Self-Help Liquidity: Unintended Consequences of Dodd-Frank on the Corporate Bond Market

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Abstract

I analyze the effect of the Volcker Rule on the corporate bond market. I develop a model in which issuers respond to secondary market regulatory costs by adjusting the maturity of their bond issuances. In my model, firms trade off expected regulatory costs against regulatory uncertainty. When expected regulatory costs are high, firms prefer to issue short debt, which is less sensitive to trading costs. In doing so, firms are acting as their own market makers: providing "self-help" liquidity. In contrast, when regulatory uncertainty is high, firms prefer to issue longer term debt, which reduces their exposure to rollover risk.

I then perform an empirical analysis and find results consistent with my model. Around the signing of Dodd-Frank, when expected future regulatory costs were high, the average term of the least liquid bonds – those likely to be most sensitive to these costs – fell relative to more liquid bonds. Later, in the lead up to the release of the Volcker Rule regulations, when regulatory uncertainty was high, the average maturity of the least liquid bonds increased dramatically. After the regulations were released, average maturity fell again. A placebo test on municipal bonds, which were exempt from Dodd-Frank, shows no similar pattern.

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1 Introduction

A common refrain after the implementation of the Volcker Rule was that it had reduced liquidity in the corporate bond market. Despite concerted efforts by both academics and regulators, evidence of such an effect is scarce. I take a different approach. Rather than looking for changes in the secondary market, I hypothesize that issuers will respond to what amounts to a tax on secondary market liquidity by adjusting the maturity of their newly issued bonds.

To investigate this hypothesis, I develop a model in which firms may chose to fund a project using either short or long term bonds. Market makers in the secondary market (i.e., intermediaries) face regulatory costs, which are passed on to secondary market traders. Anticipating these costs, investors will demand a higher stated interest rate on bonds that are particularly affected by these costs. Seeking to finance their projects at the lowest cost available, firms in turn respond by adjusting the term of their bonds at the time of issue.

This simple model provides a useful insight: if firms expect future regulatory costs to be high, they will prefer to issue shorter term bonds. I refer to this phenomenon as "self-help liquidity" – if market makers are unable to provide liquidity at a reasonable cost, firms will simply generate their own. In generating this self-help liquidity, however, firms expose themselves to roll-over risk – the risk that once their short debt has matured, they will not be able to issue new debt. High regulatory uncertainty that increases the probability of a bad state of the world at the roll-over date increases roll-over risk for firms. Because of this, firms prefer to issue longer bonds if regulatory uncertainty is high.

I then perform an empirical analysis and find that the data support my hypothesis. Around the signing of Dodd-Frank, when expected future regulatory costs were high, average term of the least liquid bonds – those likely to be most sensitive to these costs – fell. Later, in the lead up to the release of the Volcker Rule regulations, when regulatory uncertainty was likely to be extremely high, the maturities of the least liquid bonds increased. After the regulations were released, maturity fell again, and by the middle of 2015 ended substantially below its normal level. Over this same period, the maturity of the most liquid bonds hardly moved, suggesting both that this pattern was not driven by some external factor and that this effect is concentrated at the shallow end of the liquidity pool. I conduct a placebo test on municipal bonds and do not find a similar pattern, further supporting my interpretation.

In addition to providing a theoretical framework and an explanation for a persistent empirical puzzle, my results have important policy implications. When firms respond to regulatory costs by engaging in their own market marking (i.e., providing self-help liquidity), they are behaving in a manner that is privately optimal. At the same time, the issuance of short debt creates risks for the issuing firms. While the regulation at issue was intended to reduce risk, one unintended consequence could be that it actually creates a whole new set of risks in another portion of the financial system. While these new risks may be smaller or easier to manage than the risks that the regulation is intended to mitigate, they should not be ignored. An evaluation of the effect of a regulation that looks only at its effects on the secondary market will overlook both these costs and these risks.

The remainder of this Article proceeds as follows. In Part 2, I discuss the Volcker Rule, key institutional features of the corporate bond market, and existing work on the relationship between the Volcker Rule and this market. In Part 3, I present my model and discuss its interpretation. I present the empirical analysis in Part 4. I then discuss implications in Part 5. Part 6 concludes.

2 Dodd-Frank and the Corporate Bond Market

One of the primary goals of the Dodd-Frank Wall Street Reform and Consumer Protection Act[1] was to reduce systemic risk and improve the stability of the financial sector. To do so, Dodd-Frank contained provisions designed to reduce the ability of financial institutions to take on certain kinds of financial risk. One such provision is Volcker Rule, which, subject to certain exceptions, prohibits regulated banking entities from engaging in "proprietary trading."[2] In contrast to market making, proprietary trading is trading for the purpose of profiting from the difference between the purchase and sale price.[3] While the Volcker Rule specifically exempts "market-making-related activities,"[4] in practice it can be hard to distinguish between market making and proprietary trading.[5]

Because of this difficulty, there has been a great deal of concern among academics, regulators and market participants that the Volcker Rule could have the unintended effect of hampering market making activities. Market makers play an important role in the corporate bond market because bonds are primarily traded over the counter. While market participants may have incentives to overstate any detrimental impact of financial market regulations, regulators appear to have taken their concerns seriously. Stanley Fischer, then the Vice Chairman of the Board of Governors of the Federal Reserve System, addressed this

[1] Pub. L. No. 111203, H.R. 4173 (2010) (hereinafter "Dodd-Frank").

[2] 12 U.S.C. §1851; Dodd-Frank Wall Street Reform and Consumer Protection Act, Pub. L. No. 111203, §619, 24 Stat. 1376 (2010).

[3] Darrell Duffie defines proprietary trading as "the purchase and sale of financial instruments with the intent to profit from the difference between the purchase price and the sale price" Darrell Duffie, *Market Making Under the Proposed Volcker Rule*, 2 Working Paper (Jan. 2012).

[4] 12 U.S.C. §1851(d)(1)(B).

[5] *See* Charles K. Whitehead, *The Volcker Rule and Evolving Financial Markets*, 1 Harvard Business Law Review 39, 51 (2011).

question speech at the Brookings Institution. After surveying the evidence, he concluded that "overall, liquidity is adequate by most measures, in most markets, and most of the time."[6]

The Federal Reserve Bank of New York has also engaged with this issue. Citing concerns raised by both market participants and policymakers, the New York Fed's "Liberty Street Economics" blog published a series of ten posts on market liquidity between February 8, 2016 and February 19, 2016.[7] Two of these posts specifically address corporate bond market liquidity. In the first, the authors concluded that "corporate bond market liquidity appears ample based on the bid-ask spread and price impact measures."[8] They proceed to note that despite their empirical findings, "some analysts argue that liquidity has in fact deteriorated, albeit in a way that is missed by the measures examined here."[9] In the second, they discuss concerns by commentators about differential impacts on different segments of the bond market. They conclude that while "liquidity may have deteriorated slightly since the pre-crisis period for corporate bonds with the lowest credit ratings," it has actually improved in the rest of the market.[10]

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[6]Stanley Fischer, Is There a Liquidity Problem Post-Crisis?, Address at "Do We Have a Liquidity Problem Post-Crisis?" a conference sponsored by the Initiative on Business and Public Policy at the Brookings Institution (Nov. 15, 2016) (*available at* `https://www.federalreserve.gov/newsevents/speech/fischer20161115a.pdf`).

[7]Tobias Adrian, Michael Fleming & Ernst Schaumburg, *Continuing the Conversation on Liquidity*, Liberty Street Economics (Feb. 8, 2016), `http://libertystreeteconomics.newyorkfed.org/2016/02/continuing-the-conversation-on-liquidity.html`. This represented the third such series. The first such series was published in August 2015, and the second, which itself included two posts on corporate bond market liquidity, was published in October 2015. Id. *See also* Tobias Adrian, Michael Fleming & Ernst Schaumburg, *Introduction to a Series on Market Liquidity: Part 2*, Liberty Street Economics (Oct. 5, 2015), `http://libertystreeteconomics.newyorkfed.org/2015/10/introduction-to-a-series-on-market-liquidity-part-2.html#.Vo1mg3Jgmcw`.

[8]Tobias Adrian, Michael Fleming, Erik Vogt & Zachary Wojtowicz, *Corporate Bond Market Liquidity Redux: More Price-Based Evidence*, Liberty Street Economics (Feb. 9, 2016), `http://libertystreeteconomics.newyorkfed.org/2016/02/corporate-bond-market-liquidity-redux-more-price-based-evidence.html#.VsYjtL_GrLE`.

[9]Tobias Adrian, Michael Fleming, Erik Vogt & Zachary Wojtowicz, *Corporate Bond Market Liquidity Redux: More Price-Based Evidence*, Liberty Street Economics (Feb. 9, 2016), `http://libertystreeteconomics.newyorkfed.org/2016/02/corporate-bond-market-liquidity-redux-more-price-based-evidence.html#.VsYjtL_GrLE`.

[10]Tobias Adrian, Michael Fleming, Erik Vogt & Zachary Wojtowicz, *Further Analysis of Corporate Bond Market Liquidity*, Liberty Street Economics (Feb. 10, 2016), `http://libertystreeteconomics.newyorkfed.org/2016/02/further-analysis-of-corporate-bond-market-liquidity.html#.VsYj7b_GrLE`. In December 2015, the Financial Industry Regulatory Authority (FINRA), released some of its own research into corporate bond market liquidity.It concluded that "While the data indicate a robust market, they also highlight several areas of potential emerging risk that merit more attention and further study." FINRA *Corporate Bond Liquidity Healthy by Most Measures* FINRA Research (Dec. 10, 2015)). While not a regulator, FINRA is a a self-regulatory organization (SRO), and therefore enjoys substantial authority to regulate financial market actors. *See* Jennifer M. Pacella, *If The Shoe Of The SEC Doesn't Fit: Self-Regulatory Organizations And Absolute Immunity*, 58 Wayne L. Rev. 201 (2012).

This apparent contradiction has become an active research area. Several papers have focused on specific segments of the market, including dealer commitment in bank versus non-bank dealers,[11] index exclusions,[12] recently downgraded bonds,[13] dealer versus non-dealer trades,[14] and more versus less constrained intermediaries.[15] A final paper that investigated this question did not find any evidence of a decline in liquidity.[16]

I take a different approach. My hypothesis is that issuers respond to financial market regulation by adjusting maturity. The reason for this is straightforward. When we observe financial market activity, what we see is the result of an optimization problem by the participants in the market.[17] I take this view seriously, and model this optimization problem directly.

3 The Model

There is some existing theoretical work that has highlighted a link between liquidity and maturity. In these models, however, opportunistic default by equity holders plays a central role.[18] While opportunistic default is theoretical interest, in practice, opportunistic default is extremely rare.[19] In order to build a model that is grounded in realistic assumptions,

[11] Hendrik Bessembinder, Stacey Jacobsen, William Maxwell & Kumar Venkataraman, *Capital Commitment and Illiquidity in Corporate Bonds* (Working Paper, July 2016).

[12] Jens Dick-Nielsen & Marco Rossi, *The Cost of Immediacy for Corporate Bonds*, (Working Paper, Aug. 2016).

[13] Jack Boa, Maureen O'Hara & Xing Zhou, *The Volcker Rule and Market-Making in Times of Stress*, (Working Paper, Dec. 2016).

[14] Jaewon Choi & Yesol Huh, *Customer Liquidity Provision in Corporate Bond Markets*, (Working Paper, Sept. 2016).

[15] Tobias Adrian, Nina Boyarchenko & Or Shachar, *Dealer Balance Sheets and Bond Liquidity Provision*, J. of Monetary Economics (*forthcoming*, 2017).

[16] Francesco Trebbi & Kairong Xiao, *Regulation and Market Liquidity*, (Working Paper, May 2016) (looking for structural breaks in a large panel of liquidity measures, and finding that, if anything, liquidity has improved).

[17] Dick-Nielsen and Rossi acknowledge this fact in their paper. *See* Jens Dick-Nielsen & Marco Rossi, *The Cost of Immediacy for Corporate Bonds*, 5 (Working Paper, Aug. 2016).

[18] For example, He and Milbradt develop a model in which there is a tradeoff between liquidity (which is higher for short bonds) and bankruptcy risks driven by opportunistic defaults (which is also higher for short bonds). Zhiguo He & Konstantin Milbradt, *Endogenous Liquidity and Defaultable Bonds*, 82 Econometrica 1443 (2014).

[19] This assumption implies that the project represents a relatively small fraction of the total value of the company and that the company has enough shareholder equity to make up for any losses from abandoning the project. This feature of the model is grounded in both the legal and financial realities. Bondholders are senior to shareholders in a firm's capital structure. Ordinarily, bondholders will suffer losses only after equity is wiped out. In a large firm, the probability of this happening because of the abandonment of a single project is low. This assumption is also supported by the data. Empirically, the probability of an investment grade bond defaulting in any given year is very low – substantially less than 1%. A

take a different approach and assume that the firm never defaults on its debt. Instead, I assume that the firm faces a borrowing constraint.[20] The firm then trades off the expected level of secondary market liquidity against rollover risk. If the firm expects it to be very costly for investors to sell bonds in the secondary market (because of regulatory costs), it will optimally reduce the maturity of its issue so as to avoid these costs. At the same time, if uncertainty about future regulatory costs is high, the firm will optimally increase the maturity of its issue to avoid having to bear rollover risk.

My model is designed to isolate how regulatory costs imposed on financial intermediaries affect the corporate bond market. To do so, I use a simple setting. In the baseline model I focus on the decision of a single representative firm. I then extend the model in Part 3.2 to allow for heterogeneity across firms.

3.1 Baseline Model

I consider a simple 4 period model. There is a continuum of identical firms of mass 1, each of which is presented with an investment opportunity at time 0. The project costs \$1 which must be paid at time 0, and, unless it is abandoned early, will pay out \$B with certainty at time 4. The firms can finance the project with either short (2 period) or long (4 period) bonds. There is a fixed cost $F > 0$ to issuing bonds, which must be paid out at each issue.[21] I assume that $F < 1$.

Firms do not default. Each firm can always repay the face value of the debt at maturity out of its equity, and strategic default is prohibited. Firms face a borrowing constraint, and can only borrow up to some face value $K > 0$. Denote the face value of a bond issued at time a and maturing at time b by $X(a, b)$, and the bond itself by (a, b). Then the leverage

report from Standard and Poor's computed the global corporate default rate for each year from 1981 to 2017. The highest investment grade default rate in the period was 0.42%, which occurred in 2002 and in 2008. In most years it was substantially lower than that, and in 15 years – over 40% of the sample – the rate was 0.00%. Standard and Poor's Ratings Services, *2017 Annual Global Corporate Default Study And Rating Transitions*, RatingsDirect (Apr 5, 2018), https://www.spratings.com/documents/20184/774196/2017+Annual+Global+Corporate+Default+Study/a4cffa07-e7ca-4054-9e5d-b52a627d8639).

[20]This borrowing constraint is consistent with the work of John Geanakoplos and others, who have argued that credit markets often operate by constraining the amount that individuals or firms can borrow. For example, it can be interpreted as a collateral constraint. *See, e.g.* Ana Fostel and John Geanakoplos, *Endogenous Collateral Constraints and the Leverage Cycle* 6 Ann. Rev. Econ. 771 (2014) ("Lenders . . . insist on collateral, which constrains how much people can borrow: Agents cannot borrow more at the going interest rates if they do not have the collateral"). While bonds are generally unsecured, because they are senior to equity in a firm's capital structure, the effective collateral is all the firm's unpledged assets, shared pro-rata with other unsecured creditors.

[21]For example, a bond offering requires the services professionals including lawyers and investment bankers. A bond issuance might also create a distraction in the corporate treasury, potentially reducing the firm's productivity.

constraint implies that at time a, firms can issue debt with a face value $X(a, b)$ if and only if $X(a, b) \leq K$

The bonds are held by a continuum of investors of mass 1, which are endowed with $\$M$ at time 0. For simplicity, I assume that $M \geq B$. Investors face a risk of liquidity shocks in each of periods 1, 2 and 3 with probability p in each period.[22] If hit by a liquidity shock at time t, an investor must liquidate her holding by selling them to an intermediary. She then re-enters the market at the beginning of period $t + 1$. The investors' outside option is to place their money in a bank checking account which earns the risk free interest rate of 0 and can be redeemed on demand.

Intermediaries earn zero profits and face regulatory costs. For simplicity, they only hold any particular bond for one period.[23] Agents face uncertainty about future regulatory costs. All agents are risk neural and all information is common knowledge. The timelines if the firm choses to issue short and long bonds are presented in Figures 1 and 2, respectively.

Figure 1: Timeline: Short Bond

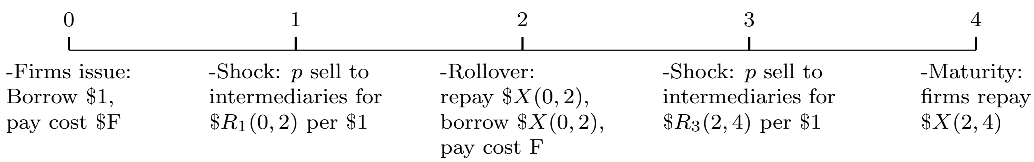
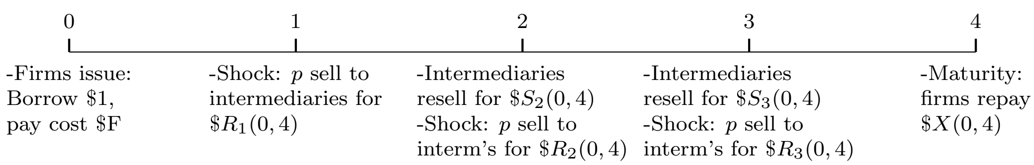


Figure 2: Timeline: Long Bond



3.1.1 Distribution of Regulatory Costs

Agents face uncertainty about future regulatory costs. I denote the regulatory cost in the future as λ_f, and assume that it will take effect at the beginning of time $t = 2$ and continue

[22]The assumption of a constant probability of a shock is for simplicity. The results hold as long as the probability of a shock in period 3 (p_3) is not too much smaller than probability of a shock in period 2 (p_2).

[23]This is consistent with holding inventory for market marking rather than for proprietary trading.

through the end of time $t = 3$. For simplicity, I assume that it can take one of three values:

$$\lambda_f = \begin{cases} \underline{\lambda}_f & \text{with probability } \alpha \\ \mu_f & \text{with probability } 1 - \alpha - \beta \\ \bar{\lambda}_f & \text{with probability } \beta \end{cases}$$

such that $E_0[\lambda_f] = \mu_f$, where $\underline{\lambda}_f \leq \mu_f \leq \bar{\lambda}_f$ and $\alpha \in (0,1)$, $\beta \in (0,1)$ and $\alpha + \beta \leq 1$. I assume that agents learn the realization of λ_f at time $t = 1$. This is consistent with the relatively long "phase-in" periods that are typical in financial regulation. I denote the regulatory cost in the first period as λ_1, and assume that it is known at time 0. To ensure that the project remains economically efficient in all states of the world, I assume that $B \geq 1 + p\lambda_1 + 2p\bar{\lambda}_f$, where the right hand side of the equation is the realized cost in the worst state of the world.

3.1.2 Intermediaries' Budget Constraint

Intermediaries operate in a competitive environment. Their bid and ask prices are therefore given by

$$R_t(a,b) + \lambda_t = E_t[S_{t+1}(a,b)] \tag{2}$$

where $R_t(a,b)$ and $S_t(a,b)$ are the intermediaries' bid and ask prices for (a,b) per dollar at time t, respectively. λ_t is the per-dollar regulatory cost of the intermediaries at time t.[24]

3.1.3 Firms' Budget Constraint

If a firm issues long, it will borrow \$1 at $t = 0$ and repay $X(0,4)$ at $t = 4$ as long as $X(0,4) \leq K$, the firm's borrowing constraint. If a firm issues short, it must roll over the debt at $t = 2$. Assuming $X(0,2) \leq K$, it will therefore borrow \$1 at $t = 0$, pay the face value $X(0,2)$ at $t = 2$, and immediately turn around and try to borrow $X(0,2)$, promising to repay $X(2,4)$ at $t = 4$. A Firm can only roll over its debt at time 2 if

$$X(2,4) \leq K. \tag{3}$$

If $X(2,4) > K$, the firm must abandon the project after repaying $X(0,2)$.

[24] This regulatory cost can be interpreted as an average regulatory cost across all intermediaries. A higher regulatory cost consistent with the finding in Adrien et al. that "institutions that face more regulations after the crisis both reduce their overall volume of trade and have less ability to intermediate customer trades." Tobias Adrian, Nina Boyarchenko & Or Shachar, *Dealer Balance Sheets and Bond Liquidity Provision*, J. of Monetary Economics (*forthcoming*, 2017).

3.1.4 Bond Prices

Combining (1) risk neutral investors, (2) no arbitrage, and (3) a competitive intermediary environment, we can solve for the face values of each of the bonds:

$$X(0,2) = 1 + p\lambda_1 \tag{4}$$

$$X(2,4) = 1 + p\lambda_1 + p\lambda_f \tag{5}$$

and

$$X(0,4) = 1 + p\lambda_1 + 2p\mu_f \tag{6}$$

3.1.5 Firms' Problem

Assuming that a firm takes the project, its goal is to minimize the total cost of borrowing. Because of the fixed cost of issuing F, it will not choose to have both short and long term debt outstanding at the same time. If it issues short, its total payoff will be

$$\begin{aligned} \mathrm{E}_0\left[\Pi_{short}\right] &= Prob_0(X(2,4) \leq K)E_0[(B - 2F - X(2,4))|X(2,4) \leq K] \\ &+ \mathrm{Prob}_0(X(2,4) > K)E_0[(-F - X(0,2))|X(2,4) > K] \end{aligned}$$

or

$$\begin{aligned} \mathrm{E}_0\left[\Pi_{short}\right] &= Prob_0(\lambda_f \leq \tfrac{K-1+p\lambda_1}{p})(B - 2F - (1 + p\lambda_1 + pE_0[\lambda_f|\lambda_f \leq \tfrac{K-1+p\lambda_1}{p}])) \\ &+ (1\text{-Prob}_0(\lambda_f \leq \tfrac{K-1+p\lambda_1}{p}))(-F - (1 + p\lambda_1)) \end{aligned}$$

Let $A = \frac{K-1+p\lambda_1}{p}$. Then we can write this as

$$= Prob_0(\lambda_f \leq A)(B - F - pE_0[\lambda_f|\lambda_f \leq A]) - F - 1 - p\lambda_1 \tag{7}$$

If it issues long, its total payoff will be

$$\Pi_{long} = B - F - X(0,4)$$

or

$$\Pi_{long} = B - F - (1 + p\lambda_1 + 2p\mu_f)$$

if $X(0,4) \leq K$, and 0 otherwise.

Define Π_{LS} as $\Pi_{long} - \Pi_{short}$ – the difference between the firm's payoff from choosing to issue short versus issuing long. If $E_0\left[\Pi_{LS}\right] < 0$, issuing short is preferable to issuing long, and when $E_0\left[\Pi_{LS}\right] > 0$ issuing long is preferable to issuing short.

To investigate the trade-off between expected future regulatory costs (which is captured by μ_f) and uncertainty about these costs (which is captured by β), I begin by assuming that $A \geq 2\mu_f$, $A < \bar{\lambda}_f$, and $\Pi_{long} \geq 0$.[25] Then we have

$$E_0\left[\Pi_{LS}\right] = \beta B + (1-\beta)F + p[\alpha\underline{\lambda}_f - (1+\alpha+\beta)\mu_f] \tag{8}$$

3.1.6 Comparative Statics

I now compare the relative desirability of short versus long bonds in the baseline model. In order to investigate the effect of a change in parameter values, I begin by taking partial derivatives of Π_{LS}. A positive partial derivative with respect to any variable implies that as that variable increases, long bonds will become relatively more attractive.

The following partial derivatives follow immediately from Equation (8):

$$\frac{\partial E_0\left[\Pi_{LS}\right]}{\partial \mu_f} = -(1+\alpha+\beta)p < 0 \tag{9}$$

since $\alpha > 0$, $\beta > 0$ and $p > 0$.

$$\frac{\partial E_0\left[\Pi_{LS}\right]}{\partial \beta} = [B - F] - p\mu_f > 0 \tag{10}$$

since $\Pi_{long} \geq 0$,

3.1.7 Interpretation and Intuition

The analysis in Part 3.1.6 provide several insights. First, a deterioration in the expected future regulatory environment – a change in the regulatory environment that results in a reduction in liquidity – will cause firms to issue shorter maturity debt. In the model, this corresponds to an increase in μ_f, which is captured in equation (9). Intuitively, firms respond to a deteriorating liquidity environment by acting as their own intermediaries. This is "self-help liquidity": Rather than relying on an intermediary to convert the bonds into cash at an intermediate period, a firm performs that service for the investors itself, effectively acting as a market maker in its own debt.

At the same time, providing this "market maker" service is both costly (captured by F) and risky. Issuing short debt implies the possibility that a firm will have to abandon an

[25]This implies that $1 + p(\lambda_1 + 2\mu_f) \leq K$, $1 + p(\lambda_1 + \bar{\lambda}_f) > K$, and $B - F - p\mu_f > 0$. Together, these assumptions imply (1) that the firm can borrow long, (2), that in the bad state of the world, the firm cannot roll over its debt, and (3) that in expectation, the firm can profitably finance the project with long debt.

otherwise profitable project before it is complete, resulting in both economic inefficiency and losses to shareholders.[26] As a result, when firms face high uncertainty about future regulatory costs, they will tend to increase maturity. As the probability of the "worst case" outcome increases (defined as an increase in β), firms prefer to issue long. This is the result in equation (10). Intuitively, as the risk of a very poor future regulatory environment increases, so does the risk that a firm will hit its borrowing constraint and not be able to roll over its short debt.

The model therefore reveals a simple and intuitive trade-off: when the *expected* future regulatory cost is high, firms issue short, preferring to act as their own intermediaries. When the *risk* of future regulatory costs is high, firms issue long as a way to manage rollover risk. Because the future regulatory costs are imposed on secondary market intermediaries, they will affect prices only to the extent that the bonds are actually traded through these intermediaries. If instead a firm acts as its own intermediary, it can avoid this cost. Avoiding this cost, in turn, is more valuable when this cost is expected to be high. At the same time, doing so creates risks for the firm. If it turns out that the regulatory cost is very bad in the future, the firm is in trouble. Whereas an intermediary simply incorporates the future regulatory cost into its bid price – effectively passing it on to investors – a firm will find itself locked out of the bond market. Because there is a limit to the amount that the firm can borrow (its leverage constraint), the firm has no choice but to abandon the project at a loss.

3.2 Model Extensions

I now extend the baseline model by allowing firms to have different sensitivities to regulatory costs, and different preferences for short and long debt. I use a reduced form approach to introduce heterogeneity in sensitivity to regulatory cost across firms. I model this heterogeneity by assigning each firm i in the continuum a multiplicative sensitivity factor ϕ_i, where $\phi_i \in [0, 1]$. Firm i's sensitivity factor captures the degree to which regulatory costs affect firm i's bonds through the intermediaries' budget constraint. The intermediaries' budget constraint becomes

$$R_{i,t}(a, b) + \phi_i \lambda_t = E_t[S_{i,t+1}(a, b)] \tag{11}$$

where $R_{i,t}(a, b)$ and $S_{i,t}(a, b)$ are the intermediaries' per-dollar bid and ask prices for (a, b) issued by firm i at time t, respectively, λ_t is as in equation (2), and ϕ_i is firm i's sensitivity factor.

[26] The model assumes that firms have enough assets to repay the bondholders even in the event of a failed rollover. This implies that losses are borne by the "firms." Of course, in reality it would be the firms' shareholders who would bear this loss.

Using the same approach as in Part 3.1, it can be shown that firm i's payoff from issuing long can be written as:

$$\Pi_{i,long} = B - F - (1 + \phi_i p \lambda_1 + 2\phi_i p \mu_f)$$

if $1 + \phi_i p \lambda_1 + 2\phi_i p \mu_f \leq K_i$, and 0 otherwise.

Under the assumptions of the baseline model, the probability that a firm would have to abandon the project at time 2 if it chose to finance using short debt was equal to the probability of a bad regulatory state of the world. While that implicit assumption was benign in the baseline model, it is less so once we introduce heterogeneity across firms. In particular, intuition suggests that a more sensitive firm is more likely to have to abandon the project in the bad state of the world. To capture this intuition in a reduced form manner, I assume that the probability that firm i must abandon the project in the event of a bad state of the world (which occurs with probability β) is also given by ϕ_i. In addition to this, analogously to Part 3.1, I assume that $A^* \geq 2\mu_f$, where $A^* = \frac{K-1+\phi_i p \lambda_1}{\phi_i p}$, and $\Pi_{long} \geq 0$. Then firm i's expected payoff from issuing short can be written as

$$\mathrm{E}_0\left[\Pi_{i,short}\right] = Prob_0(not\ abandon)(B - F - \phi_i p E_0[\lambda_f | not\ abandon]) - F - 1 - \phi_i p \lambda_1$$

or

$$\mathrm{E}_0\left[\Pi_{i,short}\right] = (1-\phi_i\beta)\left(B - F - \phi_i p\left(\frac{\alpha\underline{\lambda}_f + (1-\alpha-\beta)\mu_f + \beta(1-\phi_i)\bar{\lambda}_i}{1-\phi_i\beta}\right)\right) - F - 1 - \phi_i p \lambda_1$$

Combining these, we have that

$$E_0\left[\Pi_{i,LS}\right] = \phi_i\beta B + (1-\phi_i\beta)F + \phi_i p[\alpha\underline{\lambda}_f + \beta(1-\phi_i)\bar{\lambda}_f - (1+\alpha+\beta)\mu_f] \tag{12}$$

In order to capture the intuition that different firms have different optimal capital structures, I also allow firms to have heterogeneous preferences for short versus long debt. I model this by assigning each firm i a preference parameter $\theta_i \in \mathbb{R}$, which captures its preference for short debt relative to long debt. I assume that θ_i is independent of ϕ_i.

Adding this to the model, Equation 12 becomes

$$E_0\left[\Pi_{i,LS}\right] = \theta_i + \phi_i\beta B + (1-\phi_i\beta)F + \phi_i p[\alpha\underline{\lambda}_f + \beta(1-\phi_i)\bar{\lambda}_f - (1+\alpha+\beta)\mu_f] \tag{13}$$

3.2.1 Extended Model: Comparative Statics

I now study the effect of this heterogeneous sensitivity on the relative desirability of short versus long bonds. As in Part 3.1.6, I take partial derivatives, and a positive partial derivative with respect to any variable implies that as that variable increases, long bonds will become relatively more attractive.

The following partial derivatives follow immediately from Equation (13):

$$\frac{\partial E_0\left[\Pi_{i,LS}\right]}{\partial \mu_f} = -\phi_i(1+\alpha+\beta)p \leq 0 \tag{14}$$

since $\alpha > 0$, $\beta > 0$, $p > 0$ and $\phi_i > 0$.

$$\frac{\partial E_0\left[\Pi_{i,LS}\right]}{\partial \beta} = \phi_i[B - F + p(\bar{\lambda}_f - \mu_f) - \phi_i p \bar{\lambda}_f] \geq 0 \tag{15}$$

since $\bar{\lambda}_f > \mu_f$, $F \in (0,1)$ and $B - 1 - \phi_i p(\lambda_1 + 2\bar{\lambda}_f) \geq 0$.[27]

We can also investigate the cross-derivatives with respect to ϕ_i, which capture the cross-sectional differences in the sensitivity of these relationships as ϕ_i increases. Differentiating equations (14) and (15) with respect to ϕ_i, we have

$$\frac{\partial^2 E_0\left[\Pi_{i,LS}\right]}{\partial \mu_f \partial \phi_i} = -(1+\alpha+\beta)p < 0 \tag{16}$$

and

$$\frac{\partial^2 E_0\left[\Pi_{i,LS}\right]}{\partial \beta \partial \phi_i} = [B - F + p(\bar{\lambda}_f - \mu_f) - 2\phi_i p \bar{\lambda}_f] > 0 \tag{17}$$

since $\bar{\lambda}_f > \mu_f$, $F \in (0,1)$ and $B - 1 - \phi_i p(\lambda_1 + 2\bar{\lambda}_f) \geq 0$.

3.2.2 Interpretation and Intuition

The analysis in Part 3.2.1 provide several insights that go beyond the results in Part 3.1.6. First, equation (16) shows that, as in the baseline model, a deterioration in the expected future regulatory environment (an increase in μ_f) will cause firms to issuer shorter maturity debt. Unlike before, however, this effect varies depending on the exogenous liquidity of the firm's bonds. Equation (16) tells us that this effect is stronger ("more positive") for more sensitive firms (those with a high ϕ_i). In other words, firms that are more sensitive to regulatory costs are relatively more likely to which to shorter term debt than those that are less sensitive. As discussed in more detail in Part 3.3, these more sensitive firms are likely to be those whose bonds trade relatively little in the absence of liquidity shocks. The intuition is simple but important: firms that already enjoy a high degree of liquidity are less likely to engage in "self-help liquidity" when the regulatory environment deteriorates. Instead, it is the firms who's bonds are less liquid to begin with that will effectively act as a market maker in their own debt.

[27] As in the baseline case, this assumption ensures that the project is always ex post efficient.

At the same time, the risks of providing this "market maker" service are also greater for less liquid firms. High uncertainty about future regulatory costs is more painful for a firm whose bonds are at the shallow end of the liquidity pool. Equation (15) shows that, as before as the probability of the "worst case" outcome increases (defined as an increase in β), all firms prefer to issue long. However, this effect is particularly strong for firms that are more sensitive to these costs (i.e., those with less exogenous liquidity) which is the result in equation (17).

In other words, the main result from the first extension is that the key tradeoff identified in the baseline model – when the *expected* future regulatory cost is high, firms issue short, preferring to act as their own intermediaries; when the *risk* of future regulatory costs is high, firms issue long as a way to manage rollover risk – is particularly important for already illiquid firms. On the other hand, this tradeoff is substantially attenuated for the less sensitive firms. Rather than switching between short and long bonds, these firms are more likely to simply absorb the changes in regulatory costs.

3.3 Implications for the Corporate Bond Market Since Dodd-Frank

As discussed in Part 2, regulators, market participants, and commentators have all expressed concerns about the effect of Dodd-Frank and the Volcker Rule on the corporate bond market. In particular, it is likely to have made it more expensive to obtain secondary market liquidity, either because of compliance costs, or because some providers have exited the market entirely. Moreover, in the lead up to the promulgation of the final regulations, there was substantial uncertainty about just how costly the regulations would end up being.

A key cross-sectional prediction of the model is that regulatory costs and uncertainty are likely to have a stronger effect on issues that are more sensitive. The model is agnostic, however, as to how to identify such issues. In my empirical analysis in Part 4, I use an issue's expected secondary market liquidity prior to its issuance as a proxy for its sensitivity to regulatory costs. By definition, more liquid issues – the ones that I will treat as less sensitive – trade more than less liquid ones. There are several reasons why I use this proxy. By definition, issues that are more liquid trade more often for reasons unrelated to regulatory costs. To the extent that some or all of the regulatory costs associated with making a market in a particular issue are fixed, these costs will be spread out over more trades, and thus represent a smaller per-trade amount. Second, these issues are likely to be more profitable to, and less risky for, intermediaries. As a result, to the extent that the regulatory costs cause intermediaries to stop holding any inventory in a particular issue, they are likely to abandon the least profitable and most risky issues first.

The model therefore gives us very clear predictions. When the expected regulatory costs increase, we should expect to see the maturity at issue of the least liquid bonds fall, while the maturity at issue of the most liquid issues should be about the same. Two strong candidates for this are January 2010 (the signing of Dodd-Frank) and after December 2013 (the approval of the Volcker Rule regulations), when intermediaries gradually began to accept that their lobbying efforts were not going to succeed in stopping the implementation of the regulations. On the other hand, right before the regulations were approved, uncertainty should have been at its highest. As a result, the model predicts that the maturity at issue of the least liquid bonds should have risen leading up to December 2013, while the maturity at issue of the most liquid issues should again have stayed fairly constant.

Because the distinction between expected future regulatory costs and regulatory risk is crucial to both the model and the empirical results, it is useful to consider a simple example. Conceptually, it is straightforward to distinguish between the two. A high regulatory cost might be a rule that imposes onerous compliance costs – for example, it requires intermediaries to complete extremely onerous and costly paperwork – in order to prove that each issue it holds is being held for market making purposes. This type of regulatory requirement would raise future costs of being an intermediary, and would disproportionately affect less liquid issues. A time of high regulatory risk, on the other hand, corresponds to a time when market participants do not know what the future regulations will look like, but know that there is a reasonable probability that they will make it extremely (perhaps even prohibitively) costly for intermediaries to act as market makers. While high regulatory costs induce firms to act as their own liquidity providers, high regulatory risk induces them to rely more heavily on third party market intermediaries.

4 Empirical Analysis

I now turn to the empirical portion of the analysis. I discuss the data and variable construction in Part 4.1 and the empirical specification and results in Part 4.2. Finally, in Part 4.3, I conduct a placebo test using data from the municipal bond market. Unlike corporate bonds, municipal bonds were specifically exempted from the effects of Dodd-Frank.[28] Consistent with my hypothesis, I find no evidence of a comparable effect on bond maturity choice in the municipal bond market.

4.1 Data and Variable Construction

I obtain bond issuance data, including rating at issuance, from Mergent Fixed Income Securities Database (FISD)[29] and trade data from the Trade Reporting and Compliance

[28] *See* discussion in Part 4.3.

[29] This file contains ratings by Standard and Poor's (S&P), Moody's and Fitch. In order to ensure that the ratings map as closely as possible to the risk profile of the bonds at the time of issue, I restrict attention

Engine (TRACE).[30] I supplement this with data from a variety of sources. I use the risk-free interest rate data from Kenneth French's website, which is obtained from Ibbotson Associates.[32] I obtain spread data for each of the the four investment grade credit ratings from the Federal Reserve Bank of St. Louis's "FRED" database.[33] Data on government bonds is from the Center for Research in Security Prices (CRSP), and municipal bond issuance and ratings data from Thompson Reuters SDC Platinum Global Public Finance database. I also obtain data on the "Bond Buyer Go 20-Bond Municipal Bond Index" from the FRED database.

In constructing my final sample, I filter out all issues that are denominated in a foreign currency or are coded as asset backed, as well as secured lease obligations, putable and convertible bonds, and preferred securities, as well as agency and government issues and US bank notes. I also omit issues that are missing a CUSIP or an offering amount, as well as issues listed in FISD as having an offering amount less than or equal to 0. Because I am interested in maturity choice, I omit all bonds for which the offering date or the maturity date are missing. Finally, because I am interested in maturity choice decisions that are unrelated to credit risk, I restrict my sample to bonds with investment grade ratings at issue. I am left with a total of 38,948 issues.

I begin with three different proxies for liquidity. In each case, the goal is to capture the anticipated liquidity of an issue at the time of issue. The first is issue size. Issue size has been used as a proxy for liquidity in the literature on corporate bond liquidity,[34] with larger size acting as a proxy for higher liquidity. This "primary market" measure of liquidity has the advantage of relying only on information about the issue itself, and is therefore defined for all bonds in my sample.

I also construct two measures of anticipated liquidity for each bond based on secondary

---

to rating that are both coded as initial ratings and for which the reported rating date was no more than 30 days after the issuance date of the bond in question.

[30] I follow the procedure outlined by Jens Dick-Nielsen to clean the TRACE data. *See* Jens Dick-Nielsen, *Liquidity biases in TRACE*, 19 J of Fixed Income 43, 2009, and Jens Dick-Nielsen *How to clean Enhanced TRACE data* (Working Paper, 2014) (*on file with author*). Note that TRACE reports clean prices, which exclude accrued interest. In order to obtain the actual price that a buyer will pay in a given transaction (the "dirty price"), it is necessary to add the accrued interest to the clean price. However, since I restrict attention to secondary market liquidity measures that are computed using intra-day prices, this additional step is not necessary, since accrued interest does not change within-day. Since late 2004, TRACE coverage has included "transactions of essentially all US corporate bonds."[31] I therefore begin my main analysis in 2005, and cover the period January 2005 - March 2016.

[32] Kenneth French, *Current Research Returns*, `http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/Data_Library/f-f_factors.html` (last visited May 23, 2017).

[33] Specifically, I obtain data on the BofA Merrill Lynch US Corporate Option-Adjusted Spread for each of the following bond ratings: AAA AA A and BBB. *See FRED Economics Data*, Federal Reserve Bank of St. Louis, `https://fred.stlouisfed.org/` (last visited May 23, 2017).

[34] *See, e.g.* Patrick Houweling, Albert Mentink & Ton Vorst, *Comparing possible proxies of corporate bond liquidity*, 29 J. of Banking & Fin. 1331 (2005).

market data: Amihud liquidity, and the imputed (or "implied") round-trip transaction cost (IRC), both of which are standard in the literature on bond market liquidity.[35] For each issuance, I identify that issuer's outstanding issues the period immediately prior to the issuance.[36] I then measure the liquidity of these outstanding issues. If an issuer has more than one issuance outstanding for which the measure is well defined in the month before the issue date, I take the simple average across issues. The logic behind this approach is that a firm might reasonably expect that if its outstanding issuers are relatively liquid, its new issue will likely also be relatively liquid.

The Amihud liquidity measure is designed to measure the impact of a trade on the market price of the security. It is defined as:

$$Amihud_t = \frac{1}{N_t} \sum_{i=1}^{N_t} \frac{|r_{i,t}|}{Volume_i}$$

where $r_{i,t}$ is the return on trade i and N_t is the number of trades on date t.[37] Following recent literature,[38] I define a monthly Amihud measure as the median daily measure in each month. An issuer's Amuihud liquidity measure is defined as the simple average of the Amihud liquidity measures of each of its outstanding issues. I then average this over the three month period ending the period before the issuance to obtain the anticipated Amihud liquidity measure of an issuance.

The IRC measure is designed to capture dealer markups that are added as a trade passes through multiple intermediaries. It is constructed by first identifying multiple trades in the same bond of the same size in a given day. These trades are thought to represent a single transaction which is passing through several intermediaries before arriving at its final destination. Having identified these trades, the IRC is defined as the (scaled) price difference between the highest recored price (P_{max}) and the lowest recorded price (P_{min})

[35] *See, e.g.*, Jens Dick-Nielsen, Peter Feldhüutter & David Lando, *Corporate Bond Liquidity Before and After the Onset of the Subprime Crisis*, 103 J. FIN. ECON., 471 (2012).

[36] With two exceptions, I apply the same filters in identifying these outstanding issues as I used in the construction of my sample. First, for obvious reasons, I relax the requirement that the issue occur after 2005, and instead require only that it have been issued since 1985. Second, I do not impose the rating at issue requirement.

[37] See Jens Dick-Nielsen, Peter Feldhüutter & David Lando, *Corporate Bond Liquidity Before and After the Onset of the Subprime Crisis*, 103 J. FIN. ECON., 471, 487 (2012); Efraim Benmelech & Nittai Bergman, *Debt, Information and Liquidity* 7 (Working Paper, 2016) (*on file with author*)

[38] See Jens Dick-Nielsen, Peter Feldhüutter & David Lando, *Corporate Bond Liquidity Before and After the Onset of the Subprime Crisis*, 103 J. FIN. ECON., 471, 487 (2012); Efraim Benmelech & Nittai Bergman, *Debt, Information and Liquidity* 7 (Working Paper, 2016) (*on file with author*)

from among that series of trades[39]:

$$IRC_t = \frac{P_{max} - P_{min}}{P_{max}}$$

In order to maintain consistency with my Amihud measure, I define a monthly IRC measure as the median daily measure in each month. An issuer's IRC liquidity measure is defined as the simple average of the IRC liquidity measures of each of its outstanding issues. I then average this over the three month period ending the period before the issuance to obtain the anticipated IRC liquidity measure of an issuance.

Because the IRC measure requires that there be at least two trades of the same size on a given day, the measure is defined for only a subset of issues in the sample. While the Amihud measure has a less restrictive data requirement, it also relies on secondary market trading activity in the issuer's other issues. At a minimum, to have an Amihud liquidity measure, the issuer must have at least one outstanding issues in the 3 months leading up to the issuance, which traded at least twice on a single day in that period.

I standardize each of the three liquidity measures so that they each have a mean of 0 and a standard deviation of 1, and sum them to create a composite measure, IAS, defined as

$$IAS_j = std(IRC_j) + std(Amihud_j) + std(-size_j) \tag{18}$$

where j indexes an issue. $size_j$ enters with a negative sign.

Finally, I divide my sample into quintiles based on each of these liquidity measures.[40]

4.2 Multivariate Analysis

In order to estimate the relationship between regulatory costs and firm maturity decisions at issue, I estimate an econometric model that controls for other factors that might affect issuance decisions. The residuals from these regressions can be interpreted as the "surprise" component of the maturity choice, and captures all the factors other than those in the model, including regulatory costs. Combined with a knowledge of the timing of key aspects of Dodd-Frank and the results of the model developed in Parts 3.1 and 3.2, I argue that

[39] *See* Efraim Benmelech & Nittai Bergman, *Debt, Information and Liquidity* 7 (Working Paper, 2016) (*on file with author*). For a slightly different version of this measure, *see* Jens Dick-Nielsen, Peter Feldhüutter & David Lando, *Corporate Bond Liquidity Before and After the Onset of the Subprime Crisis*, 103 J. FIN. ECON., 471, 487 (2012).

[40] These quintiles can be constructed in two different ways. In the first, I pool all the issues in the sample and construct the quintiles based on this pool. In the second, I construct the quintiles month-by-month. I use the second approach for the main results in this section. However, to the extent that the first approach results in sufficient observations, I repeat my analysis using the first approach. In general, the results are similar.

such unusual movements are best understood as being related to the effects of Dodd-Frank.

4.2.1 Control Variables

In include a number of control variables, including the issue's credit rating at issue,[41] as well as market credit spreads at the time of issue. For maximum flexibility, I allow for both interaction effects between rating-specific spreads and an issue's credit rating *and* an overall effect of a particular credit rating. I therefore match each issue with the appropriate spread according to the issue's rating (AAA, AA, A or BBB). In my most conservative specification, I also allow spreads to affect issuance decision differently based on liquidity level. I allowed this extra degree of flexibility to capture the fact that, for example, credit spreads might matter more to less liquid firms.[42] I further allow spreads to affect issuance decision differently for different levels of credit spreads by using a piecewise linear functional form.[43]

I also include controls for the treasury rate. As with credit spreads, I allow the relationship between the risk free and term choice to vary at different levels of the risk-free rate. Based on Greenwood, Hansen and Stein, I include the face-value weighted maturity of government bonds.[44] In an abundance of caution and for additional robustness, I also include the equally weighted maturity of government bonds.

I also control for issue size, using a 5th order polynomial, both because it is a highly salient feature of an issue and because it might be related to other factors that are important to bond purchasers.[45] Finally, I include 3-digit NAICS codes to control for industry fixed effects and a dummy to control for whether or not the issue is coded as a Medium Term

[41]In some cases, an issue may receive a different rating from different rating agencies. Because my spread data is derived from the applicable BofA Merrill Lynch index, I combine the ratings according the methodology used by that index in constructing its bond indices, and I adopt their definition of investment grade. *See* Bank of America Merrill Lynch *Calculation methodologies* (on file with author).

[42]For robustness, I have repeated the analysis forcing credit spreads to have the same effect for all liquidity quintiles. The general pattern is unchanged.

[43]For robustness, I have repeated the analysis forcing credit spreads to have the same effect at all levels. The general pattern is unchanged.In an abundance of caution, I have performed two other additional robustness analysis. In the first, I forced credit spreads to have the same effect at all levels *and* for all liquidity quintiles. Finally, in the most extreme analysis, I omitted credit spreads entirely. In all cases, the general pattern is similar.

[44]Robin Greenwood, Samuel Hanson & Jeremy C. Stein, *A Gap-Filling Theory of Corporate Debt Maturity Choice*, 65 J. Fin. 993 (2010).

[45]Note that including size as a control does not contradict my use of size as a liquidity factor. That is using size quintile to sort *within a specific time period*, whereas this looks at the *average* effect of size over the entire sample period. This means that by including size as a control, the size quintile sorts will pick up the effect of size above and beyond what one would normally expect.

Note (MTN) in the FISD data.[46]

4.2.2 Regression Specification

Having assembled these controls, I estimate the following regression:

$$
\begin{aligned}
term_{j,r,t} = \alpha + \sum_{n=1}^{5} \beta_n size_j^n + \sum_{r\in R} \gamma_r \mathbb{1}_{j,r}^{rating} + \delta MTN_j \\
+ \sum_{r\in R} \sum_{l=1}^{5} \sum_{n=1}^{max} \left[\xi_{r,l,n} Spread_{r,t} \mathbb{1}_{j,r,l,n}^{spread_r} \right] \\
+ \sum_{n=1}^{max} \delta_n RiskFreeRate_t \mathbb{1}_n^{RiskFreeRate_t} \\
+ \eta Industry_j + \psi_{vw} GHS\_vw_t + \psi_{ew} GHS\_ew_t + \varepsilon_{j,r,t}
\end{aligned}
$$

for each bond j, with a rating r, issued at month t, and the variables are defined as in Appendix B. I then compute the predicted term, $\hat{term}_{j,r,t}$ based on the coefficient estimates from this regression. From this, I construct the "abnormal term," which is given by

$$
AbnormalTerm_{j,r,t} \triangleq term_{j,r,t} - \hat{term}_{j,r,t} = \varepsilon_{j,r,t} \tag{19}
$$

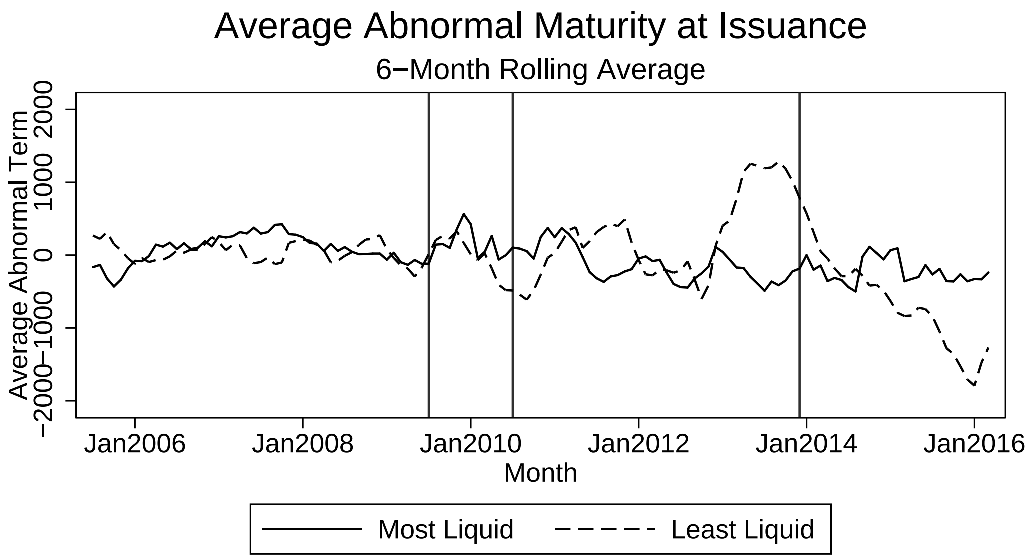
4.2.3 Multivariate Plots and Analysis

I now plot the six-month moving average surprise term, as defined in equation 19 for both the most liquid and least liquid quintiles in my sample from July 2005 through March 2016 using the "IAS" measure of liquidity, which aggregates information from all three proxies, is presented in Figure 5. The solid line represents the most liquid quintile, and the dashed line represents the least liquid quintile.

Figure 5 displays a pattern consistent with the predictions in Part 3.3. The solid line, representing that abnormal, or "surprise" term of the most liquid issues, wanders around a little, but overall it is quite stable over the entire period. The dashed line, representing the abnormal term of the least liquid issues, was also fairly stable until Dodd-Frank. We then see a drop in the dashed line around the Dodd-Frank period, and the difference between the

[46] In an abundance of caution, I repeat my analysis filtering out all issues below the first percentile of size of *non-MTN* issues. The pattern of results in unchanged, indicating that the results are not being driven by extremely small MTN issues.

Figure 3: Average Abnormal Maturity Issuance, Top and Bottom Quintile of Expected Liquidity at Issuance



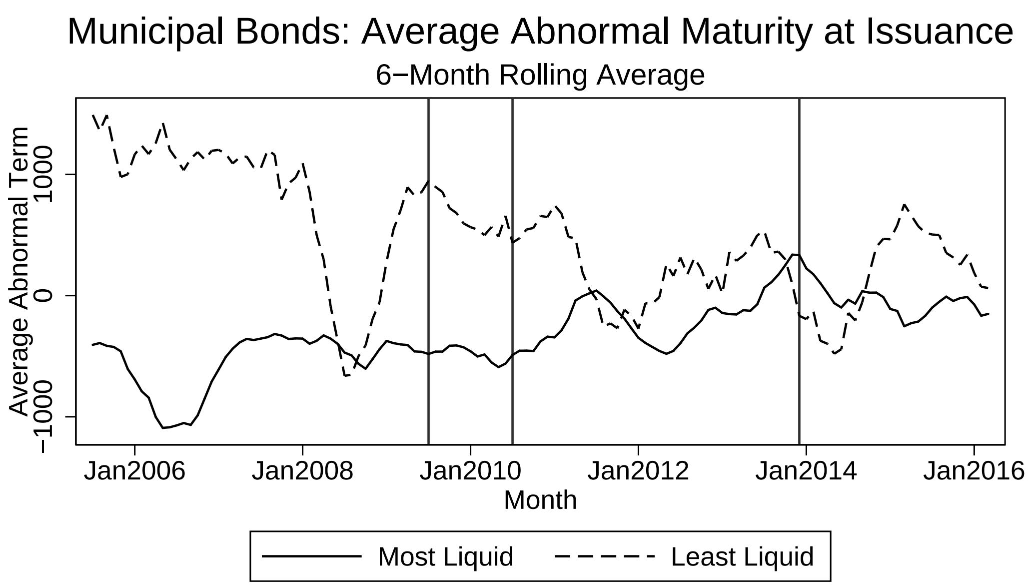
Jul. 2009: Dodd−Frank proposed in House. Jul. 2010: Dodd−Frank signed.
Dec. 2013: Volker Rules regs approved.
Investment grade corporate bonds. Most Liquid refers to the top quintile of expected liquidity, as defined by IAS, a proxy that aggregates IRC, Amihud, and Issue Size.
Least Liquid refers to the bottom quintile of expected liquidity, as defined by the same measure.
Surprise term controls for spreads, interest rates, credit rating, size, average maturity of outstanding government bonds, MTN dummy, and industry dummies.

solid line and the dashed line is significantly different from 0 at the 5% level. The dashed line then peaks shortly before the approval of the Volcker Rule regulations, followed by a marked decline. At the end of the sample period, the dashed line is substantially below the solid line. Again, this is consistent with the prediction of the model, as discussed in Part 3.3. The difference between the solid and dashed lines is statistically distinguishable from zero at both the peak and the trough at the 5% level.

4.3 Placebo: Municipal Bonds

While the results in Part 4.2 are consistent with the model in Part 3, there remains the possibility that something else was happening in the bond market at that time, and was driving these effects. To address this concern, I look at a market that is similar in important ways to the corporate bond market, but what not directly affected by Dodd-Frank: the municipal bond market. While there are some features of the municipal bond market that make it distinct from the corporate bond market, munis and corporates have several key features in common. Like corporates, munis are subject to interest rate risk. Moreover, like corporates, munis tend to trade over the counter, and are therefore reliant on market makers. Crucially, however, these market makers are explicitly exempt from the proprietary trading prohibitions in Dodd-Frank's Volcker Rule.[47]

Figure 4: Municipal Bonds: Average Abnormal Maturity Issuance, Top and Bottom Quintile of Expected Liquidity at Issuance



Jul. 2009: Dodd−Frank proposed in House. Jul. 2010: Dodd−Frank signed.
Dec. 2013: Volker Rules regs approved.
Investment grade municipal bonds. Most Liquid refers to the top quintile of expected liquidity, as defined by size of issuance. Least Liquid refers to the bottom quintile of expected liquidity, as defined by the same measure. Surprise term controls for interest rates, credit rating, size, average maturity of outstanding government bonds, and the Bond Buyer Go 20−Bond Municipal Bond Index.

The muni market therefore represents a useful placebo setting. If the same pattern does not appear in the muni market, it would suggest that an alternative explanation based on changes in either the interest rate environment or the debt market overall are responsible for the empirical results. In order to minimize any concerns about differences between trading behavior in the muni market and the market for corporate bonds, I restrict attention to size as my sole proxy for liquidity in both markets.

Unfortunately, I am aware of no indices or municipal bond spreads. I therefore repeat the analysis in Part 4.2 using the "Bond Buyer Go 20-Bond Municipal Bond Index" instead

[47] 17 CFR 255.6(a)(3) (exempting "[a]n obligation of any State or any political subdivision thereof, including any municipal security" from the prohibition of proprietary trading).

of credit spreads.[48] The results are presented in Figure 6. The vertical lines represent the same dates as in the figures in Part 4.2. I find no evidence of the pattern discussed in Part 4.2. This provides further evidence in support of my thesis. Whatever is driving the observed pattern in the market for corporate bonds, it does not appear to be having a similar effect in the market for municipal bonds.

5 Discussion

There is no indication that regulators, policymakers, or anyone else intended for firms to respond to Dodd-Frank in this way. Nevertheless, as shown in the model outlined in in Part 3, doing so is privately optimal for firms. This optimal behavior nevertheless involves additional costs and risks. Firms that choose to issue short will have to bear the fixed costs of issuance twice rather than a single time. These should be included in the indirect costs of the regulatory intervention.

More importantly, the issuance of short debt creates risks for the issuing firms. This is particularly ironic given that Dodd-Frank and the Volcker rule were intended to reduce risk in the financial system. Instead, one unintended consequence could be that it actually created a whole new set of risks in another portion of the financial market. While the intermediaries' books may be smaller, if relatively illiquid firms respond by issuing short debt a deterioration in credit conditions could lead to a wave to abandoned projects as firms find themselves unable to roll over their debt. While the model does not permit financial default (i.e., the bonds are always repaid in full), if enough firms are forced to abandon projects, this could result in a drop in output and an increase in unemployment. While these new risks may be smaller or easier to manage than the risks that the regulation is intended to mitigate, it is a mistake to overlook them.

Perhaps even more importantly, a policy evaluation that looks only at the secondary market will overlook all of these. Because firms respond to regulatory changes optimally, both these costs and these risks are essentially transfered to the primary market. As a result, these costs and risks may be overlooked, leading to an underestimation of the the regulation's true costs.

Finally, there are important distributional consequences to consider. Notice that these unintended costs are concentrated in the least liquid issues, many of which are small. The largest issues, which represent the most liquid group, were hardly affected. In other words, the primary effect of Dodd-Frank and the Volcker Rule was concentrated in the shallow

[48] While the Index has since been discontinued, it was available for the period of interest. Alternatively, I could simply continue to use the credit spreads on *corporate bonds*, recognizing that they may not be as good measure of the credit spreads in this market. I perform this analysis for robustness, and still do not find the same pattern as I do in the corporate bond market.

end of the liquidity pool – among the issues that are least well equipped to bear these costs.

6 Conclusion

I analyze the effect of the Volcker Rule on the corporate bond market. I develop a model in which firms trade off expected regulatory costs against regulatory uncertainty. When expected regulatory costs are high, firms prefer to issue short debt: providing "self-help" liquidity. In contrast, when regulatory uncertainty is high, firms prefer to issue longer term debt, which reduces their exposure to rollover risk. I then perform an empirical analysis, and find that the data are consistent with my model. My analysis highlights the importance of the interplay between the financial sector and the capital markets in conducting policy evaluations.

A Face Values – Proof

Because investors operate in a competitive market, in equilibrium they must be indifferent between buying each bond at issue. At $t = 0$, the investor is indifferent between buying $(0, 2)$ if and only if

$$pR_2(0,2) + (1-p)X(0,2) = 1$$

which implies that

$$X(0,2) = 1 + p\lambda_1 \tag{20}$$

At $t = 2$, the investor is indifferent between buying $(2, 4)$ if and only if

$$pR_3(2,4) + (1-p)X(2,4) = X(0,2)$$

which implies that

$$X(2,4) = 1 + p\lambda_1 + p\lambda_f \tag{21}$$

Finally, at $t = 0$, the investor is indifferent between buying $(0, 4)$ if and only if

$$E_0\left[pR_1(0,4) + (1-p)\left\{pR_2(0,4) + (1-p)\left[pR_3(0,4) + (1-p)X(0,4)\right]\right\}\right] = 1$$

or equivalently

$$X(0,4) = 1 + p\lambda_1 + 2p\mu_f \tag{22}$$

B Variable Definitions

The regression in Part 4.2.2 is

$$\begin{aligned} term_{j,r,t} = \alpha + \sum_{n=1}^{5} \beta_n size_j^n + \sum_{r\in R} \gamma_r \mathbb{1}_{j,r}^{rating} + \delta MTN_j \\ + \sum_{r\in R}\sum_{l=1}^{5}\sum_{n=1}^{max}\left[\xi_{r,l,n} Spread_{r,t} \mathbb{1}_{j,r,l,n}^{spread_r}\right] \\ + \sum_{n=1}^{max} \delta_n RiskFreeRate_t \mathbb{1}_n^{RiskFreeRate_t} \\ + \eta Industry_j + \psi_{vw} GHS\_vw_t + \psi_{ew} GHS\_ew_t + \varepsilon_{j,r,t} \end{aligned}$$

for each bond j, with rating $r \in \{AAA, AA, A, BBB\}$, issued in month t, and:

$term_{j,r,t}$ The number of days between the offering date and the maturity date (at issue) of bond j, with initial rating r, issued in month t.

$size_j$ The offering amount of bond j.

$\mathbb{1}_{j,r}^{rating}$ A dummy equal to 1 if bond j has an initial rating r (0 otherwise).

MTN_j A dummy equal to 1 if bond j is a medium term note (0 otherwise).

$Industry_j$ A vector of dummy variables, one for each 3-digit NAICS code, equal to 1 if bond j is issues by a firm with that code (0 otherwise).

$Spread_{r,t}$ The credit spread in month t for a corporate bond rated r.

$\mathbb{1}_{j,r,l,n}^{spread_r}$ A dummy equal to 1 if

- the spread on a bond with the rating r is greater than or equal to $\frac{n-1}{2}$ and less than $\frac{n}{2}$ in month t, and
- bond j is in the liquidity category l (where $l \in \{1, 2, 3, 4, 5\}$), and
- bond j has an initial rating of r

(0 otherwise).

$RiskFreeRate_t$ The risk free (i.e., one-month Treasury bill) rate in month t.

$\mathbb{1}_{n}^{RiskFreeRate_t}$ A dummy equal to 1 if the risk free rate in month t is greater than or equal to $1000 * (n-1)$ and less than $1000 * n$ (0 otherwise).

GHS_vw_t The value weighted average maturity of outstanding government bonds in month t.

GHS_ew_t The equally weighted average maturity of outstanding government bonds in month t.

C Additional Figures: t-statistics

Figure 5: t-statistics – Average Abnormal Maturity Issuance, Top and Bottom Quintile of Expected Liquidity at Issuance

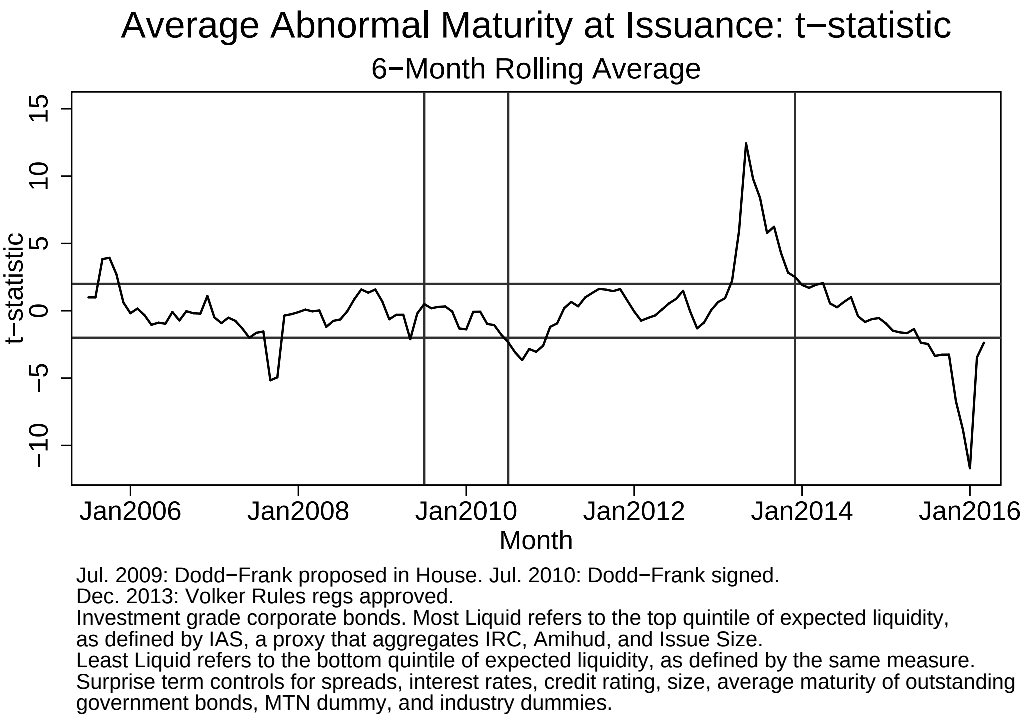
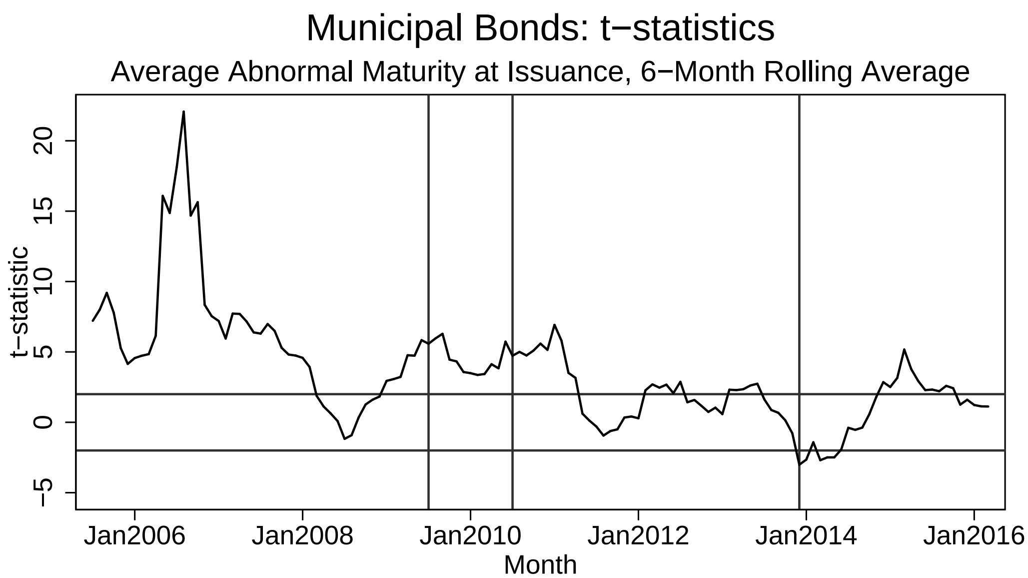


Figure 6: t-statistics – Municipal Bonds: Average Abnormal Maturity Issuance, Top and Bottom Quintile of Expected Liquidity at Issuance



Jul. 2009: Dodd−Frank proposed in House. Jul. 2010: Dodd−Frank signed.
Dec. 2013: Volker Rules regs approved.
Investment grade municipal bonds. Most Liquid refers to the top quintile of expected liquidity, as defined by size of issuance. Least Liquid refers to the bottom quintile of expected liquidity, as defined by the same measure. Surprise term controls for interest rates, credit rating, size, average maturity of outstanding government bonds, and the Bond Buyer Go 20−Bond Municipal Bond Index.