (2018). While Benmelech and Bergman (2018) compute these illiquidity measures each month for their sample of corporate bonds, I instead calculate measures semiannually to ensure adequate

coverage given the much slower moving municipal bond market.

The first measure of illiquidity, proposed by Bao et al. (2011), proxies bond illiquidity as the magnitude of the transitory movements in bond prices to which it gives rise (Grossman and Miller, 1988; Huang and Wang, 2009),

$$Roll = -\mathrm{Cov}(\Delta p_t, \Delta p_{t-1}),$$

i.e. the negative serial covariance of log-price changes Δp_t. While immediately related to the Roll bid-ask estimator (1984), this measure captures transitory price movements arising from sources of illiquidity other than the bid-ask bounce in more general settings that do not assume specific bond pricing models (Bao et al., 2011). For the calculated covariance to be meaningful, I compute this measure only for bonds with at least ten transactions in a half-year period, resulting in 1,569,057 bond/half-year observations with well-defined *Roll* illiquidity.

The second measure of illiquidity, the implied round-trip cost (IRT), represents the dealer markup or transaction costs that would be incurred by selling and repurchasing (or purchasing and then reselling) a bond. Trades are matched either with opposite-signed trades of identical trading volumes that occur within the same half-year, or else with the first set of opposite-signed trades occuring during the same half-year that together can be taken to clear the initial trading volume. I then calculate the IRT as the scaled difference between the highest, P_{max}, and lowest, P_{min} prices of these trades,

$$IRT = \frac{P_{max} - P_{min}}{P_{max}},$$

which is well-defined for 6,861,533 bond/half-year observations.

The third measure of illiquidity, originally proposed by Amihud (2002) and modified by Dick-Nielsen, Feldhutter, and Lando (2012), measures the price impact of trading volume, since more liquid securities should be able to trade in large quantities with smaller impacts on prices. I first calculate the monthly average measure of price impact,

$$\frac{1}{N_t} \sum_{i=1}^{N_t} \frac{|r_i|}{Q_i},$$

where i indexes transactions, N_t is the number of transactions in a month, r_i is the log return of transaction i, and Q_i is the number of bonds traded in transaction i. I take the semi-annual *Amihud* measure as the median monthly measure within each half-year, computed for 6,703,811

bond/half-year observations.

During the crisis, municipal bond yields rise (and prices fall) slightly relative to their pre-crisis and substantially relative to their post-crisis levels. Note that the Amihud and IRT measures of illiquidity broadly increase as expected during the recession, while the Roll measure suggests that municipal bond illiquidity decreased on average (Table 2). This unintuitive behavior of the Roll measure is largely an artifact of the minimum trade frequency embedded in its construction: requiring at least ten transactions per half-year eliminates the least-frequently traded bonds from the sample. While bond liquidity need not correspond exactly to trade frequency—a shock to creditors' beliefs concerning a municipality's creditworthiness might decrease the liquidity of the bonds it issues while nonetheless increasing the frequency with which they trade—a floor on the number of trades per period should generally exclude some of the least liquid bonds.

4.2 Bond characteristics

Transaction data are supplemented with bond characteristics from the SDC Platinum Global New Issues database. SDC Platinum provides data on issue size, credit enhancement type and provider, and issuer name and county for all municipal bond issues from 1966 through 2017. Excluding 57,043 bonds issued by state authorities leaves 525,777 bond deals, issued under 58,062 unique 6-digit issuer CUSIPs. One important limitation of the dataset is that its observations are indexed by municipality, rather than bond or even 6-digit issuer CUSIP. SDC Platinum does not provide the more granular 9-digit CUSIPs that would permit identifying its data with individual bonds. For example, Fairfax County, VA issued under four 6-digit issuer CUSIPs on January 1, 1966, 303819, 303820, 30382A, and 303867, but SDC Platinum does not list the 9-digit security CUSIPs of the bonds that Fairfax County issued. If municipalities only ever issued one bond under each issuer CUSIP, or even only one bond under each issuer CUSIP per issuance date, this method of data indexing might not present much difficulty. However, this is not the case: returning to our example, the MSRB data records 387 unique bonds with 6-digit issuer CUSIP 303820 alone (i.e. bonds whose 9-digit CUSIPs trunctate to 303820, for instance 3038202A1, 3038202B9, 3038202C7, 3038202D5, ...).

To bridge the two datasets, I first extract a list of the first trade recorded by the MSRB for each 9-digit CUSIP, including primary market transactions (which had previously been excluded from the sample used to compute illiquidity measures). I then match each bond to the first issue in SDC Platinum that (a) occurred on or before the date of its first trade, (b) was issued under its 6-digit

CUSIP, and (c) has a large enough size given previous bond-issue matches to have also encompassed it. Coupled with the assumption that the credit enhancement data SDC Platinum indexes by 6-digit CUSIP/issuance date applies to each bond with those indices, this procedure matches SDC Platinum data to 2,065,477 bonds in the MSRB dataset.

4.3 Credit ratings

While SDC Platinum provides short- and long-term ratings for both a bond's underlying issuer and its insurer, hand-checking against the credit rating agencies' online resources reveals gaps in the completeness of SDC Platinum's ratings data. Instead, I use historical ratings data for all rated municipal bonds disclosed by Moody's, Standard & Poor's, and Fitch under SEC Regulation 17g-7,[1] supplemented with ratings for the monoline insurers obtained directly from Moody's (Table 1).

I encode credit ratings on a numerical scale, with 1 corresponding to AAA/Aaa-rated bonds and 9 corresponding to D rated bonds.[2] When rated by at various time horizons (long- and short-term ratings) or taxable statuses (Moody's VMIG or MIG ratings for tax-exempt bonds), bonds are assigned, when possible, the numerical rating tier corresponding to their long-term rating. Bonds rated by more than one agency are assigned the rating tier corresponding to their highest (when possible, long-term) rating.[3]

Prior to 2008, municipal bonds were generally either unrated or Aaa rated at issuance, the latter whether carrying the ratings of their insurers or by dint of the underlying municipality's creditworthiness. After the monolines lost their Aaa ratings, municipalities in the sample increasingly issued debt with a wider range of ratings at issuance, almost entirely at investment grade and predominantly in the Aa range (see Figure 4). Note that until 2012q2, no more than a quarter (by par value) of municipal bonds were issued by municipalities that had underlying credit ratings equal to or exceeding that of their insurers (almost always FSA). This percentage represents a marked increase from before the first monoline downgrades, during which time less than one percent of insured bonds in the sample were issued by municipalities with Aaa underlying ratings at the time of issuance. The earlier infrequency of seemingly redundant insurance that suggests that for the

[1] The Center for Municipal Finance and the Center for Corporate and Securities Law at the University of San Diego School of Law have generously converted the ratings histories, which are made available as XBRL files on each rating agency's website, into CSV format, available at `ratingshistory.info`

[2] More thoroughly: 1 = Aaa/AAA/A-1+/P-1/F1+/VMIG1, 2 = Aa/AA/A-1/F1/VMIG2, 3 = A/A-2/P-2/F2/VMIG3, 4 = Baa/BBB/A-3/P-3/F3/VMIG4, 5 = Ba/BB, 6 = B/S.G., 7 = Caa/CCC, 8 = Ca/C, 9 = D.

[3] For example, a bond with an Aa long-term rating from Moody's, an A long-term rating from S&P, and an AAA short-term rating from Fitch would be classified in tier 2, along with other Aa/AA/A-1/F1/VMIG2-rated bonds.

majority of municipalities issuing insured debt before 2012, insurance had played the conventional role of permitting their bonds to circulate with higher credit ratings than they otherwise would have (Figure 5). However, from when FSA and Assured Guaranty lost their Aa3 ratings in early 2013, between 84 and 93 percent of insured municipal bonds were issued by municipalities with credit ratings at least as high as their insurers. This seemingly redundant bond insurance is not insubstantial: some municipalities continued to insure more than 1 billion USD in such debt each quarter after the monolines were downgraded, increasing to 5 to 8 billion USD per quarter from late 2014.

4.4 Municipal budgets

Lastly, the models in Sections 6 and 7 are estimated using data from municipalities' CAFRs. While the Government Accounting Standards Board imposes some requirements for their structure and content, CAFRs are far less rigidly prescribed than the equivalent accounting document for public companies (SEC Form 10-K). Accordingly, CAFRs are rarely, if at all, used in large panel studies on municipal finance; the literature often studies states instead, for which standardized fiscal data is available through the US Census (e.g. Boyer (2018)). Nevertheless, the Government Finance Officers Association, a trade organization of public finance officials at the federal, state, and municipal levels in the United States and Canada, promulgates a series of best practices for municipal financial accounting and reviews under these guidelines CAFRs voluntarily submitted by municipalities. I obtained from the GFOA standardized variables from all CAFRs submitted for accreditation between 1997 and 2013. The GFOA does not provide unique identifiers for municipalities; after standardizing municipality names by removing non-name substrings ("Municipality of", "City", etc.), the data comprise financial information from 2388 unique municipalities, averaging 13 years of observations per time series. 817 municipalities have data for the full sample period from 1995 to 2013.

I construct several measures of municipal financial strength for use in the models in Sections 6 and 7 as the ratios of stock and flow CAFR variables measuring the size of municipal deficits, debt burdens, and pension liabilities to broad measures of fiscal capacity. I compute a municipality's deficit as the sum of the expenditures of its general fund (GFOA variable `GFEXPEND`) and of other sources (`OGFEXPEND`) less the sum of revenues from its general fund (`GFREVENUE`) and from other sources (`OGFREVENUE`). I take the amount of direct general obligation debt (`DIRECTDEBT`) as a measure of the amount of outstanding debt issued by a given municipality, excluding debt stemming

from overlapping obligations shared with other municipalities (OVERLAPDEBT). Overlapping debt represents a significant share of municipal debt burdens, exceeding the amount of direct debt for 56 percent of municipality-year observations in the sample. However, it is difficult for creditors and researchers alike to distinguish overlapping debt corresponding to a particular municipality's spending and financing choices from that which arises solely from legal structures committing municipalities to joint liability, the statutory basis for which may vary between states, counties, and regions; moreover the GFOA dataset does not identify the municipalities between which overlapping debt obligations are shared. Debt service expenditures (GENGOVDEBSVC) serve as an additional measure of a municipality's debt burden that might better capture financial pressures, rather than creditworthiness or borrowing capacity.

To measure municipalities' pension commitments, I define a municipality's unfunded pension and OPEB liabilities (or shortfall) as the actuarial value of plan assets less the actuarial value of plan liabilities for the three largest pension and OPEB plans in which the municipality participates (PERSAAL + PERSAAL1 + PERSAAL2 + OPEBAAL + OPEBAAL1 + OPEBAAL2 - (PERSAVPA + PERSAVPA1 + PERSAVPA2 + OPEBAVPA + OPEBAVPA1 + OPEBAVPA2)). I also supplement this measure with aggregate pension and OPEB liabilities (both funded and unfunded, i.e. the sum of the AAL variables), as well as payrolls covered by the pension and OPEB plans (the sum of COVPAY variables). Lastly, I use four measures of fiscal capacity: tax revenues (TAXLEVY), tax base (PROPERTEAV), population (POPULATION), and total government expenditures (GENGOVTOTEXP). The variety of proxies serves to capture different aspects of debt burdens, pension liabilities, and fiscal capacity, as well as varying degrees of sensitivity (as will become relevant in Section 7) to municipalities' accounting choices.

Summary statistics for these variables are given in Tables 4 (debt measures) and 5 (pension measures). Measures of pension commitments have steadily grown over the entire sample period for most municipalities, with the exception of those with the smallest pension/OPEB payrolls, which have only seen expanded payroll coverage after the recession. Perhaps owing to statutory balanced-budget requirements becoming binding or else to policies of municipal austerity, deficits and direct debt amounts both shrank and converged during the recession, expanding in size and dispersion before and after the crisis. However, debt service expenditures increased for the upper half of the distribution during and after the recession even as debt service expenditures decreased on average, suggesting that credit market conditions may have become more sensitive to and harsher against poor borrower quality.

I then identify all but 361 of the municipalities in the GFOA dataset with (potentially multiple, see Section 4.2) 6-digit issuer CUSIPs by fuzzily matching a municipality with entries from the same state in the SDC Platinum dataset whose issuer variable contains its cleaned name as a substring. Merging with credit ratings data (Section 4.3) and illiquidity measures (Section 4.1) gives this paper's main sample of 273,310 bonds issued by 1757 municipalities and traded from 2005 to 2013. The municipalities in the sample are from 48 states, with the greatest number of bonds in Texas, California, Florida, Ohio, and Illinois (Table 3). On average, municipalities issued 156 unique bonds outstanding over some part of the sample period; the median municipality issued 58. As a rough look at potential determinants of municipalities' credit ratings, I regressed credit ratings from each of the three agencies on various raw CAFR variables (Figure 6). For all agencies, net investment in capital assets is strongly correlated with a higher credit rating. Covariances between most variables (including size and change of net position, number of pension plans, tax base, debt service expenditures, population, and overlapping debt) and credit ratings bear different signs for different agencies, suggesting that Moody's, Standard & Poor's, and Fitch are using fairly heterogeneous criteria to evaluate municipalities. Notably, for both Moody's and Fitch, debt service expenditures are strongly negatively correlated with high credit ratings, controlling for the amount outstanding of direct general obligation debt (which is itself positively correlated with high credit ratings). As might be expected, if two municipalities have equal amounts of debt outstanding, the one paying more to service it has the lower credit rating; conversely, if two municipalities have equal debt service expenditures, the one with less outstanding debt has the higher credit rating. This finding provides some validation for the justification for considering both of these measures as proxies for different aspects of a municipality's access to credit and financial pressures, and moreoever suggests that creditors largely share (or rely on) credit agencies' assessments of municipality creditworthiness.

5 Information sensitivity

We turn now to the main body of this paper, an analysis of the informational structure of the municipal bond market. I begin with a series of replications of Benmelech and Bergman's tests (2018) for information insensitivity. I first verify that the relationships between price and the illiquidity measures constructed in Section 4.1 are correctly signed. I then investigate two predictions of the asymmetric information theory of bond illiquidity in Sections 5.1 and 5.2: first, that the hockeystick

structure of bond payoffs induces a nonlinear relationship dependence of illiquidity on price, and second, that controlling for current credit rating, bonds that had previously had higher ratings are more illiquid. I depart from Benmelech and Bergman in separately investigating information sensitivity in two different subsamples (temporally delineated by the downgrade of the monolines in the second half of 2008), as well as formally testing hypotheses that these two subsamples are subject to different informational regimes from Section 5.3 onward. I also particularize their methodology to the specific institutional structure of the municipal bond market in Section 5.4, testing whether (in parallel to the replication in Section 5.2) insured bonds are more illiquid than uninsured bonds with the same underlying credit rating once the monolines are downgraded.

5.1 Liquidity and price

Before analyzing the nonlinearity of the relationship between illiquidity and price, I first confirm the well-known relationship that bond illiquidity rises as bond price falls, and as bond yield rises. In Tables 7, 8, and 9, I regress the Amihud, Roll, and IRT measures of illiquidity on lags of bond price (columns 1-6) or bond yield (columns 7-12) with half-year and either bond (columns 1-4, 7-10) or issuer fixed effects (columns 5-6, 11-12), and either robust (columns 1-2, 7-8) or issuer-clustered (columns 3-6, 10-12) standard errors. That is, I regress versions of the following specification:

$$Illiquidity_{i,t} = \beta_0 + \beta_1 \times p_{i,t-1} + \beta_2 \times \mathbf{X}_{i,t-1} + \alpha_i + \theta_t + \epsilon_{i,t}, \tag{1}$$

where *Illiquidity* is the Roll, Amihud, or IRT measure, $p_{i,t-1}$ is the lagged price or yield spread over a maturity-matched Teasury, $\mathbf{X}_{i,t-1}$ is a vector of bond characteristics, α_i is a vector of cross-sectional fixed effects (bond or issuer), θ_t is a vector of semiannual fixed effects, and $\epsilon_{i,t}$ is the residual.

While the Amihud and IRT measures fail to demonstrate the correctly signed relationships at significance, the Roll measure of illiquidity does indeed increase as price decreases and as yield increases. The effect is robust to the inclusion of time, bond, and issuer controls, as well as a vector of bond charactereristics including time to maturity and issuance size. However, it is smaller in magnitude, although not in significance, than observed in Benmelech and Bergman: a one standard deviation decrease in bond price corresponds to an increase in illiquidity of 4.3 percent of the unconditional mean. Accordingly, the remainder of the analysis solely uses the Roll measure of

illiquidity.

Turning to the "hockey-stick" structure of bond payoffs, I estimate the following model in order to capture nonlinearity in the relationship between bond illiquidity and price:

$$Illiquidity_{i,t} = \beta_0 + \sum_{k=1}^{10} \beta_k \times Decile^k_{i,t-1} + \beta_{11} \times \mathbf{X}_{i,t-1} + \alpha_i + \theta_t + \epsilon_{i,t}, \tag{2}$$

where $Decile^k_{i,t-1}$ is an indicator variable equal to one if bond i falls in price decile k at time $t-1$, $\mathbf{X}_{i,t-1}$ is a vector of bond characteristics, α_i are bond fixed-effects, and θ_t are semiannual fixed effects. In the full MSRB sample (Table 10, column 3) as well as in subsamples before and after the monoline downgrades (columns 1 and 2, respectively), illiquidity falls more rapidly in the lower quantiles of price. However, note that after the collapse of the monolines (and, indeed, in the full sample), the "flat" section of the hockeystick instead inverts: at prices higher than that of the median bond, illiquidity begins to rise rather than fall (Figure 6). This phenomenon is not unique to insured bonds—which might suggest a residue of the yield inversion puzzle after the monoline downgrades documented by Bergstresser et al. (2010) and Chun et al. (2015)—but holds for uninsured bonds as well (Figure 7). One possible explanation inheres in an earlier empirical conundrum (and the subject of most early municipal bond research) that long-term yields on tax-exempt bonds are higher than expected relative to after-tax yields on taxable bonds (see, e.g., Trzcinka, 1982; Skelton, 1983; Buser and Hess, 1986; Green, 1993; Chalmers, 1998). If tax-exempt status confers a liquidity benefit to municipal bonds, then it is reasonable that taxable bonds should be both lower yield and more illiquid, contributing to inversion of the bond illiquidity-price relationship in higher deciles of bond price.

5.2 Liquidity and credit ratings

Next, I replicate the following set of models in Benmelech and Bergman (2018), which analyze the relationship between bond illiquidity and credit ratings. I first regress illiquidity on indicators for the credit rating tiers defined in Section 4.3, with 1 corresponding to Aaa debt and 10 to unrated debt:

$$Illiquidity_{i,t} = \beta_0 + \sum_{k=1}^{10} \beta_k \times Rating^k_{i,t-1} + \beta_{11} \times \mathbf{X}_{i,t-1} + \alpha_i + \theta_t + \epsilon_{i,t}, \tag{3}$$

where $Rating^k_{i,t-1}$ equals 1 if bond i has rating tier k in period $t-1$, $\mathbf{X}_{i,t-1}$ is a vector of bond characteristics, α_i are bond fixed effects, θ_t are half-year fixed effects, and $\epsilon_{i,t}$ is the regression residual. I estimate the model for the entire sample (Table 11, column 1), as well as subsamples before and after the first monoline downgrades (columns 2 and 3, respectively).

Note first that unrated bonds, in all time periods, trade similarly to middle-to-lower-middle investment grade bonds. Illiquidity increases as credit quality degrades after the first downgrade of the monolines, before which there are significant differences in liquidity neither between rating tiers nor between rated and unrated bonds. In the temporal subsamples that exhibit dependence of illiquidity on credit rating, the relationship is highly nonlinear: illiquidity rises sharply from rating tier 4 to 5, i.e. from lower-rated investment grade bonds to speculative grade bonds, and continues to rise as bonds approach default (Figure 8). The nonlinearity is strongly economically and statistically significant, at p values less than 0.001: illiquidity increases at the cusp of investment- and non-investment grade bonds by over 10 percent of the unconditional mean, and increasing default risk from an Aaa to a Caa rated bond increases illiquidity by 30 percent of the unconditional mean. This nonlinear "hockey-stick"-like dependence again suggests an information-sensitive regime postdating but not antedating the downgrade of the monolines.

Next, I follow Benmelech and Bergman in testing a prediction due to Hanson and Sunderam (2013), in which incentives to develop a robust "information production infrastructure" are stronger for less safe debt securities, since market participants are unlikely to gain much of an advantage by acquiring more information on safe assets. In this model, when a previously highly-rated bond is downgraded, market participants initially lack the informational infrastructure that would reduce asymmetric information. Accordingly, for two bonds of equal current credit ratings, the one issued at a higher credit rating should now be less liquid. To test this prediction, I estimate variations of the following model on the familiar temporal subsamples (Tables 12, 13, and 14):

$$Illiquidity_{i,t} = \beta_0 + \beta_1 \times \Delta Rating_{i,t-1} + \beta_2 \times \Delta t_{i,t-1} + \beta_3 \times \Delta Rating_{i,t-1} \times \Delta t_{i,t-1} + \sum_{k=1}^{10} \beta_{4+k} \times Rating^k_{i,t-1} + \alpha_i + \theta_t + \epsilon_{i,t}, \tag{4}$$

where $\Delta Rating_{i,t-1}$ is the bond-level difference between the lagged rating and either the preceding rating (columns 1 and 3) or the rating at issuance (columns 2 and 4), $\Delta t_{i,t-1}$ is the elapsed time in half-years since the last rating, $Rating^k_{i,t-1}$ are ratings tier indicators, α_i and θ_t are bond-level and semiannual fixed effects.

In keeping with the previous results, there are limited signs of information sensitivity or market behavior resulting from adverse selection prior to the initial downgrade of the monolines (Table 13). Only the coefficient on the interaction term $\Delta Rating_{i,t-1} \times \Delta t_{i,t-1}$ for changes from the previous rating is significant (t statistic 3.49), but its magnitude is fairly small—less than one percent of the unconditional mean of the Roll illiquidity measure, for a one-tier downgrade from the previous half-year. By contrast, after the monolines are downgraded, the coefficient on changes in rating from issuance (rather than from the previous period) is both large and statistically significant (t statistic 7.78): downgrading a bond that had been rated Aaa at issuance, whether under the underlying rating of its issuer or under that of its insurer, to Ba1 (the highest non-investment grade speculative rating) increases its illiquidity by 18.4 percent of the unconditional mean (Table 14 column 2).

Both the magnitude and significance of this point estimate are robust to controls for time elapsed since issuance and its interaction term (Table 14 column 4), neither of which attain significance, suggesting that the effect of a downgrade on illiquidity does not substantially decay over time. That is, even in an information-sensitive regime with strong incentives to produce additional information about municipal issuers' creditworthiness, market participants fail to develop particularly robust information producing infrastructure. This finding—unlike Benmelech and Bergman's results for the corporate bond market, which do exhibit decay over time—provides some evidence for the oft-noted informational inefficiency of the municipal bond market, perhaps owing to its large number of retail investors, heterogeneity of issuers, opacity of borrower finances, or lack of amenability to shorting (see Hund et al. (2018)). Weaker support can also be read into the sign on the effect of a change in rating not from issuance, but from the most recent prior rating (Table 14 columns 1 and 3): whereas estimating the model on the earlier subsample gives the "correct" (positive) sign, after the monolines are downgraded it flips to a statistically significant (although still economically small) negative effect. One possible explanation in keeping with the supposition of market inefficiency is that credit rating revisions are incorporated as new information: in the absence of information production infrastructure, or even the expectation of developing it, market participants have little information other than credit ratings on which to base their investment and trade activities. A revised credit rating might increase a bond's liquidity even if it indicates a closer distance to default, simply by providing market participants with more up-to-date information and lowering their uncertainty as to the true quality of the municipality. In other words, a ratings downgrade might shift the distribution of creditors' beliefs concerning a municipality's value closer to the hockey-stick's kink at the face

value of the debt contract, but in providing new information, it also reduces the distribution's variance.

5.3 Causal identification

One important reservation of the foregoing analysis inheres in its lack of causal specificity. The results so far strongly suggest an information-sensitive regime postdating and not antedating the monoline downgrades, perhaps with substantial informational inefficiencies remaining even (especially) after the regime transitions. However, whether such a change in informational structure can be ascribed to the monolines' collapse—or even when, precisely, it occurred—cannot yet be inferred. In an attempt to bridge this gap, in the remainder of the paper I supplement models estimated on different temporal subsamples with more formal tests of causal identification. To begin, I estimate a difference-in-differences variant of model (4), including an indicator for the period after the monolines collapse and its interaction with the change in rating from issuance. More formally, this model can be written as

$$Illiquidity_{i,t} = \beta_0 + \beta_1 \times \Delta Rating_{i,t-1} + \beta_2 \times Event_{t-1} + \beta_3 \times \Delta Rating_{i,t-1} \times Event_{t-1} + \sum_{k=1}^{10} \beta_{4+k} \times Rating^k_{i,t-1} + \alpha_i + \theta_t + \epsilon_{i,t}, \tag{5}$$

where $\Delta Rating_{i,t-1}$ is the change in lagged rating tier from the previous period or from issuance, $Event_{t-1}$ is an indicator equal to 1 if the event (in this case, the monolines no longer bearing Aaa ratings) was in occurrence the previous period and 0 otherwise, $Rating^k_{i,t-1}$ is an indicator equal to 1 if bond i had rating k in period $t-1$ and 0 otherwise, α_i are bond-level fixed effects, and θ_t are half-year fixed effects.

Notably, the difference-in-differences estimator is far from significance for the downgrade of the monolines, with a t statistic of 0.06 for $\Delta Rating_{i,t-1}$ defined from issuance and 0.05 defined from the previous period (Table 15 columns 1 and 2). Instead, the effects noted in the previous section—a small and negative relationship between illiquidity and downgrades from the previous period, and a large and positive one between illiquidity and downgrades from issuance—are associated with two other events or interventions occuring around or after the monolines were downgraded. The difference-in-differences estimator for the former effect, indicating learning from downgrades in an exceptionally uncertain informational environment, is strongly significant (and slightly larger than in the naive OLS) for the NBER recession (Table 15 column 3). For the latter effect, which

corresponds to the Benmelech and Bergman (2018) hypothesis of adverse selection for newly-downgraded bonds with a higher rating at issuance in information-sensitive contexts, the difference-in-differences estimator is strongly significant only for an event beginning in 2012h1 (Table 15 column 4). These results suggest that while the monoline downgrades may have provided the conditions of possibility for the municipal bond market to transition from an information-insensitive to an information-sensitive environment, the event actually precipitating such a regime change may not have occured until much later, in early 2012.

5.4 Insurance

So far, the results in this paper have not distinguished between insured and uninsured bonds; to the extent that they illustrate a transition between information regimes, all municipal bonds, regardless of whether their issuers had purchased insurance, appear subject to it. However, in order to illuminate both the nature and the precise temporality of these changes, it is now necessary to further depart from Benmelech and Bergman (2018) by considering the effect of bond insurance. I modify the previous regression specification (Equation 5) by including insurance-specific interaction terms:

$$\begin{aligned} Illiquidity_{i,t} =& \beta_0 + \beta_1 \times \Delta Rating_{i,t-1} + \beta_2 \times Event_{t-1} + \beta_3 \times \Delta Rating_{i,t-1} \times Event_{t-1} \\ &+ \beta_4 Insured_i \times \Delta Rating_{i,t-1} + \beta_5 Insured_i \times Event_{t-1} + \beta_6 Insured_i \times \Delta Rating_{i,t-1} \times Event_{t-1} \\ &+ \sum_{k=1}^{10} \beta_{6+k} \times Rating^k_{i,t-1} + \alpha_i + \theta_t + \epsilon_{i,t}, \end{aligned} \tag{6}$$

where $Insured_i$ is an indicator equal to 1 if a bond is insured and 0 otherwise, $\Delta Rating_{i,t-1}$ is the bond-level difference between the lagged rating and rating at issuance, $Event_{t-1}$ is an indicator equal to 1 if the event (either the downgrade of the monolines in Table 16 column 1, or the shift in informational structure in column 2) is in effect and 0 otherwise, $Rating^k_{i,t-1}$ are ratings tier indicators, α_i and θ_t are bond-level and semiannual fixed effects. (The inclusion of $Insured_i$ simpliciter as a regressor would introduce collinearity with α_i.) Note that the number of uninsured but rated bonds prior to the monoline downgrade is small (see summary statistics in Section 4.2); as such, point estimates for this subsample should not necessarily be taken as correctly estimated.

Considering first the original identification of the intervention date with the monolines' loss of their Aaa ratings, the coefficients on the difference-in-differences estimator from Equation (5), the interaction of changes in ratings since issuance with bond insurance, and the interaction of the original difference-in-differences estimator with bond insurance each become strongly statistically and economically significant (Table 16), on the order of the effect sizes in the naive OLS regression (Equation 4, Table 14). Combining the interaction terms, we have point estimates of: (1) no change in illiquidity per ratings tier downgrade for uninsured bonds prior to the monolines' loss of their Aaa ratings; (2) an increase in illiquidity by 2.7 percent of the unconditional mean per ratings tier downgrade for an insured bond prior to the monolines' loss of their Aaa ratings; (3) an increase in illiquidity by 5.2 percent of the unconditional mean per ratings tier downgrade for an uninsured bond after the monolines' loss of their Aaa ratings; and (4) an increase in illiquidity by 2.5 percent of the unconditional mean per ratings tier downgrade for an insured bond after the monolines' loss of their Aaa ratings.

Two aspects of these results are surprising at first glance: first, that credit rating changes increased bond illiquidity for insured rather than uninsured bonds prior to the monoline downgrades, and second, that after the monoline downgrades, uninsured bonds saw a larger point estimate of sensitivity to credit rating changes than did insured bonds. For the former, one might have expected to find uninsured bonds inhabiting a relatively information-sensitive environment, coupled with the monolines insulating municipal debt from investor attention. Instead, neglecting sample size concerns, we see that the monolines' existence (or investor complacency owing to their predominance) effected information-insensitive conditions throughout the municipal bond market, beyond the portfolios of bonds they insured. This interpretation is lent additional credence by the robustness check in Table 16 column 3, which replaces $Insurance_i$ in the specification in Equation 6 with an indicator $UsingInsurance_{i,t-1}$ equal to 1 when bond i is both insured and either has an unrated issuer or one strictly lower rated than the rating of its insurer in period $t-1$. The most plausible reason that monolines' informational effects would have been restricted to their insured portfolios is that insurance renders it unnecessary to gather additional information about the issuers of insured bonds, over and above information about their insurers, to ascertain whether their default risk will deteriorate. In this case, one would expect to see a negative coefficient on $UsingInsurance_{i,t-1}$ and its interaction terms—however, no coefficients are significant. Conversely, it is reasonable that downgrades increased bond illiquidity for insured bonds prior to 2008h2: any changes in insured

bonds' credit ratings must have been due to changes in their insurer's credit rating. Insurance renders the market insensitive only to information about municipal issuers; information about insurers remains (or rather, becomes) valuable to creditors.

Our second conundrum seems less easy to resolve, in part because we can no longer avail ourselves to the explanation of distortions from small sample size. The suggestion in Section 5.3 and the foregoing passage that robust information production mechanisms failed to develop for uninsured bonds prior to the collapse of the monolines gives some reason to believe that insured municipal bonds would not be more illiquid than their uninsured counterparts after the collapse: the hypothesis derived from Hanson and Sunderam (2013) is predicated on the existence of that very informational infrastructure. However, these results are merely suggestive, and moreover do not explain why the liquidity of insured bonds should be less, rather than equally, sensitive to changes in credit ratings than is the liquidity of uninsured bonds. One possible explanation might be that even after all the monoline insurers are downgraded in 2008, some insurance continued to have value, in terms of insulating issuers from investor attention. In fact, re-estimating Equation 6, we see that it is only beginning in early 2012 that insured and uninsured bonds are equally sensitive to changes in credit ratings (Table 6 column 2). In this way, the results of our first difference-in-differences estimate in Section 5.3 can be further refined. While that model indicates that the municipal bond market did not become information sensitive until early 2012, decomposing the effects among insured and uninsured portfolios reveals that the shift in informational regime happened in stages. Immediately after the monolines were downgraded, uninsured bond liquidity became much more sensitive to information about municipal credit quality. The same transition for insured bonds did not occur until 2012. Identifying the event that precipitated this change in early 2012 is beyond the scope of this paper, but plausible candidates include the pending downgrade of FSA and Assured Guaranty (the only monolines that had retained high investment grade credit quality), or the then-largest municipal bankruptcy of Jefferson County, Alabama, which occured in November 2011.

6 Sensitivity to what information?

To briefly take stock, I have thus far marshalled a variety of evidence that the prior to the downgrade of the monolines in 2008, the municipal debt market—including uninsured bonds—was broadly insensitive to information about municipal issuers. After the monolines were initially downgraded,

the liquidity of uninsured bonds became sensitive to issuer information, while the same would only occur for insured bonds in early 2012. For the remainder of the paper, I will investigate precisely which kinds of additional information (if any) creditors began to value once the municipal debt market became information-sensitive, and how municipalities responded to their new informational environment.

While the literature suggests that the municipal bond market is primarily ratings-driven, with at times severe inefficiencies in processing information from other sources including monoline equity and CDS markets (Hund et al., 2018), there is some emerging evidence that investors in U.S. state debt price in issuers' pension commitments (Boyer, 2018). Accordingly, in the following section I repeat the structure of Sections 5.2 and 5.3 in order to determine the sensitivity of bond illiquidity to municipalities' fiscal characteristics. To begin with, for the pre- and post-monoline downgrade subsamples, I estimate the following model,

$$Illiquidity_{i,t} = \beta_0 + \beta_1 \times BudgetVar_{I(i),t-1} + \sum_{k=1}^{10} \beta_{1+k} \times Rating^k_{i,t-1} + \beta_{12}\mathbf{X}_{i,t-1} + \alpha_i + \theta_t + \epsilon_{i,t}, \quad (7)$$

where $I(i)$ is the municipal issuer of bond i; $BudgetVar_{I(i)}$ is the value of a debt burden, pension obligation, or fiscal capacity variable constructed from CAFR data as defined in Section 6; $Illiquidity_{i,t}$ is Roll illiquidity, $Rating^k_{i,t-1}$ is an indicator equal to 1 if bond i is of rating tier k in period $t-1$; $\mathbf{X}_{i,t-1}$ is a vector of bond characteristics; and α_i and θ_t are bond and half-year fixed effects. I also estimate a version of Equation 7 using indicators $BudgetQuartile_{I(i),t-1}$ for the quartiles of $BudgetVar$, rather than its cardinal value:

$$Illiquidity_{i,t} = \beta_0 + \sum_{j=1}^{4} \beta_j \times BudgetQuartile_{I(i),t-1} + \sum_{k=1}^{10} \beta_{5+k} \times Rating^k_{i,t-1} + \beta_{16}\mathbf{X}_{i,t-1} + \alpha_i + \theta_t + \epsilon_{i,t}. \quad (8)$$

Lastly, I estimate difference-in-differences variants on (7) and (8) for the monoline downgrade and a few later events. I conduct this procedure for all debt burden and pension obligation variables scaled by fiscal capacity, as defined in Section 6.[4] In the interest of economical presentation, I report results only for budget variables with difference-in-differences estimators significant at $p < 0.05$, namely the ratios of debt service expenditures, unfunded pension/OPEB liabilities, and total pension/OPEB

[4] That is, for $\frac{\text{Deficit}}{\text{TaxRevenue}}$, $\frac{\text{Deficit}}{\text{TaxBase}}$, $\frac{\text{DirectDebt}}{\text{TaxRevenue}}$, $\frac{\text{DirectDebt}}{\text{TaxBase}}$, $\frac{\text{DebtServiceExpenditures}}{\text{TaxRevenue}}$, $\frac{\text{DebtServiceExpenditures}}{\text{TaxBase}}$, $\frac{\text{DebtServiceExpenditures}}{\text{TotalExpenditures}}$, $\frac{\text{UnfundedLiabilities}}{\text{TaxRevenue}}$, $\frac{\text{UnfundedLiabilities}}{\text{TaxBase}}$, $\frac{\text{TotalLiabilities}}{\text{TaxRevenue}}$, $\frac{\text{TotalLiabilities}}{\text{TaxBase}}$, $\frac{\text{CoveredPayroll}}{\text{TaxRevenue}}$, $\frac{\text{CoveredPayroll}}{\text{TaxBase}}$, and $\frac{\text{CoveredPayroll}}{\text{Population}}$.

liabilities to tax revenue.

Bond illiquidity appears sensitive only to a municipality's quartile in debt service expenditures as a fraction of tax revenue, among all measures I consider of debt burdens or budgetary imbalance. First considering the naive OLS (Equation 8) on temporal subsamples, the quartile of debt service expenditures to tax revenue to which a municipality belongs is not significant prior to the monoline downgrades (Table 17 column 1), but highly significant after (column 2). After the monolines are downgraded, bonds issued by a municipality above the 25th percentile in debt servicing expenditures to tax revenue are statistically ($p < 0.001$) and economically (an increase by 5.5 percent of the unconditional mean) more illiquid than those of a municipality below the 25th percentile. More precisely identifying the causal event in difference-in-differences estimation, I find that municipal bond markets became sensitive to debt servicing expenditures-to-tax revenue quartiles from early 2010 (Table 18), a year's delay after the monoline downgrades.

Note first that there is, by contrast, no significant dependence of illiquidity on debt service expenditures-to-tax revenue simpliciter, i.e. included not as quartile indicators but as a cardinal value per Equation 7. Rather than evincing a lack of robustness, this result is reasonable given the institutional context of the municipal bond market. If for a given investor, total investment in municipal debt is fairly inelastic relative to municipal debt quality, then ordinal measures of a municipality's fiscal health as compared to others' should matter more to the investor than cardinal measures. This antecedent is likely to go through for certain institutional investors with government issuer or ratings requirements on investments, including 2a-7 MMMFs, which are required by the SEC to invest at least 80 percent of their assets in, or derive at least 80 percent of their income from, municipal bonds (Sirri, 2008).

The opposite valuation of relative and absolute measures holds for pension obligations. Whereas illiquidity does not vary in (funded or unfunded) pension liability quartiles, municipalities with cardinally greater unfunded and total pension liabilities have significantly less liquid bonds after the monoline downgrades (Table 19). While the effect is statistically and economically small in the difference-in-differences setting, it is suggestive that bond illiquidity may be sensitive to cardinal rather than ordinal measures of pension obligations—and moreover, to both unfunded and funded pension/OPEB liabilities. In contrast with the analysis of creditor attentiveness to municipal deficits and debt service expenditures, these two features suggest that investors look at pension commitments not to select the healthiest issuers to fill a municipal bond portfolio of roughly predetermined size,

but instead to avoid large competing claims on municipalities' revenue streams or assets (particularly in the case of default).

7 Signalling

After having examined creditors' attunement to municipality-level characteristics in the wake of the monolines' downgrade, I now turn to how municipalities have adjusted to their new informational context. If a municipality believes that market participants are paying attention to its finances, it may alter the appearance or reality of its financial standing. To achieve the former, a municipality may favor more flattering accounting methods in its CAFRs; for the latter, it may engage in costly (and potentially welfare-reducing) signalling. While assessing the real effects of the new information-sensitive regime postdating the collapse of the monolines is beyond the scope of this paper, the sample assembled in this paper provides novel opportunities for investigating the former possibility.

First, I construct municipality-level measures of information sensitivity that proxy creditor attention as the degree of nonlinearity in the relationship between the illiquidity and price of bonds issued by each municipality (see Section 5.1). In particular, I estimate Equation 2 using quartiles instead of deciles, and on each subsample of bonds issued by a given municipality and traded in a particular year, rather than for the entire sample. That is, I estimate the following model for each municipality and year,

$$Illiquidity_{i,t} = \beta_0 + \sum_{k=1}^{4} Quartile_{i,t-1}^{k} + \beta_5 \times \mathbf{X}_{i,t-1} + \alpha_i + \theta_t + \epsilon_{i,t-1}, \tag{9}$$

where $Illiquidity_{i,t}$ is Roll illiquidity, $Quartile_{i,t-1}^{k}$ is an indicator equal to 1 if bond i is in price quartile i in period k, $\mathbf{X}_{i,t-1}$ is a vector of bond characteristics, and α_i and θ_t are bond and half-year fixed effects. For each municipality I and year t, I then construct the following measures of linearity in (9),

$$Insensitivity_{I,t}^{32} = \frac{\beta_3^{I,t} - \beta_2^{I,t}}{\beta_2^{I,t}} \tag{10}$$

$$Insensitivity_{I,t}^{43} = \frac{\beta_4^{I,t} - \beta_3^{I,t}}{\beta_3^{I,t} - \beta_2^{I,t}}. \tag{11}$$

The more information sensitive (in a given year) the market for a municipality's bonds, the more

pronounced the hockey-stick nonlinearity in the relationship between its bonds' illiquidity and price, and hence the smaller measures (10) and (11). Conversely, the less information sensitive the market for a municipality's bonds, the more linear the relationship between bond illiquidity and price, and hence the closer measures (10) and (11) to 1. Finally, I estimate the following model on the entire yearly panel of municipalities,

$$\begin{aligned} ChangedValuation_{I,t} =& \beta_0 + \beta_1 \times Insensitivity^{32}_{I,t-1} + \beta_2 \times Insensitivity^{43}_{I,t-1} + \beta_3 Event_{t-1} \\ &+ \beta_4 \times Insensitivity^{32}_{I,t-1} \times Event_{t-1} + \beta_5 \times Insensitivity^{43}_{I,t-1} \times Event_{t-1} \\ &+ \alpha_I + \theta_t + \epsilon_{I,t}, \end{aligned} \tag{12}$$

where $ChangedValuation_{I,t}$ is an indicator equal to 1 if any of the actuarial methods used to evaluate pension or OPEB liabilities have changed from the previous year (GFOA variables `PERSVAL`, `PERSVAL1`, `PERSVAL2`, `OPEBVAL`, etc.), $Event_{t-1}$ is equal to 1 if the monolines are no longer rated Aaa, and α_I and θ_t are municipality and year fixed effects.

The coefficient on $Event_{t-1}$ is strongly significant ($p < 0.001$) and large in magnitude (Table 20); after the monolines are downgraded, municipalities in general are far more likely to voluntarily change the accounting procedures they use to evaluate pension obligations. Moreover, the difference-in-differences estimator on $Insensitivity^{43}$ is also significant at $p < 0.001$ and negative in sign. That is, after the monolines are downgraded, the more information-sensitive a municipality's bonds, the more likely it is to change its accounting methods. This result is robust to the inclusion or exclusion of various insensitivity measures and interaction terms (Table 20 columns 1-2). Municipalities, this analysis suggests, are not only aware that the information structure of the municipal bond market changed drastically with the collapse of monoline insurance, but also willing and able to interact strategically within it.

8 Conclusion

Analyzing the information structure of municipal financing, I presented a wide variety of Benmelech and Bergman (2018)-type evidence that the municipal bond market broadly transitioned from an information insensitive to an information sensitive environment after monoline insurers lost their Aaa

ratings. The hypothesis that even uninsured bonds were information insensitive prior to this event could not be rejected; nor could the possibility that monoline insurance issued by FSA and Assured Guaranty continued to have value in suppressing information sensitivity until late 2011 to early 2012, owing potentially to either the continued degredation of municipal finances or the pending loss of high investment-grade ratings for even these final monolines. Turning to creditors and borrowers' interactions in their new informational context, results suggest that creditors acquired and valued information about relative debt service payments to tax revenue and absolute unfunded and funded pension liabilities. Municipalities in turn react to creditor attention by strategically altering the accounting methods used to evaluate their finances.

A few concluding remarks are in order concerning the particular types of information creditors became incentivized to acquire. Reliance on debt servicing expenditures is deeply troubling from the perspective of public policy, in that it entails that municipalities will face escalating debt burdens—and diminished capacities to engage in countercyclical spending—as their financial condition weakens. While this concern in some ways represents a standard critique of municipal debt financing, my findings suggest that real deterioration in municipalities' fiscal health may not even be necessary to trigger or maintain the vicious cycle. By looking only at debt servicing expenditures, creditors are effectively acquiring information not about municipalities' true financial standings (which might be better proxied by e.g. the other candidate measures I considered: deficits, direct debt burdens, tax revenues, tax bases) but instead about *other creditors'* revealed beliefs about those values. The information sensitive environment postdating the collapse of monoline insurers, intrinsic to the structure of debt securities, may subject municipalities to a damaging, procyclical beauty contest.

These observations raise the question as to why, with the exception of pension liabilities, creditors do not acquire additional information that might more directly reflect municipal health. One possibility emerges from my analysis of municipalities' attempts to use their financial reports to costlessly signal borrower quality. If creditors anticipate this behavior, they may put very little weight on information produced by the municipalities themselves. In fact, the substantially lower statistical significance of the effect of pension commitments on illiquidity, as compared to that of debt service payments, suggests that there may be some truth to this conjecture. And if creditors disregard municipalities' costless signalling, it stands to reason that municipalities may attempt to generate much more costly signals about borrower quality. My paper suggests strategic information production by municipal borrowers and creditors, within models of information insensitivity, as a

rich site for further research.

Finally, the results of this study carry important implications for post-crisis reforms to the municipal debt market. Perhaps in recognition of the newly information sensitive environment, the policy response has chiefly taken the form of increased issuer disclosure requirements (see the Dodd-Frank Act §975). While these changes made possible this paper, which relied on the MSRB's publicly available transaction data, my analysis of information sensitivity suggests that increased transparency may have been deeply misguided. As Bengt Holstrom notes, debt has "two faces: a quiet one and a tumultuous one" (Holmstrom, 2015). By minimizing information sensitivity, debt pushes the need to ask question and acquire information (as well as the risk of adverse selection) far out on the tail. While the transition to this information insensitive state imposes high costs on municipalities, "the quiet, liquid state is hugely valuable"—monoline insurers developed for this very reason. To prevent creditors and municipalities from playing damaging information games at the expense of the latter's residents, regulators may have to restore not transparency but opacity, with its guarantors and guarantees, to the municipal debt market.

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Table 1: Moody's credit ratings for major monolines

Downgrade date	New rating
AMBAC	
·	Aaa
6/19/2008	Aa3
11/5/2009	Baa1
7/29/2009	Caa2
Assured Guaranty	
·	Aa1
7/1/2007	Aaa
11/21/2009	Aa3
1/17/2013	A2
Build America Mutual	
·	AA
CIFG	
·	Aaa
3/6/2008	A1
5/20/2008	Baa2
10/28/2008	B3
1/22/2009	Ba3
8/20/2009	Caa2
11/1/2009	Ca
FGIC	
·	Aaa
2/14/2008	A3
3/31/2008	Baa3
6/20/2008	B1
12/19/2008	Caa1
3/24/2009	Caa3
11/24/2009*	Baa3

Downgrade date	New rating
FSA	
·	Aaa
11/21/2008	Aa3
1/17/2013	A3
MBIA	
·	Aaa
6/19/2008	A2
11/7/2008	Baa1
6/25/2009	Baa3
Radia	
·	Aa3
6/25/2008	A3
3/12/2009	Ba1
11/22/2011	Caa1
4/17/2012	Caa2
4/1/2015	A2
XL Capital	
·	Aaa
3/6/2008	A3
6/20/2008	B2
10/24/2008	Caa1
3/17/2009	Ca

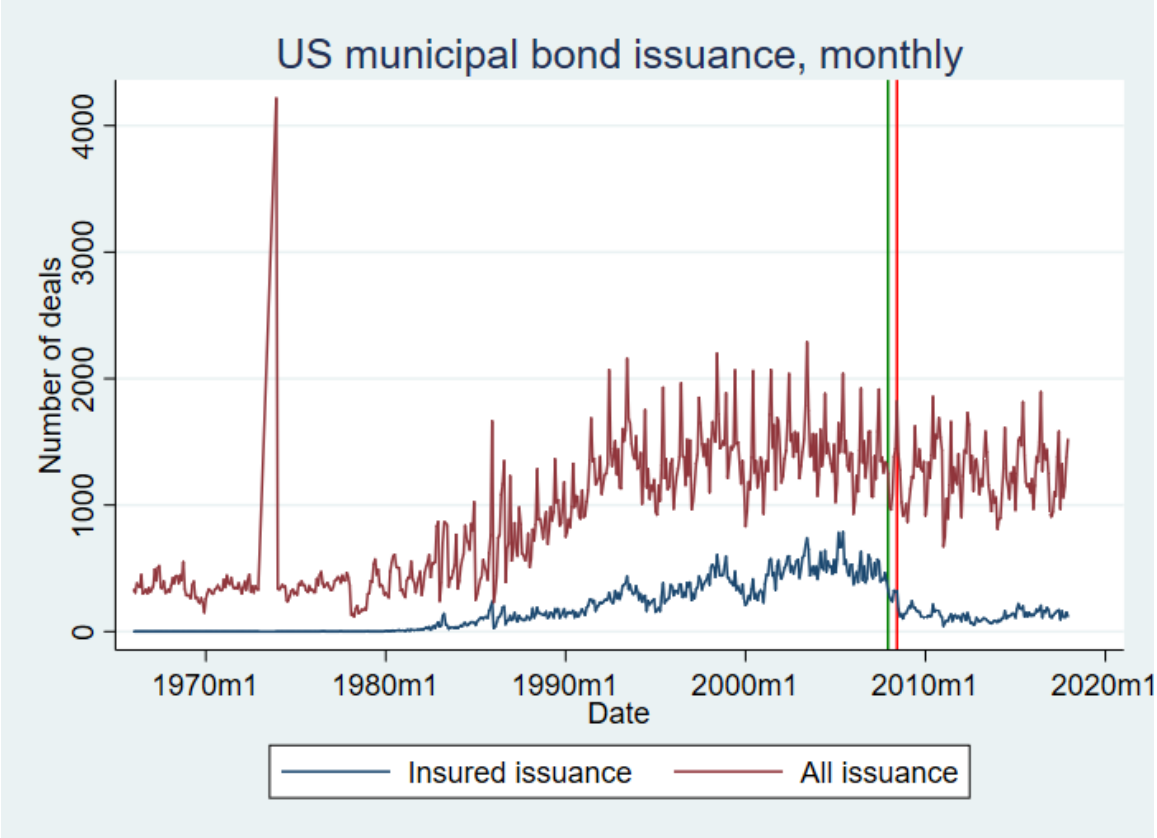


Figure 1: Number of new US municipal bond deals issued per month, from January 1, 1966 to December 31, 2017. Green vertical line correponds to the Moody's rating action on December 14, 2007 placing Financial Guaranty and XL Capital Assurance on review for possible downgrade, and affirming but with newly negative outlook the ratings for Financial Guaranty and MBIA. Red vertical line corresponds to the downgrade on June 19, 2008 of Ambac and MBIA. "Insured issuance" refers to deals containing at least one insured bond.

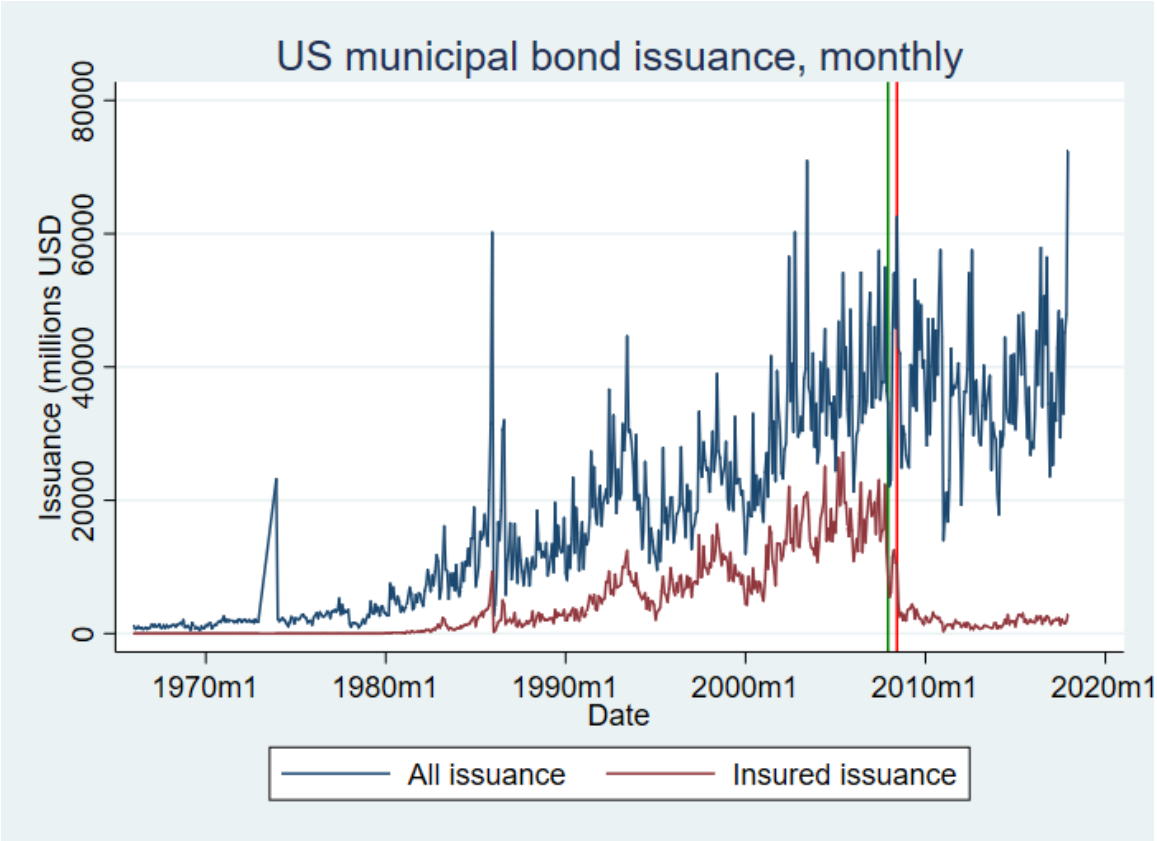


Figure 2: Volume in millions USD of new US municipal bond issuance per month, from January 1, 1966 to December 31, 2017. Green vertical line correponds to the Moody's rating action on December 14, 2007 placing Financial Guaranty and XL Capital Assurance on review for possible downgrade, and affirming but with newly negative outlook the ratings for Financial Guaranty and MBIA. Red vertical line corresponds to the downgrade June 19, 2008 of Ambac and MBIA.

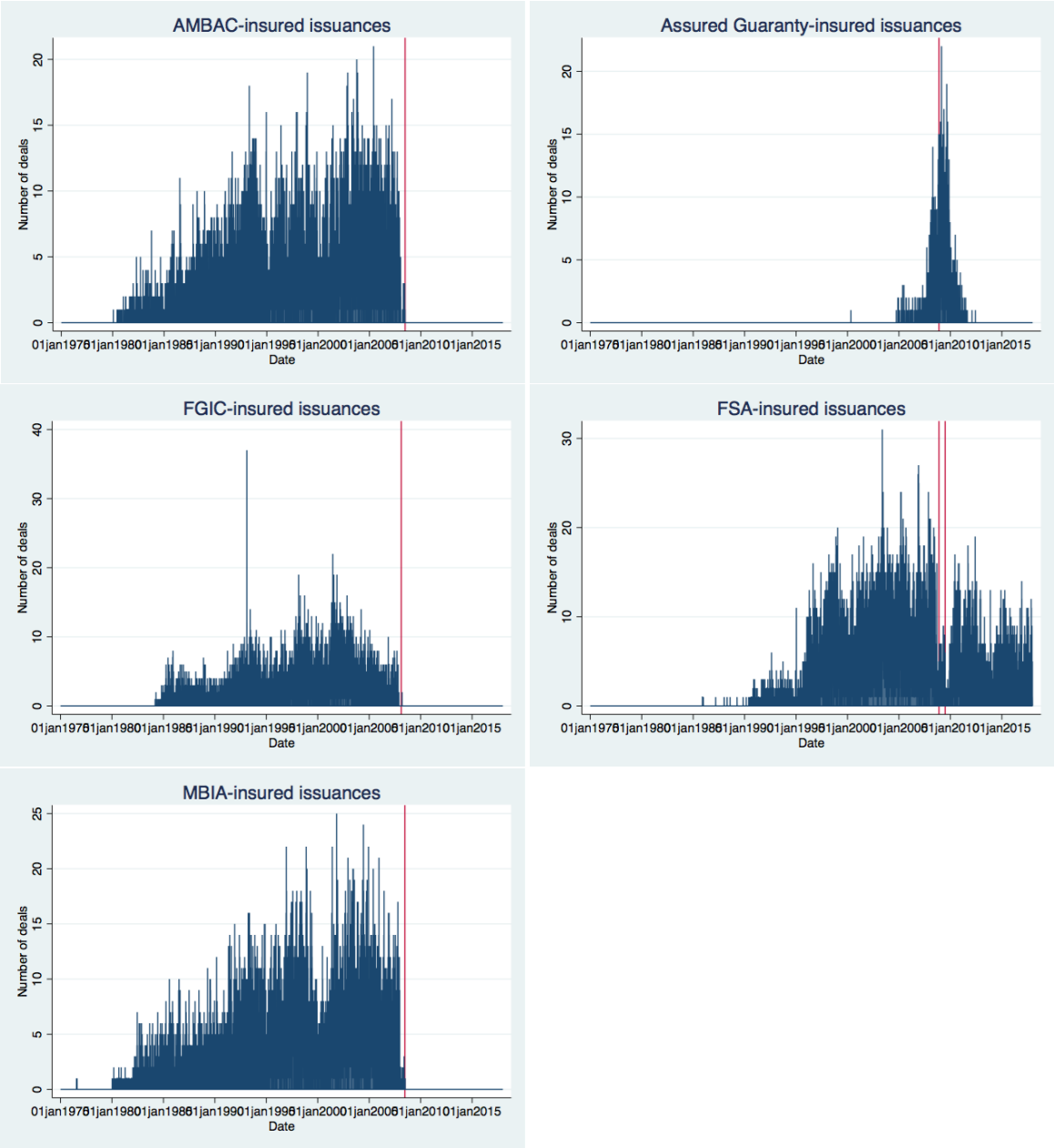


Figure 3: Daily issuance of municipal bond deals insured by the largest monolines, from January 1, 1966 to December 31, 2017. Vertical lines correspond to the first Moody's ratings downgrade for each insurer: Ambac on June 19, 2008 from Aaa to Aa3; Assured Guaranty on November 21, 2008 from Aaa to Aa2; Financial Guaranty Insurance Company on February 14, 2008 from Aaa to A3; FSA on November 21, 2008 from Aaa to Aa3; and MBIA on June 19, 2008 from Aaa to A2. The sale of FSA to Assured Guaranty on July 1, 2009 is also marked. A deal is counted as insured by a monoline if at least one bond was insured by that monoline; some deals may different bonds insured by different insurers.

Table 2: MSRB municipal bond transaction data

Variable	Mean	SD	25th percentile	Median	75th percentile	N
Panel A: Pre-crisis (2005-2007)						
Yield	3.76	1.95	3.47	3.81	4.20	971203
Price	101.48	6.74	100.00	101.66	104.45	1024418
Illiquidity (Amihud)	0.96	3.03	0.12	0.44	1.15	773369
Illiquidity (Roll)	0.44	0.26	0.28	0.49	0.63	193390
Illiquidity (IRT)	0.08	53.02	0.01	0.01	0.02	937946
Panel B: Crisis (2007-2009)						
Yield	3.75	2.04	3.15	3.85	4.44	1626110
Price	100.81	7.23	99.71	101.18	104.18	1691145
Illiquidity (Amihud)	1.12	11.74	0.14	0.47	1.21	1523408
Illiquidity (Roll)	0.38	0.26	0.20	0.41	0.56	337194
Illiquidity (IRT)	0.15	75.05	0.01	0.01	0.03	1547878
Panel C: Post-crisis (2009-2018)						
Yield	2.31	2.13	1.26	2.11	3.19	4552715
Price	105.10	8.42	100.96	104.48	109.62	4752837
Illiquidity (Amihud)	1.32	555.43	0.17	0.47	1.12	4407034
Illiquidity (Roll)	0.41	0.25	0.27	0.44	0.58	1038473
Illiquidity (IRT)	0.06	53.91	0.00	0.01	0.02	4375709
Panel D: Full sample						
Yield	2.84	2.20	1.64	2.94	3.93	7150028
Price	103.63	8.19	100.21	103.06	107.49	7468400
Illiquidity (Amihud)	1.23	450.38	0.16	0.47	1.14	6703811
Illiquidity (Roll)	0.41	0.25	0.26	0.44	0.58	1569057
Illiquidity (IRT)	0.08	59.23	0.01	0.01	0.02	6861533

Note: Illiquidity measures computed for MSRB sample described in Section 4.1.

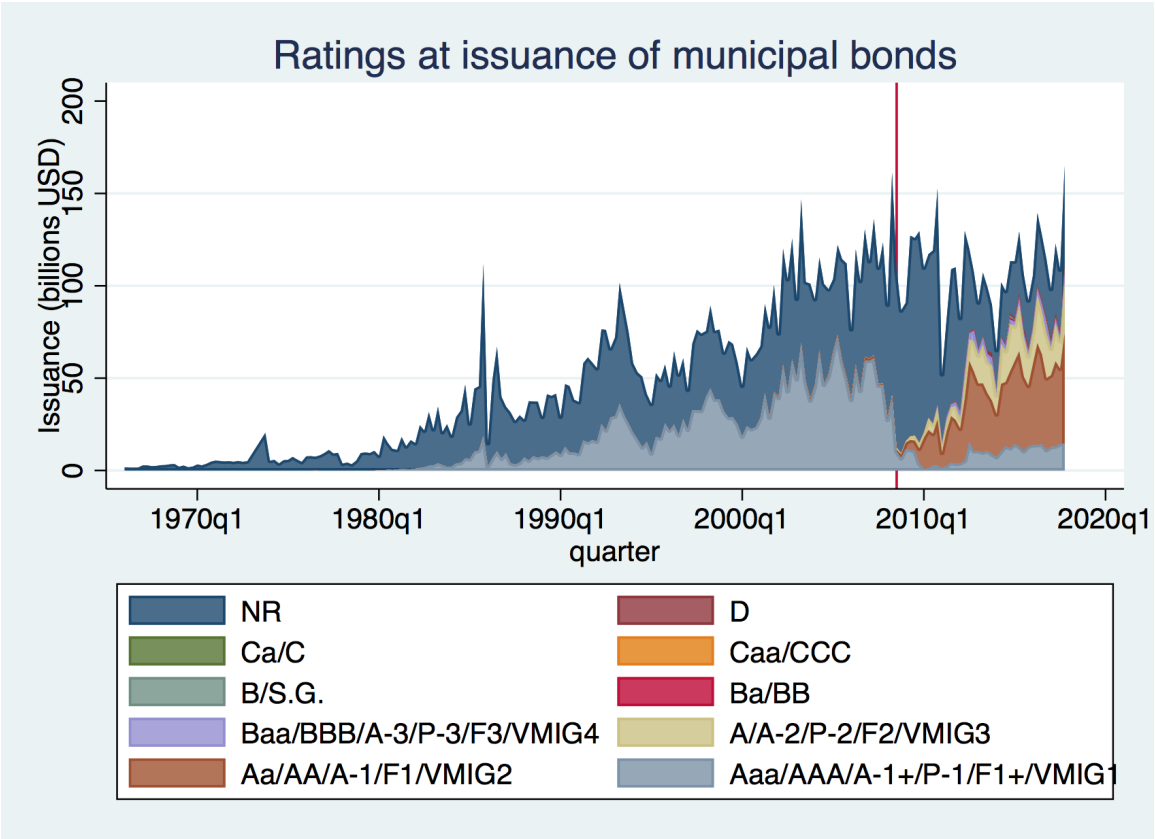


Figure 4: Credit ratings at issuance of new issues per quarter in the SDC Platinum dataset that could be matched with bonds in the Moody's, Standard & Poor's, or Fitch's regulatory filings. When rated by multiple agencies and at various time horizons or taxable statuses, bonds are attributed their long-term rating, when possible, followed by the highest rating attained among different rating agencies. Red line indicates the downgrades of Ambac and MBIA in 2008q3.

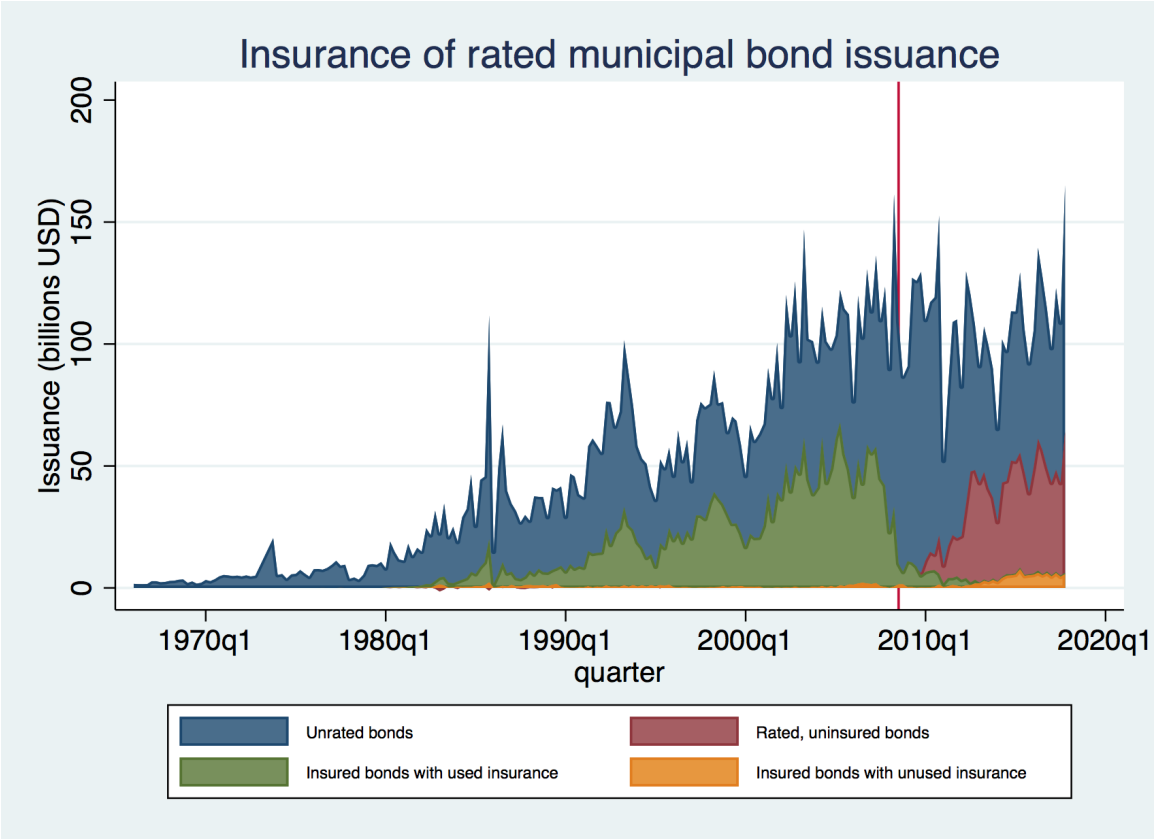


Figure 5: Insurance of rated municipal bonds of new issues per quarter in the SDC Platinum dataset that could be matched with bonds in the Moody's, Standard & Poor's, or Fitch's regulatory filings. Insurance is described as "unused" if the highest underlying rating of the bond's issuer equals or exceeds that of its insurer. Red line indicates the downgrades of Ambac and MBIA in 2008q3.

Table 3: Unique bonds in sample by state

State	#	State	#	State	#
TX	51695	IA	4643	NE	1110
CA	51175	WI	4638	NM	1093
FL	14681	NC	4512	ND	959
OH	13525	MA	4068	RI	947
IL	12895	SC	3952	AR	919
MN	12272	MO	3545	AK	752
MI	8838	GA	3218	NH	720
CT	7864	CO	2894	LA	632
NY	7007	AL	2799	HI	456
VA	6051	TN	2623	MT	436
AZ	6027	IN	2204	MS	424
PA	5978	MD	1683	ID	407
KS	5478	NV	1571	DE	250
OK	4939	ME	1539	SD	146
OR	4810	UT	1393	WY	55
WA	4735	KY	1200	WV	30

Note: Merged final sample from illiquidity measures (constructed from MSRB transaction data), credit ratings (from Moody's, S&P, and Fitch), bond insurance at issuance (from SDC Platinum), and municipal budget data (from GFOA), including 866,401 half-year/9-digit CUSIP observations from 1,757 municipalities across 48 states. On average, municipalities have 156 different bonds (p25 = 22, p50 = 58, p75 = 158).

Table 4: Municipal CAFR variables (deficits and debts)

Variable	Mean	SD	25th %ile	Median	75th %ile	N
Panel A: Full sample						
Deficit/Tax Revenue	-0.746	20.233	-0.611	-0.200	0.003	8569
Deficit/Tax Base	-0.005	0.124	-0.003	-0.001	0.000	8761
Direct Debt/Tax Revenue	3.165	22.956	0.820	1.798	3.409	7323
Direct Debt/Tax Base	0.036	0.645	0.004	0.008	0.016	7478
Debt Servicing/Tax Revenue	1.090	24.181	0.162	0.313	0.568	8273
Debt Servicing/Tax Base	0.007	0.099	0.001	0.001	0.002	8459
Debt Servicing/Total Expenditures	0.101	0.078	0.052	0.084	0.129	8731
Panel B: Pre-crisis (2005-2007)						
Deficit/Tax Revenue	-0.925	21.029	-0.607	-0.177	0.057	1924
Deficit/Tax Base	-0.004	0.062	-0.003	-0.001	0.000	1971
Direct Debt/Tax Revenue	3.166	11.015	0.832	1.831	3.474	1591
Direct Debt/Tax Base	0.012	0.015	0.004	0.008	0.016	1625
Debt Servicing/Tax Revenue	2.030	38.540	0.144	0.292	0.535	1721
Debt Servicing/Tax Base	0.006	0.107	0.001	0.001	0.002	1761
Debt Servicing/Total Expenditures	0.095	0.079	0.047	0.078	0.123	1791
Panel C: Crisis (2007-2009)						
Deficit/Tax Revenue	-0.567	3.989	-0.721	-0.254	-0.028	2737
Deficit/Tax Base	-0.005	0.179	-0.003	-0.001	0.000	2803
Direct Debt/Tax Revenue	2.818	5.226	0.822	1.710	3.246	2346
Direct Debt/Tax Base	0.038	0.706	0.004	0.008	0.015	2400
Debt Servicing/Tax Revenue	0.617	2.747	0.173	0.322	0.576	2703
Debt Servicing/Tax Base	0.007	0.100	0.001	0.001	0.002	2770
Debt Servicing/Total Expenditures	0.098	0.075	0.051	0.081	0.124	2869
Panel D: Post-crisis (2009-2013)						
Deficit/Tax Revenue	-0.784	25.862	-0.544	-0.173	0.004	3908
Deficit/Tax Base	-0.005	0.097	-0.003	-0.001	0.000	3987
Direct Debt/Tax Revenue	3.406	32.616	0.811	1.838	3.472	3386
Direct Debt/Tax Base	0.046	0.744	0.004	0.009	0.017	3453
Debt Servicing/Tax Revenue	1.001	24.233	0.163	0.314	0.579	3849
Debt Servicing/Tax Base	0.008	0.095	0.001	0.001	0.003	3928
Debt Servicing/Total Expenditures	0.106	0.079	0.055	0.088	0.135	4071

Note: Full GFOA sample of municipal CAFRs.

Table 5: Municipal CAFR variables (pension and OPEB commitments)

Variable	Mean	SD	25th %ile	Median	75th %ile	*N*
Panel A: Full sample						
Pension Shortfall/Tax Revenue	4.53	71.95	0.33	1.16	2.94	6841
Pension Shortfall/Tax Base	0.07	1.82	0.00	0.00	0.01	6934
Pension Liabilities/Tax Revenue	14.25	452.09	0.13	2.66	8.03	8590
Pension Liabilities/Tax Base	0.14	3.72	0.00	0.01	0.03	8782
Pension Payroll/Population	710.15	8119.13	0.00	368.57	702.74	9058
Pension Payroll/Tax Revenue	3.27	58.58	0.01	1.04	2.26	8590
Pension Payroll/Tax Base	0.03	0.49	0.00	0.00	0.01	8782
Panel B: Pre-crisis (2005-2007)						
Pension Shortfall/Tax Revenue	5.64	136.23	0.16	0.74	1.77	1283
Pension Shortfall/Tax Base	0.01	0.06	0.00	0.00	0.01	1309
Pension Liabilities/Tax Revenue	30.44	940.79	0.00	1.65	6.53	1930
Pension Liabilities/Tax Base	0.04	0.87	0.00	0.01	0.03	1977
Pension Payroll/Population	243.27	369.15	0.00	176.06	399.30	2013
Pension Payroll/Tax Revenue	4.18	106.22	0.00	0.45	1.53	1930
Pension Payroll/Tax Base	0.01	0.16	0.00	0.00	0.01	1977
Panel C: Crisis (2007-2009)						
Pension Shortfall/Tax Revenue	2.49	12.96	0.31	1.13	2.63	2115
Pension Shortfall/Tax Base	0.04	1.00	0.00	0.00	0.01	2146
Pension Liabilities/Tax Revenue	6.60	32.93	0.07	2.44	7.52	2743
Pension Liabilities/Tax Base	0.11	2.05	0.00	0.01	0.03	2810
Pension Payroll/Population	518.86	3370.22	0.00	330.99	602.26	2906
Pension Payroll/Tax Revenue	1.84	9.33	0.00	0.90	1.95	2743
Pension Payroll/Tax Base	0.02	0.37	0.00	0.00	0.01	2810
Panel D: Post-crisis (2009-2013)						
Pension Shortfall/Tax Revenue	5.38	57.17	0.42	1.43	3.63	3443
Pension Shortfall/Tax Base	0.11	2.44	0.00	0.01	0.02	3479
Pension Liabilities/Tax Revenue	11.63	106.58	0.38	3.27	9.12	3917
Pension Liabilities/Tax Base	0.22	5.20	0.00	0.02	0.04	3995
Pension Payroll/Population	1071.53	11661.03	244.85	526.29	948.20	4139
Pension Payroll/Tax Revenue	3.81	43.66	0.54	1.38	2.81	3917
Pension Payroll/Tax Base	0.05	0.65	0.00	0.01	0.01	3995

Note: Full GFOA sample of municipal CAFRs.

Table 6: Credit ratings and CAFR variables

Variable	Description	(1) Standard & Poor's	(2) Moody's	(3) Fitch
GAINVCAP	Net investment in capital assets	-7.42e-11***	-3.90e-10***	-1.68e-09***
		(1.37e-11)	(2.43e-11)	(1.99e-10)
GARESNET	Restricted net position	2.95e-10***	5.89e-12	-3.54e-09***
		(3.76e-11)	(2.80e-11)	(7.46e-10)
GADIRECTEXP	Direct program costs	-1.03e-12**	7.70e-11***	5.19e-10
		(3.87e-13)	(1.89e-11)	(5.72e-10)
GACHANGENET	Change in net position	-4.16e-11***	1.27e-10***	1.47e-10
		(8.67e-12)	(1.61e-11)	(4.78e-10)
PERSAAL	Pension liability	-4.89e-12	1.35e-10***	1.49e-10
		(2.80e-12)	(1.90e-11)	(1.22e-10)
PERSAAL	Number of pension plans	-0.0340***	-0.0563***	0.541***
		(0.00566)	(0.00591)	(0.116)
TAXLEVY	Tax revenues	1.63e-11	-8.23e-12	4.33e-11*
		(1.87e-11)	(9.71e-12)	(2.08e-11)
PROPERTEAV	Tax base	2.70e-14**	-1.06e-12***	-5.23e-11***
		(8.80e-15)	(2.13e-13)	(1.27e-11)
GENGOVDEBSVC	Debt service expenditures	-1.97e-12***	5.92e-12***	5.68e-11***
		(1.75e-13)	(8.12e-13)	(1.19e-12)
DIRECTDEBT	General obligation debt	1.93e-11	-9.39e-11***	-3.94e-10*
		(2.40e-11)	(1.24e-11)	(1.96e-10)
OVERLAPDEBT	Debt overlapping from other jurisdictions	1.29e-11	-2.98e-11***	2.25e-09***
		(8.26e-12)	(7.05e-12)	(2.04e-10)
POPULATION	Population	-0.000000163***	0.000000104***	0.00000100**
		(4.48e-08)	(1.61e-08)	(0.000000328)
N		215500	358002	63297
adj. R^2		0.014	0.041	0.162

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: Dependent variable in all regressions is an encoded variable describing the highest credit rating of the issuer (1 = Aaa/AAA/A-1+/P-1/F1+/VMIG1, 2 = Aa/AA/A-1/F1/VMIG2, 3 = A/A-2/P-2/F2/VMIG3, 4 = Baa/BBB/A-3/P-3/F3/VMIG4, 5 = Ba/BB, 6 = B/S.G., 7 = Caa/CCC, 8 = Ca/C, 9 = D). Estimated on sample of all municipalities with CAFRs in the GFOA dataset and disclosed ratings in the credit ratings agencies' 17g-7 filings.

Table 7: Amihud illiquidity and price

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Lag price	0.00302	0.00288	0.00302	0.00288	0.00302	0.00288						
	(0.00368)	(0.00371)	(0.00368)	(0.00371)	(0.00368)	(0.00371)						
Lag yield							-0.00757	-0.00754	-0.00757	-0.00754	-0.00757	-0.00754
							(0.00863)	(0.00862)	(0.00863)	(0.00862)	(0.00863)	(0.00862)
Constant	0.917*	3.398	0.917*	3.398	0.917*	3.398	1.299***	4.705	1.299***	4.705	1.299***	4.705
	(0.401)	(2.187)	(0.401)	(2.187)	(0.401)	(2.187)	(0.0812)	(2.761)	(0.0812)	(2.761)	(0.0812)	(2.761)
Bond characteristics	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Fixed effects	Bond	Bond	Bond	Bond	Issuer	Issuer	Bond	Bond	Bond	Bond	Issuer	Issuer
Error clustering	Bond	Bond	Issuer	Issuer	Issuer	Issuer	Bond	Bond	Issuer	Issuer	Issuer	Issuer
Observations	5852673	5852671	5852673	5852671	5852673	5852671	5583091	5583091	5583091	5583091	5583091	5583091

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Note: Estimated on full sample of cleaned MSRB transactions (Section 4.1).

Table 8: Roll illiquidity and price

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Lag price	-0.00220***	-0.00220***	-0.00220***	-0.00220***	-0.00220***	-0.00220***						
	(0.0000539)	(0.0000538)	(0.0000539)	(0.0000538)	(0.0000539)	(0.0000538)						
Lag yield							0.00854***	0.00854***	0.00854***	0.00854***	0.00854***	0.00854***
							(0.000408)	(0.000408)	(0.000408)	(0.000408)	(0.000408)	(0.000408)
Constant	-0.152***	-0.00879	-0.152***	-0.00879	-0.152***	-0.00879	-0.435***	-0.186***	-0.435***	-0.186***	-0.435***	- 0.186***
	(0.00576)	(0.0337)	(0.00576)	(0.0337)	(0.00576)	(0.0337)	(0.00225)	(0.0420)	(0.00225)	(0.0420)	(0.00225)	(0.0420)
Bond characteristics	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Fixed effects	Bond	Bond	Bond	Bond	Issuer	Issuer	Bond	Bond	Bond	Bond	Issuer	Issuer
Error clustering	Bond	Bond	Issuer	Issuer	Issuer	Issuer	Bond	Bond	Issuer	Issuer	Issuer	Issuer
Observations	1349442	1349442	1349442	1349442	1349442	1349442	1215868	1215868	1215868	1215868	1215868	1215868

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Note: Estimated on full sample of cleaned MSRB transactions (Section 4.1).

Table 9: IRT illiquidity and price

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Lag price	-0.147	-0.147	-0.147	-0.147	-0.147	-0.147						
	(-1.88)	(-1.88)	(-1.88)	(-1.88)	(-1.88)	(-1.88)						
Lag yield							-0.000283	-0.000279	-0.000283	-0.000279	-0.000283	-0.000279
							(-0.00)	(-0.00)	(-0.00)	(-0.00)	(-0.00)	(-0.00)
Constant	14.63	15.00	14.63	15.00	14.63	15.00	-0.189	-1.741	-0.189	-1.741	-0.189	-1.741
	(1.88)	(1.62)	(1.88)	(1.62)	(1.88)	(1.62)	(-0.82)	(-0.98)	(-0.82)	(-0.98)	(-0.82)	(-0.98)
Bond characteristics	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Fixed effects	Bond	Bond	Bond	Bond	Issuer	Issuer	Bond	Bond	Bond	Bond	Issuer	Issuer
Error clustering	Bond	Bond	Issuer	Issuer	Issuer	Issuer	Bond	Bond	Issuer	Issuer	Issuer	Issuer
Observations	5504688	5504688	5504688	5504688	5504688	5504688	5249848	5249848	5249848	5249848	5249848	5249848

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Note: Estimated on full sample of cleaned MSRB transactions (Section 4.1).

Table 10: Roll illiquidity on price deciles

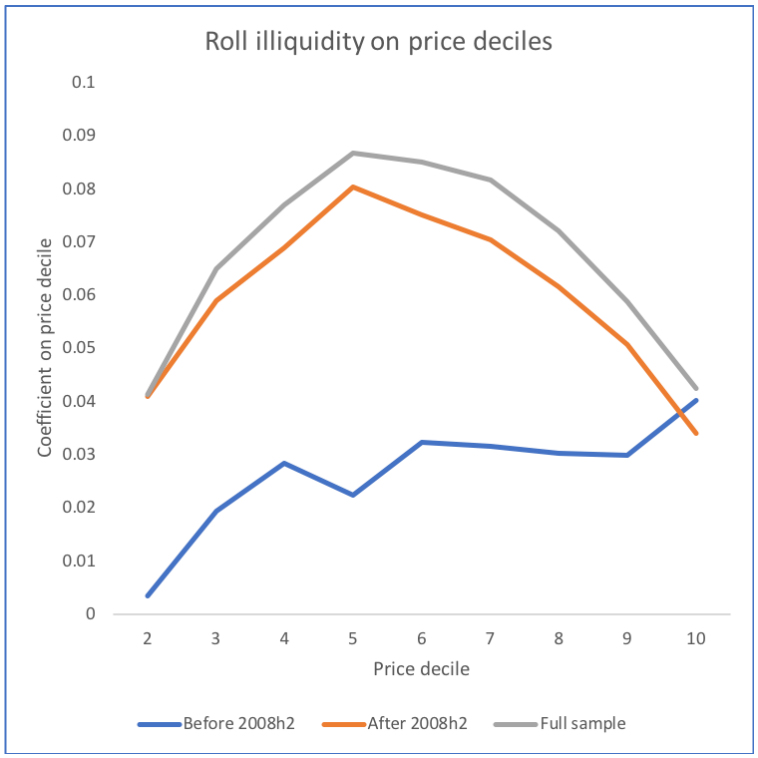
	(1)	(2)	(3)	(4)	(5)	(6)
Decile 1	0	0	0	0	0	0
	(.)	(.)	(.)	(.)	(.)	(.)
Decile 2	-0.00355	-0.0411***	-0.0414***	-0.000704	0.0119***	0.0142***
	(-0.84)	(-33.10)	(-36.48)	(-0.21)	(8.36)	(11.25)
Decile 3	-0.0194***	-0.0590***	-0.0651***	0.00131	0.0313***	0.0345***
	(-4.43)	(-42.62)	(-52.75)	(0.38)	(20.28)	(25.86)
Decile 4	-0.0284***	-0.0689***	-0.0771***	0.00703*	0.0493***	0.0517***
	(-6.13)	(-47.99)	(-60.24)	(1.99)	(29.99)	(36.88)
Decile 5	- 0.0224***	-0.0804***	- 0.0868***	0.00802*	0.0635***	0.0641***
	(-4.50)	(-55.20)	(-67.23)	(2.17)	(36.44)	(43.73)
Decile 6	-0.0323***	-0.0751***	- 0.0851***	0.0121**	0.0720***	0.0714***
	(-6.36)	(-49.62)	(-64.23)	(3.18)	(39.22)	(46.43)
Decile 7	-0.0316***	-0.0705***	-0.0817***	0.0178***	0.0766***	0.0758***
	(-6.10)	(-45.52)	(-60.76)	(4.48)	(39.79)	(47.28)
Decile 8	-0.0303***	-0.0616***	-0.0722***	0.0297***	0.0817***	0.0821***
	(-5.69)	(-39.32)	(-52.87)	(7.36)	(40.57)	(49.31)
Decile 9	-0.0299***	-0.0507***	-0.0588***	0.0380***	0.0889***	0.0897***
	(-5.37)	(-31.64)	(-41.61)	(9.27)	(42.05)	(51.91)
Decile 10	-0.0403***	-0.0341***	-0.0426***	0.0471***	0.120***	0.122***
	(-6.69)	(-20.37)	(-28.42)	(10.49)	(52.17)	(65.40)
Constant	0.415***	0.225***	0.335***	0.513***	0.359***	0.492***
	(98.09)	(146.06)	(202.04)	(151.41)	(157.29)	(227.60)
Variable deciles	Price	Price	Price	Yield	Yield	Yield
Time period	Before 2008h2	After 2008h2	All	Before 2008h2	After 2008h2	All
Observations	260463	1088979	1349442	215380	1000488	1215868

t statistics in parentheses.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

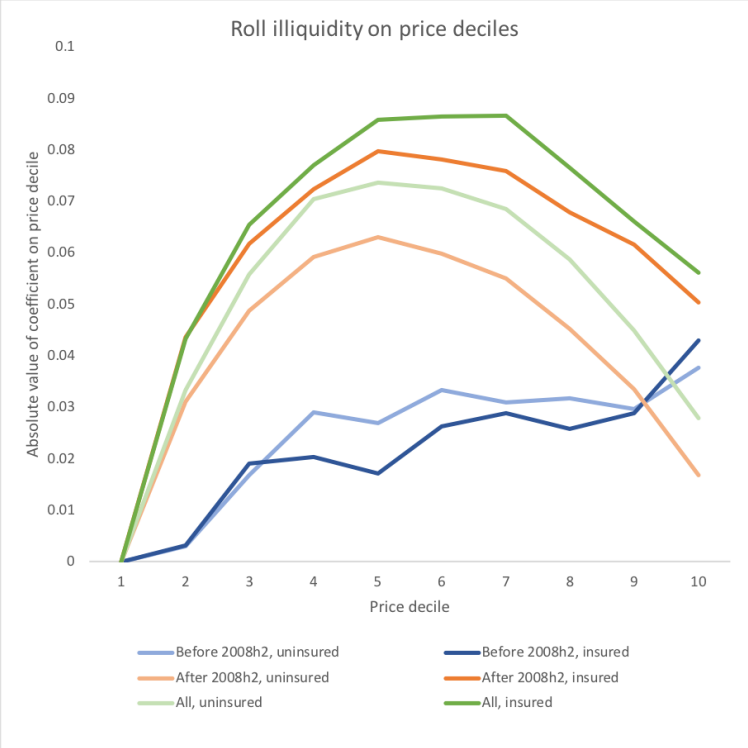
Note: Estimated on full sample of cleaned MSRB transactions (Section 4.1). Independent variable in all columns is Roll illiquidity, with bond characteristic controls and bond and half-year fixed effects. Standard errors are clustered by issuer.

Figure 6: Hockey stick relationship between bond liquidity and bond price



Note: Estimated on full sample of cleaned MSRB transactions merged with SDC Platinum bond characteristic data (Section 4.1). Plotted are the absolute values of the coefficients of lagged price deciles in specification (2) for Roll illiquidity, controlling for bond characteristics and with bond- and half-year fixed effects (see Table 10).

Figure 7: Hockey stick relationship between bond liquidity and bond price



Note: Estimated on cleaned MSRB transactions merged with SDC Platinum bond characteristic data (Section 4.1). For insured and uninsured subsamples, plotted are the absolute values of the coefficients of lagged price deciles in specification (2) for Roll illiquidity, controlling for bond characteristics and with bond- and half-year fixed effects.

Table 11: Roll illiquidity on credit ratings

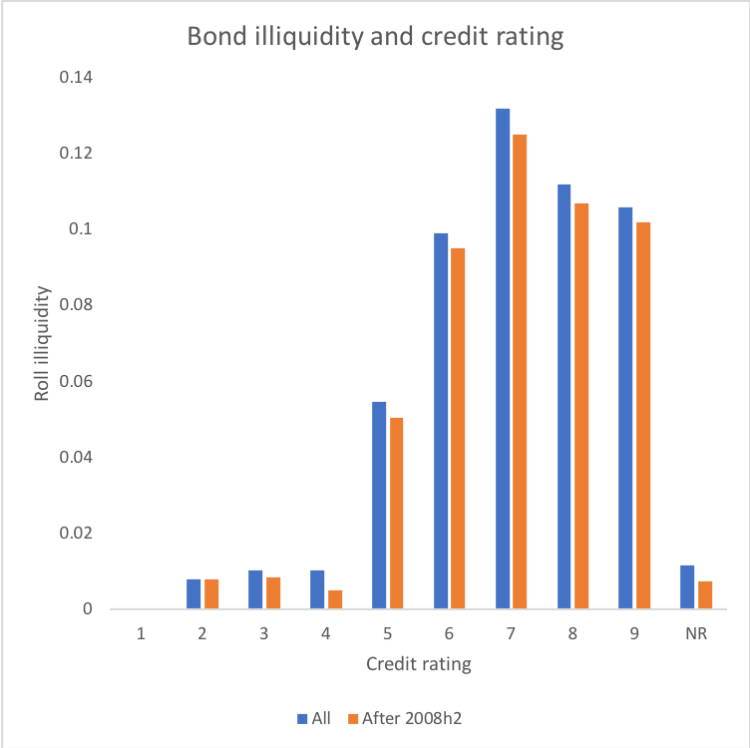
Rating tier	(1)	(2)	(3)
1	0	0	0
	(.)	(.)	(.)
2	0.00795**	0.00645	0.00785**
	(0.00279)	(0.0597)	(0.00255)
3	0.0103***	-0.0513	0.00829**
	(0.00302)	(0.0644)	(0.00284)
4	0.0102**	0.0134	0.00496
	(0.00363)	(0.0840)	(0.00370)
5	0.0546***		0.0506***
	(0.00766)		(0.00780)
6	0.0991***		0.0951***
	(0.0126)		(0.0125)
7	0.132***		0.125***
	(0.0169)		(0.0183)
8	0.112***		0.107***
	(0.0127)		(0.0134)
9	0.106***		0.102***
	(0.00582)		(0.00583)
10	0.0115***	-0.0187	0.00743**
	(0.00289)	(0.0442)	(0.00266)
Constant	-0.349***	-0.374***	-0.265***
	(0.00328)	(0.0443)	(0.00291)
Period	All	Before 2008h2	After 2008h2
N	1569057	355147	1213910

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: Dependent variable in all regressions is Roll illiquidity. 1 = Aaa/AAA/A-1+/P-1/F1+/VMIG1, 2 = Aa/AA/A-1/F1/VMIG2, 3 = A/A-2/P-2/F2/VMIG3, 4 = Baa/BBB/A-3/P-3/F3/VMIG4, 5 = Ba/BB, 6 = B/S.G., 7 = Caa/CCC, 8 = Ca/C, 9 = D, 10 = NR). Estimated on sample of all municipalities with CAFRs in the GFOA dataset and disclosed ratings in the credit rating agencies' 17g-7 filings, per specification (3). Includes bond, halfyear, and ratings fixed effects. Standard errors are clustered by municipality.

Figure 8: Hockey stick relationship between bond liquidity and credit rating



Note: Dependent variable in all regressions is Roll illiquidity. Specification (3) estimated on cleaned MSRB transactions merged with SDC Platinum bond characteristic data and 17g-7 filings. Plotted are the coefficients of credit rating tiers, controlling for bond characteristics and with bond- and half-year fixed effects. 1 = Aaa/AAA/A-1+/P-1/F1+/VMIG1, 2 = Aa/AA/A-1/F1/VMIG2, 3 = A/A-2/P-2/F2/VMIG3, 4 = Baa/BBB/A-3/P-3/F3/VMIG4, 5 = Ba/BB, 6 = B/S.G., 7 = Caa/CCC, 8 = Ca/C, 9 = D.

Table 12: Roll illiquidity and credit ratings, full sample period

	(1)	(2)	(3)	(4)
$\Delta Rating_{i,t-1}$ (from previous)	-0.00537***		-0.00529***	
	(-4.39)		(-4.33)	
$\Delta Rating_{i,t-1}$ (from issuance)		0.0194***		0.0176***
		(7.97)		(5.52)
$\Delta t_{i,t-1}$ (from previous)			-0.000397***	
			(-3.94)	
$\Delta Rating_{i,t-1} \times \Delta t_{i,t-1}$ (from previous)			0.0000103	
			(0.52)	
$\Delta t_{i,t-1}$ (from issuance)				-0.000726
				(-1.45)
$\Delta Rating_{i,t-1} \times \Delta t_{i,t-1}$ (from issuance)				-0.00000162
				(1.07)
Constant	-0.368***	-0.355***	-0.327***	0.0894
	(-148.53)	(-122.32)	(-31.28)	(0.29)
Observations	821029	821029	821029	821029

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: Dependent variable in all regressions is Roll illiquidity. Specification (4) estimated on cleaned MSRB transactions merged with SDC Platinum bond characteristic data and 17g-7 filings. Rating tiers defined as follows: 1 = Aaa/AAA/A-1+/P-1/F1+/VMIG1, 2 = Aa/AA/A-1/F1/VMIG2, 3 = A/A-2/P-2/F2/VMIG3, 4 = Baa/BBB/A-3/P-3/F3/VMIG4, 5 = Ba/BB, 6 = B/S.G., 7 = Caa/CCC, 8 = Ca/C, 9 = D. Includes bond, halfyear, and ratings fixed effects. Errors clustered by municipality.

Table 13: Roll illiquidity and credit ratings, before monoline downgrade

	(1)	(2)	(3)	(4)
$\Delta Rating_{i,t-1}$ (from previous)	-0.00316		-0.00333	
	(-0.89)		(-0.95)	
$\Delta Rating_{i,t-1}$ (from issuance)		-0.00147		0.00113
		(-0.37)		(0.23)
$\Delta t_{i,t-1}$ (from previous)			-0.00102*	
			(-2.05)	
$\Delta Rating_{i,t-1} \times \Delta t_{i,t-1}$ (from previous)			0.00329***	
			(3.49)	
$\Delta t_{i,t-1}$ (from issuance)				-0.0110**
				(-3.08)
$\Delta Rating_{i,t-1} \times \Delta t_{i,t-1}$ (from issuance)				-0.00000538
				(-0.88)
Constant	-0.443***	-0.443***	-0.422***	4.662**
	(-283.75)	(-286.84)	(-40.33)	(2.81)
Observations	153633	153633	153633	153633

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: Dependent variable in all regressions is Roll illiquidity. Specification (4) estimated on cleaned MSRB transactions merged with SDC Platinum bond characteristic data and 17g-7 filings. Rating tiers defined as follows: 1 = Aaa/AAA/A-1+/P-1/F1+/VMIG1, 2 = Aa/AA/A-1/F1/VMIG2, 3 = A/A-2/P-2/F2/VMIG3, 4 = Baa/BBB/A-3/P-3/F3/VMIG4, 5 = Ba/BB, 6 = B/S.G., 7 = Caa/CCC, 8 = Ca/C, 9 = D. Includes bond, halfyear, and ratings fixed effects. Errors clustered by municipality.

Table 14: Roll illiquidity and credit ratings, after monoline downgrade

	(1)	(2)	(3)	(4)
$\Delta Rating_{i,t-1}$ (from previous)	-0.00503***		-0.00494***	
	(-3.80)		(-3.75)	
$\Delta Rating_{i,t-1}$ (from issuance)		0.0189***		0.0153***
		(7.78)		(4.42)
$\Delta t_{i,t-1}$ (from previous)			-0.000341**	
			(-3.04)	
$\Delta Rating_{i,t-1} \times \Delta t_{i,t-1}$ (from previous)			0.00000461	
			(0.23)	
$\Delta t_{i,t-1}$ (from issuance)				-0.000774
				(-1.23)
$\Delta Rating_{i,t-1} \times \Delta t_{i,t-1}$ (from issuance)				0.00000338
				(1.86)
Constant	-0.247***	-0.233***	-0.204***	0.272
	(-102.08)	(-76.40)	(-14.51)	(0.66)
Observations	667396	667396	667396	667396

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: Dependent variable in all regressions is Roll illiquidity. Specification (4) estimated on cleaned MSRB transactions merged with SDC Platinum bond characteristic data and 17g-7 filings. Rating tiers defined as follows: 1 = Aaa/AAA/A-1+/P-1/F1+/VMIG1, 2 = Aa/AA/A-1/F1/VMIG2, 3 = A/A-2/P-2/F2/VMIG3, 4 = Baa/BBB/A-3/P-3/F3/VMIG4, 5 = Ba/BB, 6 = B/S.G., 7 = Caa/CCC, 8 = Ca/C, 9 = D. Includes bond, halfyear, and ratings fixed effects. Errors clustered by municipality.

Table 15: Roll illiquidity and credit ratings, difference-in-differences estimate

	(1)	(2)	(3)	(4)	(5)	(6)
$Event_{t-1}$	0.0856***	0.0856***	0.0428***	0.0428***	-0.0225***	-0.0738***
	(25.14)	(25.10)	(13.90)	(13.90)	(-4.67)	(-16.56)
$\Delta Rating_{i,t-1}$ (from previous)	-0.00165		0.000400		0.000558	
	(-0.06)		(0.62)		(0.77)	
$\Delta Rating_{i,t-1}$ (from issuance)		0.0142		0.0162***		0.0137***
		(0.50)		(5.60)		(4.48)
$\Delta Rating_{i,t-1} \times Event_{t-1}$	0.00135	0.00172	-0.00552***	-0.00244	-0.00235*	0.00321**
	(0.05)	(0.06)	(-3.32)	(-1.91)	(2.61)	
Constant	-0.359***	-0.346***	-0.359***	-0.346***	-0.359***	-0.346***
	(-113.33)	(-89.79)	(-113.48)	(-90.06)	(-113.35)	(-91.15)
Event	2008h1	2008h1	2007h2-2009h1	2007h2-2009h1	2012h1	2012h1
Observations	755493	755493	755493	755493	755493	755493

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: Dependent variable in all regressions is Roll illiquidity. Specification (5) estimated on cleaned MSRB transactions merged with SDC Platinum bond characteristic data and 17g-7 filings. Rating tiers defined as follows: 1 = Aaa/AAA/A-1+/P-1/F1+/VMIG1, 2 = Aa/AA/A-1/F1/VMIG2, 3 = A/A-2/P-2/F2/VMIG3, 4 = Baa/BBB/A-3/P-3/F3/VMIG4, 5 = Ba/BB, 6 = B/S.G., 7 = Caa/CCC, 8 = Ca/C, 9 = D. Includes bond, halfyear, and ratings fixed effects. Errors clustered by issuer.

Table 16: Insurance and difference-in-differences estimator sample periods

	(1)	(2)	(3)
$Event_{t-1}$	0	-0.108***	0
	(.)	(-22.23)	(.)
$\Delta Rating_{i,t-1}$ (from issuance)	0	0.0125**	0.0420
	(.)	(3.02)	(1.79)
$\Delta Rating_{i,t-1} \times Event_{t-1}$	0.0215***	0.00950**	-0.0256
	(9.42)	(2.70)	(-1.09)
$\Delta Rating_{i,t-1} \times Insured_i$	0.0111***	-0.00335	-0.0282
	(3.79)	(-0.95)	(-1.22)
$\Delta Rating_{i,t-1} \times Event_{t-1} \times Insured_i$	-0.0224***	-0.00705	0.0244
	(-6.83)	(-1.95)	(1.06)
$UsingInsurance_{i,t-1}$			0.0158**
			(3.05)
Constant	-0.352***	-0.351***	-0.361***
	(-90.19)	(-92.36)	(-53.67)
Event	2008h2	2012h1	2008h2
Observations	755493	755493	755493

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: Dependent variable in all regressions is Roll illiquidity. Specification (6) estimated on cleaned MSRB transactions merged with SDC Platinum bond characteristic data and 17g-7 filings. Rating tiers defined as follows: 1 = Aaa/AAA/A-1+/P-1/F1+/VMIG1, 2 = Aa/AA/A-1/F1/VMIG2, 3 = A/A-2/P-2/F2/VMIG3, 4 = Baa/BBB/A-3/P-3/F3/VMIG4, 5 = Ba/BB, 6 = B/S.G., 7 = Caa/CCC, 8 = Ca/C, 9 = D. Includes bond, halfyear, and ratings fixed effects. Errors clustered by issuer.

Table 17: Roll illiquidity on debt servicing/tax revenues

	(1)	(2)	(3)
Quartile 1	0	0	0
	(.)	(.)	(.)
Quartile 2	0.00398	0.0227***	0.0141**
	(0.52)	(3.61)	(3.26)
Quartile 3	-0.00736	0.0179**	0.00918
	(-0.86)	(2.78)	(1.92)
Quartile 4	-0.0108	0.0208**	0.0132*
	(-.095)	(2.69)	(2.19)
Constant	-0.316***	-0.309***	-0.349***
	(-4.92)	(-48.32)	(-56.33)
Period	Before	After	All
Observations	46758	105444	152202

t statistics in parentheses.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: Dependent variable in all regressions is Roll illiquidity. Explanatory variables are indicators that a bond's issuer was in the nth quartile for the ratio of two CAFR variables, debt servicing expenditures to tax revenues, as defined in Section 6. Specification (8) estimated on cleaned MSRB transactions merged with SDC Platinum bond characteristic data, municipal CAFRs, and 17g-7 filings. Includes bond, halfyear, and ratings fixed effects. Errors clustered by issuer.

Table 18: Roll illiquidity on debt servicing/tax revenues, difference-in-differences

Quartile 1	0
	(.)
Quartile 2	0.00882
	(0.00473)
Quartile 3	0.00341
	(0.00521)
Quartile 4	0.00310
	(0.00650)
After 2010h1	-0.152***
	(0.00796)
Quartile 1 × After 2010h1	0
	(.)
Quartile 2 × After 2010h1	0.0153**
	(0.00573)
Quartile 3 × After 2010h1	0.0155**
	(0.00562)
Quartile 4 × After 2010h1	0.0210***
	(0.00555)
Constant	-0.342***
	(0.00659)
Observations	152189

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: Dependent variable is Roll illiquidity. Explanatory variables are indicators that a bond's issuer was in the nth quartile for the ratio of two CAFR variables, debt servicing expenditures to tax revenues, as defined in Section 6. Difference-in-differences variant of (8) estimated on cleaned MSRB transactions merged with SDC Platinum bond characteristic data, municipal CAFRs, and 17g-7 filings. Includes bond, halfyear, and ratings fixed effects. Errors clustered by issuer.

Table 19: Roll illiquidity on pension obligations, difference-in-differences

	(1)	(2)
$BudgetVar_{I(i),t-1}$	-0.000176	-0.000474
	(-1.77)	(-1.49)
$Event_{t-1}$	-0.136***	-0.131***
	(-20.27)	(-21.26)
$BudgetVar_{I(i),t-1} \times Event_{t-1}$	0.000257*	0.000817*
	(2.34)	(2.42)
Constant	-0.340***	-0.346***
	(-61.80)	(-73.34)
Pension variable	Unfunded Liab$_{t-1}$	Liab$_{t-1}$
Scaling variable	Tax Rev$_{t-1}$	Tax Rev$_{t-1}$
Event	2008h2	2008h2
Observations	145072	161754

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: Dependent variable is Roll illiquidity. Explanatory variables are defined in Section 6. Difference-in-differences variant of (7) estimated on cleaned MSRB transactions merged with SDC Platinum bond characteristic data, municipal CAFRs, and 17g-7 filings. Includes bond, halfyear, and ratings fixed effects. Errors clustered by issuer.

Table 20: Information insensitivity and signalling

	(1)	(2)	(3)
$Insensitivity^{32}_{I,t-1}$	0.0000891		0.00251**
	(0.0000609)		(0.000737)
$Insensitivity^{43}_{I,t-1}$	0.00289***	0.00284***	0.00167***
	(0.000645)	(0.000646)	(0.000439)
$Event_{t-1}$	0.482***	0.482***	0.723***
	(0.0465)	(0.0465)	(0.0510)
$Insensitivity^{32}_{I,t-1} \times Event_{t-1}$			-0.00239**
			(0.000721)
$Insensitivity^{43}_{I,t-1} \times Event_{t-1}$	-0.00302***	-0.00290***	-0.00183***
	(0.000641)	(0.000642)	(0.000453)
Constant	-0.0174	-0.0173	-0.0168
	(0.0230)	(0.0231)	(0.0242)
Event	2008h2	2008h2	2008h2
Observations	3511	3511	3511

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: Dependent variable is an indicator variable equal to 1 if municipality I changes the actuarial method used to assess its pension or OPEB liabilities from the previous year. Explanatory variables are municipality-level measures of information insensitivity constructed in Section 7. Specification (12) estimated on cleaned MSRB transactions merged with SDC Platinum bond characteristic data, municipal CAFRs, and 17g-7 filings. Includes municipality, year, and ratings fixed effects.