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REGULATIONS IN THE U.S. AND BOND MARKET LIQUIDITY

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This paper investigates the impacts of financial regulations on bond market liquidity, focusing on the U.S. regulations such as the Dodd-Frank Act and the Volcker Rule. Our analyses at market level and bond level suggest that the mentioned regulations do not harm the liquidity of the bond market as a whole. It is evident that the regulations actually improve the bond market liquidity, especially for investment grade bonds. Non-investment grade bonds are not affected by changes in regulations. These findings are also evident in the event study of announcement effects regarding regulations milestones. The analysis also suggests that the transaction costs are affected by the changes in regulations more than the price impacts. Additionally, the event study indicates that the anticipation of regulatory changes do lead to lower liquidity but these impacts only occur for big milestones and eventually die out

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1. INTRODUCTION

In contrast to some believes, the "boring" fixed-income market actually is a very essential part of the global economy. According to Federated Investors (2017), the global bond market has a massive size of $127 trillion, which is almost twice as large as the global stock market. Furthermore, in the U.S., the bond market clearly outweighs the stock market. In such a massive market, liquidity is very important in order to keep the market moving. Because of the large size and potential impacts on global economy, there are a lot of regulations involved in the bond market, which are very important factors in the market. Moreover, ever since the Global Financial Crisis in 2008 (the Crisis), regulators, especially in the U.S., have been very active in making interventions in the bond market with the ultimate goal of ensuring the market stay in good shape, and thus, preventing another crisis. Two of the essential regulatory frameworks that are worth mentioning are the Dodd-Frank Act and the Basel III, which raise the concerns about bond market liquidity being over-constrained.

One of the most controversial parts of the Dodd-Frank Act is the Volcker Rule, which prohibits banks from doing speculative activities such as proprietary trading. The purpose of the Rule is to prevent banks from overexposure to risk that might leads to inevitable bailouts. The controversy surrounding the Dodd-Frank Act, in general, and the Volcker Rule, in particular, is becoming more relevant since the Trump administration announced their plan to roll back Dodd-Frank. Another important regulatory framework is the Basel III. The key points in Basel III that influence market liquidity is an increase in the capital requirement for banks and the introduction of liquidity coverage ratio requirement. They are believed to constrain banks' ability to use their capital for market-making activities, and hence, force them to charge their customers more. This paper focuses on the Dodd-Frank Act and the Volcker Rule as they have more direct impacts on the U.S. market and also because they have a clearer timeline of implementation. Moreover, this framework is subject to a lot of debate. On one hand, some people (Duffie, 2012) worried that the Volcker Rule could have a severe side effect of limiting bond market liquidity. This could be due to the decrease in market making activities as they could be easily mistaken as proprietary trading. On the other hand, there are people applauding the regulation, stating that because the Volcker Rule only affects some dealers, those that are unaffected would step in and make up for the lack of market making activities from banks. Thus, the liquidity will remain unchanged. There have been some studies about the market liquidity after the depression (Trebbi and Xiao, 2015; Bessembinder et al., 2018; Dick-Nielsen and Rossi, 2016; Bao et al., 2018) but the results are mixed. In addition, there is evidence that Dodd-Frank has unfavorable impacts on credit ratings. Dimitrov et al. (2015) find that the strengthened regulations made the credit ratings less informative and more inaccurate. This leads us to two important research questions: Do these regulations have significant impacts on the bond market liquidity? And which type of bond is most likely to be affected? By answering these two questions, we could get an implication on whether rolling back the regulations is necessary.

In this paper, with the focus on the implementation of Dodd-Frank Act, and specifically the Volcker Rule, we aim to provide more comprehensive studies about the impact of the regulation on market liquidity post-Crisis through subsample analysis (based on ratings), and event study (based on announcements about the regulation). Motivated by Bao et al. (2018) paper about the impact of the Volcker Rule on downgraded bonds, we suspect that the regulation would have different impacts on bonds with different levels of ratings. Through time-series analysis, we find that the effects are favorable to the market liquidity. Furthermore, our subsample analysis suggests that the regulations have more impacts on investment grade bonds than non-investment grade bonds. This finding is also evident in our event study of regulation announcements.

Various paper examines stock markets and bond market in the literature (Batten and Vo, 2016; Vo and Daly, 2005, 2007; Vo, 2016a, 2016b, 2017, 2019). This research is related to papers about bond market liquidity after the crisis like Mizrach (2015), which

states that the liquidity after the crisis is better than before. The most relevant papers are those about the relationship between regulation and market liquidity. These papers commonly choose to concentrate on the regulations in the post-crisis era. Using complicated structural breaks analysis, Trebbi and Xiao (2015) find no evidence of a liquidity decline subjected to regulations after the crisis. They actually find the liquidity increasing after the regulation implementation in some cases. Bessembinder et al. (2018) agree with these findings. However, as they make additional investigation about dealer behavior, it is discovered that dealers apparently change their behaviors after the reform of regulations even though the transaction costs do not increase. Anderson and Stulz (2017) get similar findings but also report higher transaction costs and price impact for large trades. In contrast, evidence of a deterioration in liquidity is uncovered in Dick-Nielsen and Rossi (2016), which investigates the liquidity level surrounding index exclusion events. Choi and Huh (2017) claims that liquidity is decreasing as the transaction cost increases. Additionally, Bao et al. (2018), which studies price impacts in stress event, discovers that liquidity is decreasing for downgraded bonds, especially after the Volcker Rule is implemented. These papers all illustrate the changes in liquidity and market-making activities, responding to the implementation of new rules in the years following the crisis. However, most of these studies focus on one aspect of liquidity, either transaction costs or price impacts. They also only focus on a part of the market. For instance, Bao et al. (2018) presented remarkable findings. Taking advantage of regulators' database, they uncover the lack of liquidity provision in time of stress. Nonetheless, due to the nature of this study, they only focus on downgraded bonds and only use price impacts as their main measure and realized spread for the robust check. Therefore, our research aims to provide more color to the big picture by looking at the market as a whole and investigating if the new regulations are helping or worsening the market liquidity. Furthermore, some of these papers, like Bessembinder et al. (2018) and Dick-Nielsen and Rossi (2016) have a shorter horizon than ours and only concentrate on the years before the Volcker Rule is fully implemented, whereas this study compares the pre-Volcker and post-Volcker period. Although Trebbi and Xiao (2015) analyzes a longer period (up to the end of 2014), their focus is not on Volcker Rule. Additionally, we also investigate more recent events in light of the Trump administration's attempt to roll back Dodd-Frank through Financial Choice Act in 2017.

The remainder of the paper is arranged as follow. Section 2 provides more information about the regulations. Section 3 describes the data we use for our analysis. In Section 4, we discuss our methodology, including the variable constructions and model specifications. The main results using market-level data are reported in Section 5, whereas Section 6 presents our results for bond-level analysis. Event studies are discussed in Section 7 and Section 8 contains our conclusion.

2. DODD-FRANK ACT AND VOLCKER RULE

Dodd-Frank Act is the biggest attempt by the U.S. government in reforming the financial market after the 2008 crisis. In response to the financial crisis in 2008, Dodd-Frank Wall Street Reform and Consumer Protection Act, commonly known as the Dodd-Frank Act was first proposed by the Obama administration on June 15, 2009, and introduced in the House on December 2, 2009. The bill passed the House on December 11, 2009, and passed the Senate on May 20, 2010, with amendments. In June 2010, two Chambers jointly held a conference and filed the conference report on June 29, 2010. The report was agreed by the House on June 30, 2010, and by the Senate on July 15, 2010. On July 21, 2010, the Dodd-Frank Act was signed by President Barack Obama and officially became Public Law. Although the Volcker Rule is a part of the Dodd-Frank Act (Section 13), it was not in the initial proposal of the Dodd-Frank Act. It was introduced later, on January 20, 2010. Added to the Bank Holding Company Act of 1956, the Volcker Rule bans banks from making speculative investments using their own resources and restrict them from having any relationships with hedge funds or private equity funds. Unlike the major parts of the Dodd-Frank Act, the Volcker Rule's implementation was delayed for a few years. The Financial Stability Oversight Council (2011) conducted a research regarding the implementation of the Rule and published its suggestions on January 18, 2011. In November 2011, five financial regulatory agencies (namely the Treasury, the Federal Reserve, the CFTC, the FDIC, and the SEC) worked together and released the proposal of the regulation for public comments in the Federal Register (2011). The proposal sparked a lot of debates and received major criticism from both the banks and the reform supporters. Thus, although the Rule is scheduled to be statutory effective on July 21, 2012, it was not ready by then and the implementation was delayed. The finalized version was released on December 10, 2013, and on January 31, 2014, the final regulation was published in the Federal Register (2014). The actual implementation took place on April 1, 2014. The Rule requires banks with more than $50 billion worth of trading assets to report from July 2014. As the Act allows a conformance period for organizations to conform to the requirements, banks do not need to fully comply with the Rule until July 21, 2015. However, they need to demonstrate efforts in complying during this period. Therefore, the impact of the Volcker Rule should be evident from April 2014. On the note of financial regulation, we should also take into consideration the Trump administration's recent attempt to roll back the Dodd-Frank Act and repeal the Volcker Rule through Financial Choice Act. Financial Choice Act was first proposed by the Republicans on September 9, 2016, but it was not introduced to the House until April 27, 2017. It received massive support from the Trump administration and passed the House of Representative on June 8, 2017.

Some studies like Bessembinder et al. (2018) and Dick-Nielsen and Rossi (2016) state that due to the anticipation of the changes in regulations, the market would reacts and starts changing earlier than the actual implementation. Our research although concentrates on the implementation of the regulations - as we expect the effects to be the

most intense at this point, we do not rule out any possibilities that the impacts could earlier than the official implementation. In fact, our analysis aims to explore any additional effects the Dodd-Frank Act or the Volcker Rule brings to the bond market by comparing the post-implementation period to the period right before it. Furthermore, we also investigate the anticipation effects through event study. If the anticipation of new regulation indeed leads to earlier change in the market, we should see some significant abnormal liquidity around the milestones prior to the official implementation.

3. DATA

We use FINRA's enhanced TRACE (Trade Reporting and Compliance Engine), which includes all secondary over-the-counter corporate bond trades. This database is commonly used in recent studies, including Bao et al. (2018), Dick-Nielsen et al. (2012) regarding bond market liquidity. The enhanced version of TRACE is used because it contains more information regarding the bond transaction like the uncapped volume of the transactions. However, the drawback of the enhanced version is its lack of current data. Data is only available up to June 30, 2017. As pointed out by Dick-Nielsen (2009), the raw TRACE or enhanced TRACE data contents a great number of errors, which if not corrected, would dramatically overestimate the liquidity in the market. Thus, following Dick-Nielsen (2014) process, we cleaned the enhanced TRACE data to eliminate report errors. In this process, all the transactions with known errors, agency transactions, and interdealer double-counted transactions are deleted. We also retrieved bond formation, such as bond ratings, age, time to maturity, from FISD (Fixed Income Securities Database) for our analysis. We use the ratings from S&P and the bonds are sorted into investment grade and non-investment grade based on the following criteria: Bonds with ratings BBB- or above (i.e. AAA, AA+, AA, AA-, A+, A, A-, BBB+, BBB, and BBB-) are investment grade bonds and those with speculative ratings (BB+, BB, BB-, B+, B, B-, CCC+, CCC, CCC-, CC, C, and D) are non-investment grade bonds. The horizon of our sample focuses on the post-crisis period: from January 1, 2009, to June 30, 2017. Due to the specifications of our model, our analysis only involves the transactions of bonds with available information on FISD.

4. METHODOLOGY

In this study, two measures of liquidity would be used, which are the Amihud (2002) measure and the Roll (1984) measure. They are calculated separately. Thus, despite being constructed using the same set of transactions, each measure has its own datasets. Note that both of these measures proxy the illiquidity of the market and hence, higher measures mean the market is less liquid. We compute these measures at both market level and bond level.

4.1. Amihud Measure

Amihud (2002) has been used frequently in various studies regarding financial market liquidity (Batten and Vo, 2014; Dang et al., 2018; Vo, 2016, 2019; Vo and Bui, 2016). This measure, which is constructed based on Kyle (1985), proxies the price impact aspect of liquidity i.e. how much impact can the price of one trade has, per unit traded. For the ease of interpretation, the volume used for the construction in our analysis is measured in million dollars. The formula (as used in Dick-Nielsen et al. (2012)) for the measure of each bond is as follow:

$$Amihud_t = \frac{1}{N_t}\sum_{i=1}^{N_t}\frac{|r_i|}{Q_i}. \quad (1)$$

Here, r_i and Q_i are the return and volume (in million) of each transaction of a particular bond. N_t is the number of transactions of that bond on day t. However, we find using the arithmetic averages produces very noisy results and thus, we choose to take the medians instead of the means for this construct. We first calculate the return-to-volume ratio for each trade (sorted by date and bond ID). Then, for each bond on each day, we find the median, which is the Amihud measure for that bond on that specific day. This gives us the Amihud at bond level, where we have a panel data of liquidity measure across time and bond ID. From this, we take the median for each day to get the daily measure for the aggregate market level.

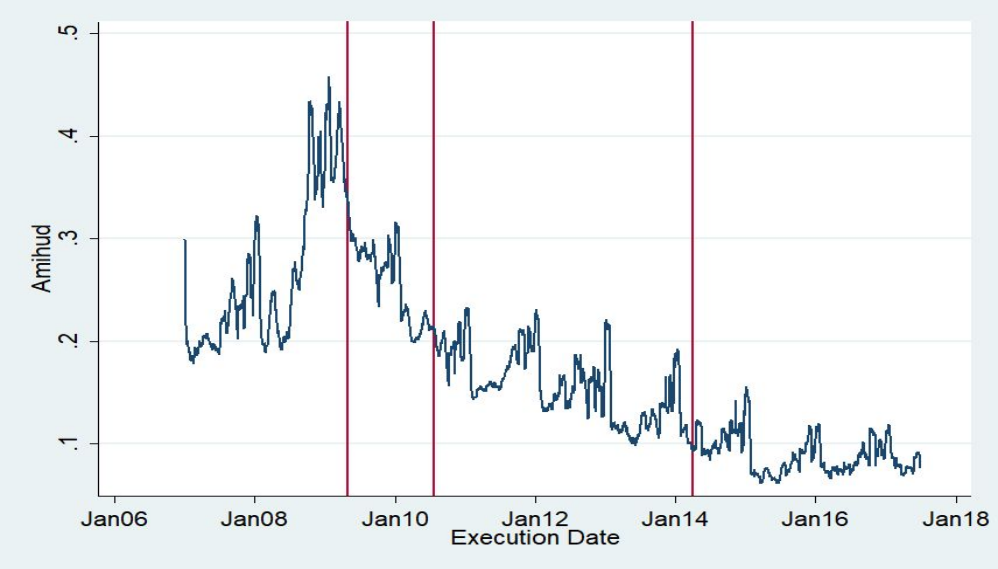

Figure 1. Amihud Series Using 30-day Moving Average

We then check our construct by graphing the 30-day moving average of the Amihud series, which is illustrate in Figure 1. For this part only, to check the liquidity pattern during the Global Financial Crisis, we extend our horizon back to January 01, 2007 and all transactions are included. The first red line indicates the start of the post-crisis period. The second and the third red line illustrate the beginning of post-Dodd- Frank period and post-Volcker period, respectively. The graph shows that the illiquidity climbs substantially during the Crisis and decreases afterwards, which confirms that this construct does capture the liquidity, or in this case, the illiquidity of the bond market.

4.2. Roll Measure

The other commonly used measure that we implemented in this study is the Roll (1984) measure. The Roll measure is a low frequency measure that proxies the effective spread using serial covariance of price changes. Originally, the formula for daily Roll measure of each bond is:

$$Roll_t = 2\sqrt{-cov(\Delta P_i, \Delta P_{i-1})}. \quad (2)$$

Here, the bid-ask spread is estimated using the covariance between the price changes of two consecutive transactions. The reasoning behind this formula is that the bond prices fluctuate around the bid-ask spread and when the bid-ask spread gets wider, the covariance would be more negative. However, this formula would become undefined if the covariance is positive. Thus, a slight adjustment is implemented (as in Goyenko et al. (2009) and other papers):

$$Roll_t = \begin{cases} 2\sqrt{-cov(\Delta P_i, \Delta P_{i-1})} & if\ cov(\Delta P_i, \Delta P_{i-1}) < 0 \\ 0 & otherwise \end{cases}. \quad (3)$$

To find the Roll at bond level, we first use the ARIMA process to retrieve the auto-covariance at first lag for each bond on each day and then, make adjustments for the positive covariance. Afterward, similar to the Amihud measure, we take the median within each day to get the daily measure at market level.

Similar to the Amihud measure, the 30-day moving average process is plotted for the Roll series (Figure 2), using all transactions from January 1, 2007, to June 30, 2017. We witness a quite similar pattern in comparison to the Amihud measure: the illiquidity increases greatly during the Crisis and declines afterward. The first, second and last vertical line mark the beginning of post-Crisis period, post-Dodd-Frank period, and post-Volcker period, respectively.

Note that in the process of computing the auto-covariance of a bond in a particular day, observations with extremely-close-to-zero covariances (up to 12 decimal points) are automatically dropped from the data for the Roll measure. Moreover, similar to Dick-Nielsen et al. (2012), at bond level, each measure is winsorized at 0.5 percentile

and 99.5 percentile within each bond on each day. In addition, we also trimmed the market-level measures at 0.5 percentile and 99.5 percentile within each dataset. Therefore, there are some mismatches in the number of observations between the Roll and the Amihud. Nonetheless, as shown in Table 1, the bonds used in both measures still share similarities such as age and time to maturity, despite the mismatches in numbers of observations.

Table 1. Summary Statistics - Full Sample

	N	Mean	Std.	Median
Panel A - Market Level - Amihud				
Amihud	2,401	0.0569	0.0313	0.0482
log(Age)	2,401	0.6939	0.3122	0.7314
log(Maturity)	2,401	1.7807	0.1369	1.7609
log(Volume)	2,401	10.3526	0.3039	10.3890
Panel B - Market Level - Roll				
Roll	2,157	0.4051	0.0999	0.3937
log(Age)	2,157	0.6944	0.3121	0.7316
log(Maturity)	2,157	1.7807	0.1362	1.7610
log(Volume)	2,157	10.3531	0.3048	10.3090
Panel C - Bond Level - Amihud				
Amihud	2,856,552	0.1602	0.3644	0.0441
log(Age)	2,856,552	0.4776	1.2436	0.7685
log(Maturity)	2,856,552	1.6651	0.9516	1.7293
log(Volume)	2,856,552	10.8111	1.6009	10.3090
Panel D - Bond Level - Roll				
Roll	2,754,922	0.5064	0.7571	0.3677
log(Age)	2,754,922	0.4788	1.2411	0.7695
log(Maturity)	2,754,922	1.6656	0.9509	1.7296
log(Volume)	2,754,922	10.8116	1.6008	10.3090

Notes: This table presents the summary statistics for the variables used in the regression analysis for the full sample. Panel A reports the descriptive statistics for the set of market-level variables related to the time series regression on the Amihud measure. This panel includes the Amihud measure of illiquidity, the log of Age measured in years, the log of Maturity measured in years and the log of the uncapped Volume in dollars at bond level. Panel B reports the descriptive statistics for the set of bond-level variables related to the time-series regression on the Roll measure. This panel includes the Roll measure of illiquidity, the log of Age measured in years, the log of Maturity measured in years and the log of the uncapped Volume in dollars at bond level. Panel C reports the descriptive statistics for the set of bond-level variables related to the panel-data-regression on the Amihud measure. This panel includes the Amihud measure of illiquidity, the log of Age measured in years, the log of Maturity measured in years and the log of the uncapped Volume in dollars at bond level. Panel D reports the descriptive statistics for the set of bond-level variables related to the panel-data-regression on the Roll measure. This panel includes the Roll measure of illiquidity, the log of Age measured in years, the log of Maturity measured in years and the log of the uncapped Volume in dollars at bond level.

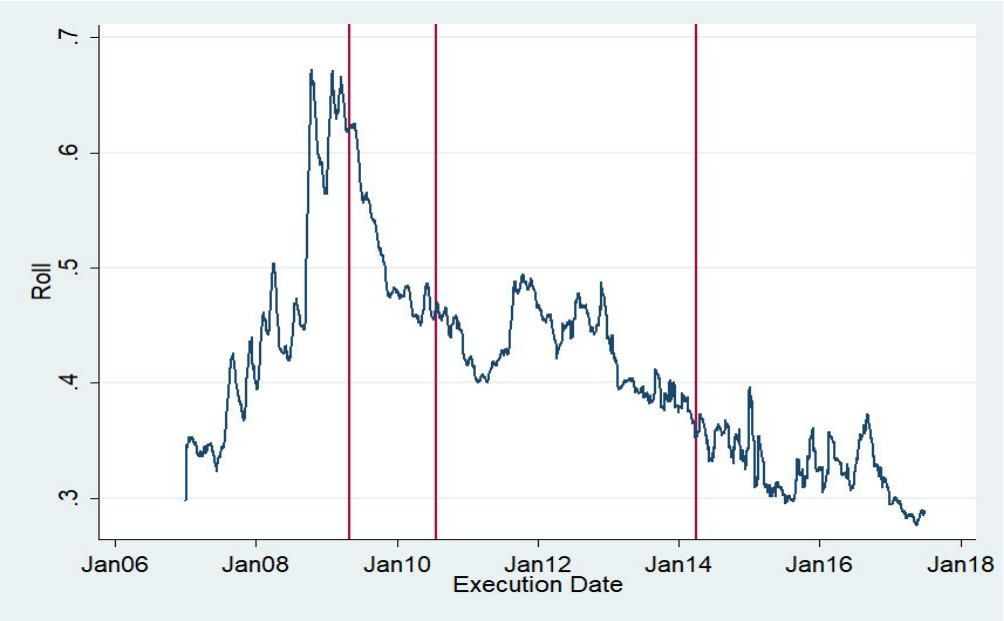

Figure 2. Roll Series Using 30-day Moving Average

4.3. Main Analysis

4.3.1. Market Level Analysis

At the aggregate market level, we analyze the impacts of regulations on market liquidity using the regression below, which we adapt from Bao et al. (2018) with some modifications. Furthermore, Bao at al. (2011) find a strong correlation between several bond characteristics (namely the age, the time to maturity and the traded volume of the bond) and liquidity measure. In addition, Bao et al. (2011) also find that past value of liquidity also affects current liquidity level. Thus, based on these findings, we added multiple control variables and build our model as follow:

$$\begin{aligned} Illiquidity_t = \ & \beta_0 + \beta_1 PostCrisis_t + \beta_2 PostDoddFrank_t + \beta_3 PostVolcker_t \\ & + \theta_1 Time_t + \theta_2 Time^2{}_t + \varphi_1 \log(Age_t) + \varphi_2 \log(Maturity_t) \\ & + \varphi_3 \log(Volume_t) + \delta Illiquidity_{t-1} + s_t. \end{aligned} \quad (4)$$

We assign a dummy for each sub-period and to keep the consistency, we take the medians to get the aggregate-level measurement for the control variables (i.e. the age, the time to maturity and the traded volume of the bond).

The omitted period dummy is the Crisis period (January 1, 2009 to April 30, 2009).

- $PostCrisis$: Dummy variable equal to 1 if the observation takes place between May 1, 2009 and July 20, 2010 and 0 otherwise.

- $PostDoddFrank$: Dummy variable equal to 1 for observations take place between July 21, 2010 to March 31, 2014 and 0 otherwise.
- $PostVolcker$: Dummy variable equal to 1 for observations take place between April 1, 2014 to June 30, 2017 and 0 otherwise.
- $Time$: Time trend variable, which runs from 1 to 9 as the year goes from 2009 to 2017.
- $Time^2$: The quadratic term is added to allow for curvature in time trend.
- Age: The number of years since a bond is issued at the time the transaction is made.
- $Maturity$: The number of years left until the bond the bond mature at the time the trade is made.
- $Volume$: The uncapped traded volume of a bond in a transaction.

Taking into account the scale issue in age, time to maturity and traded volume, we use the natural logarithm instead of the actual level in the model.

4.3.2. Subsample Analysis

Using the data from FISD, we categorized the bonds into investment grade and non-investment grade based on S&P ratings. Bonds classified as non-rated in FISD are not included in this analysis. The descriptive statistics for the two subsample are reported in Table 2 at both market level and bond level. This table illustrates that on average, two subsamples share some similarities in bond characteristics with the bonds in non-investment grade subsample being slightly older, having shorter maturities and being traded at larger volumes.

4.3.3. Bond Level Analysis

At bond level, we follow the same analysis but with control for bond-specific fixed-effects and clustering errors by bonds for more robust results.

$$\begin{aligned} Illiquidity_t = \ & \beta_0 + \beta_1 PostCrisis_{i,t} + \beta_2 PostDoddFrank_{i,t} \\ & + \beta_3 PostVolcker_{i,t} + \theta_1 Time_{i,t} + \theta_2 Time^2{}_{i,t} \\ & + \delta Illiquidity_{i,t-1} + yFixedEffect_i + s_{i,t}. \end{aligned} \quad (5)$$

4.4. Event Study

The event study focuses on the timeline of the Dodd-Frank Act, the Volcker Rule and the Financial Choice Act. We study the announcement effects surrounding the milestones based on the timeline discussed in Section 2. We choose the milestones as the event days because they are when the official announcements are recorded and presumably when the media coverage of the regulation reforms reach its peaks. The expected illiquidity is calculated for each sample separately base on the model specification in column (9) of Table 3, 4, 5 for the full sample, the investment grade

subsample and the non-investment grade subsample, respectively. Afterward, the average abnormal illiquidity would be computed for several windows including three symmetric windows, three windows before the event and three windows after the event. The windows used are: [-5,5] [-10,10] [-10,-5] [-5,-1] [-10,-1] [1,5] [5,10] [1,10]. The averages of abnormal illiquidity are then tested for significant difference against zero using two-tail t-tests.

Table 2. Summary Statistics - Subsamples

	Investment Grade				Non-investment Grade			
	N	Mean	Std.	Median	N	Mean	Std.	Median
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A- Market Level - Amihud								
Amihud	2,143	0.0639	0.0378	0.0516	2,143	0.0421	0.0284	0.0372
log(Age)	2,143	0.7120	0.2907	0.7673	2,143	0.7776	0.2664	0.7246
log(Maturity)	2,143	1.7981	0.1508	1.7616	2,143	1.7475	0.0849	1.7640
log(Volume)	2,143	10.2739	0.1885	10.2751	2,143	10.7734	0.7730	10.5966
Panel B - Market Level - Roll								
Roll	2,149	0.3944	0.1074	0.3834	2,145	0.4575	0.0997	0.4449
log(Age)	2,149	0.7073	0.3234	0.7671	2,145	0.7769	0.2687	0.7246
log(Maturity)	2,149	1.7988	0.1526	1.7620	2,145	1.7468	0.0877	1.7640
log(Volume)	2,149	10.2828	0.2716	10.2751	2,145	10.7733	0.7729	10.5966
Panel C - Bond Level - Amihud								
Amihud	2,031,731	0.1628	0.3593	0.0476	595,545	0.1542	0.3661	0.0379
log(Age)	2,031,731	0.4713	1.2668	0.7665	595,545	0.6579	1.0286	0.8831
log(Maturity)	2,031,731	1.6822	0.9887	1.7419	595,545	1.6708	0.6914	1.7297
log(Volume)	2,031,731	10.6912	1.4994	10.2751	595,545	11.1102	1.7911	10.5966
Panel D - Bond Level - Roll								
Roll	2,031,421	0.4836	0.7026	0.3572	595,422	0.5643	0.8229	0.4193
log(Age)	2,031,421	0.4714	1.2665	0.7665	595,422	0.6579	1.0285	0.8831
log(Maturity)	2,031,421	1.6822	0.9886	1.7419	595,422	1.6708	0.6913	1.7298
log(Volume)	2,031,421	10.6914	1.4993	10.2751	595,422	11.1106	1.7910	10.5966

Notes: This table presents the summary statistics for the variables used in the regression analysis for the subsamples. Panel A reports the descriptive statistics for the set of market-level variables related to the time-series-regression on the Amihud measure. This panel includes the Amihud measure of illiquidity, the log of Age measured in years, the log of Maturity measured in years and the log of the uncapped Volume in dollars at bond level. Panel B reports the descriptive statistics for the set of bond-level variables related to the time-series regression on the Roll measure. This panel includes the Roll measure of illiquidity, the log of Age measured in years, the log of Maturity measured in years and the log of the uncapped Volume in dollars at bond level. Panel C reports the descriptive statistics for the set of bond-level variables related to the panel-data-regression on the Amihud measure. This panel includes the Amihud measure of illiquidity, the log of Age measured in years, the log of Maturity measured in years and the log of the uncapped Volume in dollars at bond level. Panel D reports the descriptive statistics for the set of bond-level variables related to the panel-data-regression on the Roll measure. This panel includes the Roll measure of illiquidity, the log of Age measured in years, the log of Maturity measured in years and the log of the uncapped Volume in dollars at bond level. Column (1), (2), (3), (4), present the statistics for investment grade subsample and column (5), (6), (7), (8) present the statistics for non-investment grade subsample.

Table 3. Full Sample Analysis - Market Level

	Amihud				Roll				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
PostCrisis	-0.0606***	-0.0626***	-0.0566***	-0.0485***	-0.1345***	-0.1326***	-0.1242***	-0.0548***	-0.0569***
	(0.0159)	(0.0161)	(0.0156)	(0.0157)	(0.0052)	(0.0052)	(0.0055)	(0.0051)	(0.0049)
PostDoddFrank	-0.0669***	-0.0760***	-0.0696***	-0.0606***	-0.1680***	-0.1594***	-0.1458***	-0.0624***	-0.0653***
	(0.0166)	(0.0196)	(0.0191)	(0.0192)	(0.0054)	(0.0064)	(0.0067)	(0.0063)	(0.0055)
PostVolcker	-0.0926***	-0.1004***	-0.0943***	-0.0836***	-0.2003***	-0.1934***	-0.1821***	-0.0800***	-0.0827***
	(0.0223)	(0.0240)	(0.0233)	(0.0234)	(0.0075)	(0.0080)	(0.0082)	(0.0076)	(0.0072)
Time	-0.0021	0.0042	-0.0190***	-0.0185**	-0.0233***	-0.0293***	-0.0221***	-0.0071***	-0.0074***
	(0.0026)	(0.0077)	(0.0075)	(0.0075)	(0.0009)	(0.0026)	(0.0027)	(0.0023)	(0.0010)
$Time^2$		-0.0006	0.0013**	0.0013*		0.0006**	0.0003	0.0000	
		(0.0007)	(0.0007)	(0.0007)		(0.0002)	(0.0002)	(0.0002)	
log(*Age*)			-0.0312**	-0.0300***			-0.0173***	-0.0071	
			(0.0064)	(0.0064)			(0.0055)	(0.0046)	
log(*Maturity*)			0.0941***	0.0931***			0.0707***	0.0713***	0.0730***
			(0.0121)	(0.0121)			(0.0126)	(0.0105)	(0.0105)
log(*Volume*)			-0.0364***	-0.0361***			-0.0176***	-0.0148***	-0.0128***
			(0.0030)	(0.0030)			(0.0034)	(0.0028)	(0.0025)
*Lag*1				0.0634***				0.5446***	0.5467***
				(0.0197)				(0.0178)	(0.0177)
Constant	0.2155***	0.2098***	0.4067***	0.3872***	0.6855***	0.6910***	0.7204***	0.3152***	0.2897***
	(0.0143)	(0.0158)	(0.0379)	(0.0381)	(0.0047)	(0.0051)	(0.0416)	(0.0371)	(0.0332)
N	2401	2401	2401	2399	2157	2157	2157	2156	2156
R^2	0.0331	0.0334	0.0331	0.0981	0.8291	0.8296	0.8339	0.8839	0.8838
PostDoddFrank vs.*PostCrisis*				-0.0121				-0.0076	
PostVolcker vs *PostCrisis*				-0.0351				-0.0252***	
PostVolcker vs PostDoddFrank				-0.0230				-0.0176**	

Notes: This table presents how corporate bond market liquidity in the full sample changes during the period between January 1, 2009 and June 30, 2017, especially after the implementation of the Dodd-Frank Act and the Volcker Rule. The Amihud measure is used as the dependent variable in column (1) (2) (3) (4) and the Roll measure is used as the dependent variable in column (5) (6) (7) (8) (9). The Amihud proxies the price impacts whereas the Roll represents the transaction costs. The main analysis of the proposed model is under column (4) and (8) for the Amihud and the Roll, respectively. The primary independent variables of interest are the dummies *PostCrisis, PostDoddFrank* and *PostVolcker*. Multiple versions of the full model using different levels of control are tested to investigate which aspects are crucial to the prediction of market liquidity. Column (1) and (5) only control for linear deterministic time trend, whereas column (2) and (6) allow for curvature in time trend. For column (3) and (6), additional controls for bond characteristics are added and the full model with further control for serial correlation is under column (4) and (8). Column (9) report the model used in the event study, where the variables redundant to the prediction of Roll measure are dropped. The coefficients of each regressions are reported with the standard errors shown in the parentheses. The significance of the coefficients is two-tail tested. One-tail test is used for the difference in coefficients between each pair of sub-periods with the hypothesis that the coefficients of the later periods are smaller than the coefficients of the earlier periods. *, **, and *** indicate the significance at 10%, 5%, and 1% levels, respectively.

Table 4. Investment Grade Subsample Analysis - Market level

	Amihud				Roll				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
PostCrisis	-0.0481***	-0.0424***	-0.0359***	-0.0200***	-0.1452***	-0.1424***	-0.1373***	-0.0593***	-0.0590***
	(0.0026)	(0.0025)	(0.0026)	(0.0024)	(0.0053)	(0.0053)	(0.0055)	(0.0051)	(0.0051)
PostDoddFrank	-0.0814***	-0.0564***	-0.0461***	-0.0249***	-0.1850***	-0.1726***	-0.1644***	-0.0705***	-0.0675***
	(0.0028)	(0.0031)	(0.0034)	(0.0033)	(0.0056)	(0.0065)	(0.0069)	(0.0063)	(0.0060)
PostVolcker	-0.0868***	-0.0665***	-0.0531***	-0.0282***	-0.2135***	-0.2035***	-0.2030***	-0.0915***	-0.0891***
	(0.0038	(0.0039)	(0.0039)	(0.0037)	(0.0077)	(0.0082)	(0.0084)	(0.0076)	(0.0074)
Time	-0.0058***	-0.0237***	-0.0162***	-0.0083***	-0.0259***	-0.0347***	-0.0196***	-0.0009	-0.0040***
	(0.0004)	(0.0013)	(0.0013)	(0.0012)	(0.0009)	(0.0026)	(0.0029)	(0.0024)	(0.0010)
$Time^2$		0.0017***	0.0009***	0.0004***		0.0009***	0.0002	-0.0003	
		(0.0001)	(0.0001)	(0.0001)		(0.0002)	(0.0002)	(0.0002)	
log(*Age*)			-0.0188***	-0.0165***			0.0079	0.0129***	0.0133***
			(0.0047)	(0.0042)			(0.0061)	(0.0050)	(0.0050)
log(*Maturity*)			-0.0190***	-0.0111**			0.1616***	0.1566***	0.1543***
			(0.0062)	(0.0056)			(0.0138)	(0.0113)	(0.0112)
log(*Volume*)			-0.0595***	-0.0492***			-0.0171***	-0.0168***	-0.0158***
			(0.0022)	(0.0020)			(0.0038)	(0.0031)	(0.0030)
*Lag*1				0.3790***				0.5583***	0.5566***
				(0.0172)				(0.0170)	(0.0170)
Constant	0.1673	0.1834	0.8180***	0.6281***	0.7011***	0.7090***	0.5311***	0.1431***	0.1415***
	(0.0024)	(0.0025)	(0.0249)	(0.0241)	(0.0048)	(0.0053)	(0.0478)	(0.0408)	(0.0408)
N	2143	2143	2143	2142	2149	2149	2149	2148	2148
R^2	0.6872	0.7173	0.7916	0.8292	0.8441	0.8450	0.8554	0.9035	0.9034
PostDoddFrank vs.*PostCrisis*				-0.0049				-0.0112*	
PostVolcker vs *PostCrisis*				-0.0082**				-0.0322***	
PostVolcker vs PostDoddFrank				-0.0033				-0.021**	

Notes: This table presents how corporate bond market liquidity in the investment grade subsample changes during the period between January 1, 2009 and June 30, 2017, especially after the implementation of the Dodd-Frank Act and the Volcker Rule. The Amihud measure is used as the dependent variable in column (1) (2) (3) (4) and the Roll measure is used as the dependent variable in column (5) (6) (7) (8) (9). The Amihud proxies the price impacts whereas the Roll represents the transaction costs. The main analysis of the proposed model is under column (4) and (8) for the Amihud and the Roll, respectively. The primary independent variables of interest are the dummies *PostCrisis, PostDoddFrank* and *PostVolcker*. Multiple versions of the full model using different levels of control are tested to investigate which aspects are crucial to the prediction of market liquidity. Column (1) and (5) only control for linear deterministic time trend, whereas column (2) and (6) allow for curvature in time trend. For column (3) and (6), additional controls for bond characteristics are added and the full model with further control for serial correlation is under column (4) and (8). Column (9) report the model used in the event study, where the variables redundant to the prediction of Roll measure are dropped. The coefficients of each regressions are reported with the standard errors shown in the parentheses. The significance of the coefficients are two-tail tested. One-tail test is used for the difference in coefficients between each pair of sub-periods with the hypothesis that the coefficients of the later periods are smaller than the coefficients of the earlier periods. *, **, and *** indicate the significance at 10%, 5%, and 1% levels, respectively.

Table 5. Non-investment Grade Subsample Analysis - Market level

	Amihud				Roll				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
PostCrisis	0.0218***	0.0230***	-0.0579***	-0.0443***	-0.1130***	-0.1157***	-0.1144***	-0.0866***	-0.0880***
	(0.0034)	(0.0035)	(0.0034)	(0.0031)	(0.0090)	(0.0091)	(0.0117)	(0.0118)	(0.0096)
PostDoddFrank	0.0302***	0.0353***	-0.0651***	-0.0517***	-0.1054***	-0.1175***	-0.1051***	-0.0759***	-0.0741***
	(0.0036)	(0.0043)	(0.0042)	(0.0037)	(0.0095)	(0.0112)	(0.0143)	(0.0143)	(0.0096)
PostVolcker	0.0214***	0.0256***	-0.0667***	-0.0509***	-0.1551***	-0.1648***	-0.1515***	-0.1101***	-0.1096***
	(0.0050)	(0.0053)	(0.0047)	(0.0042)	(0.0131)	(0.0140)	(0.0163)	(0.0163)	(0.0133)
Time	0.0004	-0.0032*	-0.0066***	-0.0046***	-0.0162***	-0.0076*	-0.0078	-0.0067	-0.0152***
	(0.0006)	(0.0017)	(0.0014)	(0.0012)	(0.0016)	(0.0045)	(0.0048)	(0.0046)	(0.0021)
$Time^2$		0.0004**	0.0004***	0.0003**		-0.0008**	-0.0012**	-0.0010**	
		(0.0002)	(0.0001)	(0.0001)		(0.0004)	(0.0005)	(0.0005)	
log(*Age*)			0.0113**	0.0041			0.0470***	0.0503***	0.0375***
			(0.0047)	(0.0041)			(0.0144)	(0.0140)	(0.0128)
log(*Maturity*)			-0.0317***	-0.0305***			0.0422*	0.0509**	0.06737***
			(0.0081)	(0.0071)			(0.0253)	(0.0245)	(0.0232)
log(*Volume*)			-0.0351***	-0.0263***			0.0045	0.0043	
			(0.0009)	(0.0009)			(0.0032)	(0.0032)	
*Lag*1				0.3896***				0.2491***	0.2506***
				(0.0157)				(0.0209)	(0.0209)
Constant	0.0157***	0.0190***	0.5496***	0.4212***	0.6563***	0.6485***	0.4917***	0.3169***	0.3555***
	(0.0031)	(0.0034)	(0.0203)	(0.0186)	(0.0082)	(0.0090)	(0.0643)	(0.0645)	(0.0482)
N	2143	2143	2143	2142	2145	2145	2145	2144	2144
R^2	0.0526	0.0548	0.4579	0.5750	0.4734	0.4744	0.4775	0.5104	0.5099
PostDoddFrank vs.*PostCrisis*				-0.0074*				-0.0107	
PostVolcker vs *PostCrisis*				-0.0066				-0.0235	
PostVolcker vs PostDoddFrank				0.0008				-0.0342*	

Notes: This table presents how corporate bond market liquidity in the non-investment grade subsample changes during the period between January 1, 2009 and June 30, 2017, especially after the implementation of the Dodd-Frank Act and the Volcker Rule. The Amihud measure is used as the dependent variable in column (1) (2) (3) (4) and the Roll measure is used as the dependent variable in column (5) (6) (7) (8) (9). The Amihud proxies the price impacts whereas the Roll represents the transaction costs. The main analysis of the proposed model is under column (4) and (8) for the Amihud and the Roll, respectively. The primary independent variables of interest are the dummies *PostCrisis, PostDoddFrank* and *PostVolcker*. Multiple versions of the full model using different levels of control are tested to investigate which aspects are crucial to the prediction of market liquidity. Column (1) and (5) only control for linear deterministic time trend, whereas column (2) and (6) allow for curvature in time trend. For column (3) and (6), additional controls for bond characteristics are added and the full model with further control for serial correlation is under column (4) and (8). Column (9) report the model used in the event study, where the variables redundant to the prediction of Roll measure are dropped. The coefficients of each regressions are reported with the standard errors shown in the parentheses. The significance of the coefficients are two-tail tested. One-tail test is used for the difference in coefficients between each pair of sub-periods with the hypothesis that the coefficients of the later periods are smaller than the coefficients of the earlier periods. *, **, and *** indicate the significance at 10%, 5%, and 1% levels, respectively.

5. MARKET LEVEL ANALYSIS

5.1. Full Sample Analysis

Although the main analysis is based on the full model (as in column (4) and (8), we run the regression using four versions of the proposed model to not only check for the robustness of the results, but also to identify which aspects help us predict the bond market liquidity for the event study. We first regress the liquidity measure against period dummies and control for the linear time-trend variable as there are signs of a decreasing trend in the data. The results are in column (1) for the Amihud measure and column (5) for the Roll measure. In column (2) and (6), we added $Time^2$ to allow for curvature in the time trend. We then added some bond characteristics to the regressions in column (3) and (7). Column (4) and (8) are where we further control for serial correlation in liquidity using lag 1 of the measure, i.e. the full model proposed in section 4. One remarkable finding from the table is that the coefficients for the sub-periods are all negatively significant, regardless of the measures or the modifications of the model. This means the liquidity is improved after the crisis. As we move from the post-Crisis period to the post-Dodd-Frank to the post-Volcker, the coefficients increase in absolute values, suggesting that the regulations have been improving the liquidity at the aggregate market level. This is consistent with Trebbi and Xiao (2015) as they do find liquidity to be improved after the implementation of new regulation. Nonetheless, it is important to note the differences in coefficients between the post-Volcker era and the two precedent periods are only significant for the Roll measure. This implies that the impacts of regulation are more intense for the transaction costs than for the price impacts. The reason for this could be because the two different methods measure different aspects of liquidity. The price impacts reflect the depth and breadth of the market while the transaction costs illustrate the tightness of the market Lybek and Sarr (2002). Since the dealers face the risk of asymmetric information, sometimes, trades are executed not for the demand but for information purpose. Sometimes, trades are made to provide liquidity to the market, keeping it continuous. Thus, this means that some price changes in the market are just transitory, opposite to permanent changes that arrive due to the surface of new information. As noted by Lybek and Sarr (2002), the price impacts measure (the Amihud) do not discriminate the transitory from permanent changes. The Roll, on the other hand, shows us how quickly the market absorbs these changes, so it focuses more on the permanent changes. One other crucial finding is the effects of time trend. According to the results, it is apparent that the time trend in the Amihud series is indeed concave downward, while the time trend exhibited in the Roll series is linear and downward sloping. These findings are consistent with the time-series graphs above.

Another noteworthy finding here is the dramatic differences in R^2 for the regressions ran against the Amihud measure and the regressions ran against the Roll measure. For the Amihud measure, even if we use the full model as in column (4), only under 10% of the variation in liquidity can be explained by the model, whereas for the Roll measure,

the full model can explain 88.39% of the variation in liquidity. Note that even if we only control for the linear time trend, the model could already explain roughly 83% the variation in the Roll. This means that even though the proposed model can indeed capture the impacts of regulations on the bond market liquidity, it is only suitable to forecast the Roll measure. Since using this model generates poor predictions of Amihud values, it would create biased and inconsistent results if it is used in the event study. Therefore, as discussed later, the proposed model would be used for the event study, but with Roll as the only measure for liquidity.

5.2. Subsample Analysis

The procedure is repeated for the investment grade and the non-investment grade subsample. Table 4 and 5 report the results of investment grade and non-investment grade subsample, respectively. The findings in this section confirm that firstly, the analyzed regulations tend to have positive impacts on bond market liquidity, i.e. the implemented regulations lead to lower transaction costs and lower price impacts. Secondly, different measures measure different aspects of liquidity. Furthermore, the determinants of each aspect depend largely on the bond rating classes. Therefore, isolating the two classes of ratings from each other provide more consistency between the Amihud and the Roll. While the Roll shows great uniformity throughout all analysis, there are noticeable differences in the Amihud. When we treat all bond ratings as equal and analyze them together, the Amihud is not explained well by the model, even with the addition of bond characteristics. With the absent of non-investment bonds, both regulatory changes and bond characteristics help explain well the Amihud. In the case of non-investment bonds, the explanatory power of the model is mainly owing to the bond characteristics and the regulatory changes only play a minor role. Last but not least, due to this difference in liquidity structure between two bond-rating classes, changes in the regulatory framework have different levels of impacts on different bond rating classes. This further explains why Bao et al. (2018) find deterioration in liquidity for downgraded bonds following the implementation of the Volcker Rule. As a bond is downgraded from investment grade to non-investment grade, it moves from a market where its liquidity is improved by the regulation, to a market where it receives no help from the regulations. Additionally, one common finding here is that the effects of regulatory changes are evidently stronger in transaction costs than in price impacts.

Particularly, for the investment grade subsample, the results remain consistent through all versions of the model. Similar to the full sample analysis, we focus on the coefficients of the full model in column (4) and (8). As reported in Table 4, the coefficients of the period of new regulations are significantly negative with an increase in magnitude as the horizon move from post-Crisis to post-Dodd-Frank to the post-Volcker period. Similar to the previous section, we find the differences between the coefficients of the post-Volcker period and other periods significant for the model using Roll measure. Additionally, we also find a significant difference between the

coefficients of *PostVolcker* and *PostCrisis* in the regression using Amihud measure. Another noticeable feature here is the dramatic increase in R^2 for the model using Amihud measure in comparison to the full sample. In this subsample, the proposed model could explain up to 82.92% of the variation in the Amihud measure, while the R^2 for the Roll still remains very high (up to 90.35% using full model). These findings indicate two points. Firstly, the structure of liquidity is different for bond groups with different ratings. Moreover, probably due to this difference, when we investigate the investment grade bonds and the non-investment grade bonds separately, the produced results show more consistency between two measures of liquidity. Secondly, the impacts of new regulations, the Volcker Rule, in particular, is more profound for bonds with good ratings. The new regulations improve these bonds' liquidity mainly through lowering transaction costs.

In non-investment grade subsample analysis, we find even more fascinating results. Although all the coefficients are still significant, the signs are somewhat different. For the model using Amihud, if we only control for the time trend, the coefficients are significant and positive, meaning that the liquidity is worsened after new regulation. However, after controlling for some bond characteristics, the coefficients became more consistent with previous findings as they are significantly negative. Furthermore, using the Amihud, there is a big jump in R^2 between versions with and without control for bond characteristics. As shown in Table 5, by simply adding control for the average age, maturity and volume, the R^2 increases from 5.48% in (2) to 57.30% in (3). More importantly, there is no significant difference between *PostVolcker* coefficients and that of other sub-periods. These results imply that the high illiquidity (in breadth and depth) we see in the non-investment grade subsample has more to do the bond characteristics and less to do with changes in the regulatory framework. As for the Roll measure, the results largely remain unchanged. We still see significantly negative coefficients of sub-periods regardless of the modifications of the model. Furthermore, unlike the results with Amihud measures, there is no big jump in R^2 when we additionally control for bond characteristics. Nonetheless, the coefficient of *PostVolcker* is no longer significantly different from that of *PostCrisis*, but we still find a significant difference between *PostVolcker* and *PostDoddFrank* coefficients as in Table 5, suggesting that the Volcker Rule's impacts to transaction costs are persistent in the market regardless the bond ratings. In addition, it is noteworthy that the R^2 of the models with the use of Roll in this subsample is quite lower than that in investment grade subsample or the full sample. As mentioned before, using the full model in the investment grade subsample or the full sample could explain approximately 90% the variation in Roll, but that figure is only 51.04% in the non-investment grade subsample. Notwithstanding, this level of R^2 is more consistent with the findings with Amihud. This means that there is more consistency between the two liquidity measures when we separate the non-investment grade bonds from the investment grade bonds.

Table 6. Bond Level Analysis

	Amihud			Roll		
	Full Sample	Investment Grade	Non-investment Grade	Full Sample	Investment Grade	Non-investment Grade
	(1)	(2)	(3)	(4)	(5)	(6)
PostCrisis	-0.1154***	-0.0995***	-0.1440***	-0.1846***	-0.1752***	-0.2614***
	(0.0081)	(0.0073)	(0.0309)	(0.0089)	(0.0087)	(0.0371)
PostDoddFrank	-0.1377***	-0.1183***	-0.1649***	-0.2231***	-0.2139***	-0.2845***
	(0.0092)	(0.0083)	(0.0338)	(0.0106)	(0.01042)	(0.0382)
PostVolcker	-0.1432***	-0.1299***	-0.1538***	-0.2341***	-0.2252***	-0.2989***
	(0.0095)	(0.0087)	(0.0336)	(0.0120)	(0.0124)	(0.0398)
Time	-0.0476***	-0.0447***	-0.0253***	-0.0324***	-0.0348***	-0.0122
	(0.0022)	(0.0023)	(0.0041)	(0.0043)	(0.0043142)	(0.0113)
$Time^2$	0.0020***	0.0017***	0.0012***	-0.0005	-0.0004	-0.0010
	(0.0001)	(0.0001)	(0.0003)	(0.0003)	(0.0003)	(0.0009)
log(*Age*)	0.0145***	0.0124***	0.0080***	0.0194***	0.0174***	0.0164***
	(0.0007)	(0.0008)	(0.0015)	(0.0017)	(0.0017)	(0.0051)
log(*Maturity*)	0.0019	-0.0014	0.0098	-0.0411***	-0.0461***	0.0193
	(0.0022)	(0.0023)	(0.0072)	(0.0067)	(0.0071)	(0.0161)
log(*Volume*)	-0.0780***	-0.0778***	-0.0731***	-0.0088***	-0.0150***	0.0017
	(0.0009)	(0.0011)	(0.0018)	(0.0009)	(0.0010)	(0.0018)
*Lag*1	0.0014	0.0753***	0.0693***	0.1002***	0.1076***	0.0556
	(0.0012)	(0.0033)	(0.0076)	(0.0161)	(0.0109)	(0.0374)
Constant	1.3216***	1.2827***	1.1929***	1.0322***	1.0809***	0.8708***
	(0.0207)	(0.0220)	(0.0475)	(0.0279)	(.0245)	(0.0617)
N	2,743,821	2,015,355	591,818	2,725,208	2,015,055	591,695
R^2	28,284	14,466	3,466	23,307	14,456	3,463
PostDoddFrank vs.*PostCrisis*	857.74***	691.65***	243.67***	169.05***	182.19***	23.12***
PostVolcker vs *PostCrisis*	-0.0223**	-0.0188**	-0.0209	-0.0385***	-0.0387***	-0.0231
PostVolcker vs PostDoddFrank	-0.0279***	-0.0304***	-0.0098	-0.0495***	-0.0500***	-0.0375

Notes: This table presents results of robust checks of the analyses on how corporate bond market liquidity evolves after the implementation of the Dodd-Frank Act and the Volcker Rule. Column (1) and (4) show the results for the full sample. Column (2) and (5) shows the results for the investment grade subsample. Column (3) and (6) shows the results for the non-investment grade subsample. The Amihud measure is used as the dependent variable in column (1) (2) (3) and the Roll measure is used as the dependent variable in column (4) (5) (6). The Amihud proxies the price impacts whereas the Roll represents the transaction costs. The coefficients of each regressions are reported with the standard errors shown in the parentheses. The significance of the coefficients are two-tail tested. One-tail test is used for the difference in coefficients between each pair of sub-periods with the hypothesis that the coefficients of the later periods are smaller than the coefficients of the earlier periods. *, **, and *** indicate the significance at 10%, 5%, and 1% levels, respectively.

6. BOND LEVEL ANALYSIS

Beside the main time-series analyses using liquidity measures at the aggregate market level, we also investigate the movement in liquidity following the regulatory changes using bond-level liquidity measures. The use of panel data instead of time-series not only allows for more variations to be used in the regression but also allows us to further control for bond-specific fixed effects and clustering errors by bonds. The results of bond-level regressions are reported in Table 6. The results indicate that overall, the proposed model is quite robust to bond fixed effects and clustering errors as the coefficients for the primary explanatory variables remain significantly negative. Furthermore, the changes in regulations still have positive impacts on market liquidity (as illiquidity decreases) and similar to the analyses above, the effects are more obvious for the transaction costs (the Roll) than the price impact (the Amihud). There are significant differences between the post-Crisis period, and both post-Dodd-Frank and post-Volcker Rule period. Nevertheless, we witness that the difference between the post-Dodd-Frank period and the post-Volcker period is no longer significant. This indicates that the Volcker Rule does not generate any extra liquidity compared to the general Dodd-Frank Act. In other words, the effects of regulatory change on the general bond market liquidity only occur for the major changes in the regulatory environment (Dodd-Frank Act), rather than the small regulatory changes (Volcker Rule), and the effects are more profound for investment grade bonds. For non-investment grade bonds, there is no significant difference among the three analyzed periods.

7. EVENT STUDY

From the analysis above, we see that some variables in the full model are quite redundant in predicting the Roll measure. Thus, under column (9), those variables are dropped from the full model. The expected illiquidity is calculated for each sample separately based on the model specification in column (9) of Table 3, 4, 5 for the full sample, the investment grade sample and the non-investment grade sample, respectively. The results of the event study are reported in Table 7, 8, 9 for the full sample, the investment grade subsample and the non-investment grade subsample, respectively. As shown in the tables, not all events generate significant abnormal illiquidity. Some events only affect one sample and not the others. Among all 13 analyzed events, only two events are strongly and consistently significant in all three samples, which are when Volcker Rule is scheduled to take effect and when full compliance for the Volcker Rule is required. In all three samples, there is significant positive abnormal illiquidity occurring around when the Volcker Rule is scheduled to take effect in 2012, meaning the transaction costs are abnormally high around the event. This is reasonable because the Volcker Rule limits the activities of the banks, and hence, we would see fewer actions in the market.

However, for the other event, when banks are required to fully comply with the Volcker Rule, we witness negative abnormal illiquidity, meaning the transaction costs became lower around this event. This finding contradicts our previous reasoning. Nonetheless, the activities in the stock market could be the reason we see this strange liquidity in the bond market. On July 27, 2015, the China stock market suffered another crash after being volatile for a few months. This is a reasonable explanation as the crash took place after our regulatory milestone and we mainly find significant results for the windows after the events and the symmetric windows. In addition, we also find some reasonable market reactions. In the full sample, we see a decline in transaction costs owing to the Financial Choice Act (when it is introduced and when it passed the House). This decline is also evident in the two subsamples but not as profound. Additionally, in the investment grade subsample experience significantly higher transaction costs following Obama's initial proposal, but this event is not significant in other samples. Nevertheless, the milestones of the progress of the Volcker Rule are quite puzzling. For instance, when Obama proposed the Volcker Rule, there is an abnormal decrease in transaction costs, meaning the market is more liquid. This event is quite significant in the three samples, yet the significance is not very strong as the results are only significant in three out of nine windows for each sample. This event is puzzling because we do not find any other news in either the stock or the bond market that could explain this counterintuitive reaction. Furthermore, we also see a drop in transaction costs, in the non-investment grade subsample, when Obama signed the Dodd-Frank Act into law. However, these results are rather weak as they are only significant at 10% level. Aligning with our previous findings, we find that the non-investment grade market reacts less to the regulation milestones as the number of significant results in this subsample is less than that of the investment grade sample. One other important finding in the event study is that the significant impacts of regulation announcements are more profound in longer time windows than in shorter time windows, implying that it takes time for the market to absorb impacts of the regulations announcements and that those impacts took place gradually. This is reasonable because regulation changes do not happen as quickly or as often as announcements regarding a specific industry or company and thus, the market participants do not need to act quickly upon those announcements. Another reason could be that the Roll measure account for permanent changes, not transitory changes and hence, it needs time to absorb the impact. Therefore, for future event study regarding impacts of regulation, we highly recommend including longer windows to allow for the market to react.

8. CONCLUSION

Bond and stock market is an interesting topic in the globalization and financial integration (Batten and Vo, 2010; Vo, 2009, 2018a, 2018b; Vo et al., 2017; Vo and Ellis, 2018). There is a huge volume of papers investigating bond and stock markets from

various viewpoints (Ha and Vinh, 2017; Nguyet et al., 2018; Vo, 2018c, 2018d; Vo and Tran, 2020a, 2020b). This paper investigates the impacts of financial regulations on bond market liquidity. Our main results indicate that there is no significant deterioration in liquidity following the implementation of either the Dodd-Frank Act or the Volcker Rule. Instead, we find that the analyzed regulations, namely the Dodd-Frank Act and the Volcker Rule, are actually improving the liquidity. Using subsample analysis, we find that the impacts of regulations are different for bonds in different grades. For investment grade bonds, the regulations have favorable impacts and improve the liquidity level. For non-investment bonds, the regulations do not improve their liquidity but also do not worsen the situation. This explains why in other papers, liquidity is found to be decreasing after the Volcker Rule for downgraded bonds. Our event study confirms that there are anticipation effects of changes in the regulatory framework. As the regulations pass their milestones, the market reacts to them accordingly in the direction that aligns with the regulations. However, these milestones sometimes overlap with other events in the financial market and thus these announcement effects are often overshadowed by other effects like the shocks in stock markets. This suggests that future studies could find a method to isolate these effects and further investigate how the market behaves related to the changes in regulations and the announcements of these changes. Overall, since it is conspicuous that the Dodd-Frank Act and the Volcker Rule do not overly constrain bond market liquidity, it is unnecessary to roll back the Dodd-Frank Act and repeal the Volcker Rule. As the Volcker Rule also brings social benefits by preventing huge bailouts, repealing the Rule would not only unleash unnecessary liquidity to the market, but also make the bond market riskier and less stable.

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