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Effects of Increased Competition on Liquidity in OTC Derivatives Markets

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Abstract

Partial repeal of Dodd-Frank was signed into law on May 24th, 2018, and it enabled banks with less than 10 billion dollars in assets to participate as market makers in OTC derivatives markets. The deregulations provide an opportunity to study how liquidity is affected in OTC derivatives markets when competition among the market makers increases. Therefore, this research looks into whether the exemption to the Volcker Rule improved market liquidity in OTC derivatives markets. The research utilizes Roll and Amihud measures, which are transaction cost and price impact proxies, respectively, on all IRS trades executed between January 2nd, 2018 and August 10th, 2018. The differences in daily Roll and Amihud measures are tested with independent sample t-tests. The results illustrate that liquidity has not improved in the OTC derivatives market after the deregulations were implemented.

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1. Introduction

1.1 Volcker Rule

After the Global Financial Crisis of 2008, policy makers in the United States of America (US) have decided to impose restrictions on various activities within the financial markets to minimize risks of future market failures (Thakor, 2012). As a result, on July 21st, 2010 the Dodd-Frank Wall Street Reform and Consumer Protection Act (Dodd-Frank) was enacted, which introduced new regulatory changes in the financial service industry. Anderson (2019) mentions that the Dodd-Frank regulations implied that some banks are too important for the US economy and their failure must be prevented. Therefore, Dodd-Frank identified certain banks, also known as the systemically important financial institutions (SIFIs), that need to operate by certain rules to minimize the risk of their failures. In particular, it specified minimal size of SIFIs banks' capital reserves as well as it required all banks to perform routine stress tests to indicate their abilities to cope with a potential crisis. Moreover, Dodd-Frank prevented all banks from using customer deposits to make what the regulators deem as risky bets on the financial markets, and this paper will focus on the effects of the latter restriction.

Volcker Rule refers to a Section 619 of Dodd-Frank. Among other things, it restricts the proprietary trading of banks and its affiliates in OTC (Over-The-Counter) derivatives markets. Proprietary trading refers to a short-term trading that aims to profit from the difference between purchase and sale prices. The exemption to this rule includes municipal bonds that are issued by the government. Also, it restricts banking entities from investing into any pooled investment vehicles and privately offered funds.[1] Banks are qualified for the exemption if the bank owns less than 3 percent of the fund (Thakor, 2012). The Volcker Rule regulations came into effect on April 1st, 2014.

This has changed on May 24th, 2018 when partial repeal of Dodd-Frank was signed into law. Anderson (2019) mentions that the partial repeal lifted a requirement to perform regular stress tests that test the abilities of banks to cope with a potential crisis for all banks with less than 250 billion dollars in assets. Also, it eased capital requirements for banks with less than 250 billion dollars in assets. These banks are no longer required to hold back a certain amount of cash or its equivalents to ensure that they are still liquid in case of a crisis. The new legislation now also exempts banks with less than 10 billion dollars in assets from complying with the Volcker Rule. These banks can now participate as proprietary traders at various financial markets. This illustrates a significant change in the US financial system. According to the

[1] *(These include hedge funds, venture capital funds, real estate funds, structured finance vehicles, private equity funds*).

Federal Reserve (2020), there were 5281 local and national banks in US at end of the first quarter of 2020. 550 of those banks have total assets ranging from 1 to 10 billion dollars. This means that more than 10% of banks together with its affiliates are no longer required to abide with the Volcker Rule.

1.2 Research Question

It raises yet unanswered question whether the exemption to the Volcker Rule has enabled the financial institutions to provide additional liquidity in markets, such as OTC derivatives market, where price impacts of trades can be significantly diminished by institutions, which aim to benefit from proprietary trading (Duffie, 2012). In this paper, liquidity is defined as the ability for a market participant to purchase or sell a particular security without moving the price against itself (Thakor, 2012). Therefore, the research question of this paper is as follows:

Does the exemption to the Volcker Rule improve liquidity in OTC derivatives markets?

It is important to understand whether the partial repeal of Dodd-Frank has achieved its goals, and what are the implications of the new regulatory environment for the US financial system. After the introduction of Dodd-Frank, OTC derivatives markets were going through fundamental changes. The market itself is significant as approximately 60% of the outstanding notional amount of derivatives were traded in OTC markets in 2016, and the share had been increasing over the years (Loon & Zhong, 2016). Unlike before, the financial institutions are now required by law to report information about the traded financial instruments in the OTC markets, thus enabling public to access the data regarding the trades. Moreover, Duffie (2012) mentions that before Dodd-Frank large banks were the most prominent liquidity providers for the securities traded in the OTC markets, where trade frequency is relatively low and trade sizes are relatively large. Therefore, the characteristics of OTC derivatives market make it a suitable market for this study because it has been established that the banks play a significant role in providing liquidity, information on the trades is readily available and OTC derivatives market is relatively large, thus indicating its importance.

1.3 Scientific Relevance

Loon and Zhong (2016) looked into how liquidity and transaction costs differed before and after the Dodd-Frank regulations were implemented. They found that liquidity improved on index CDS (Credit Default Swaps) trades after the regulations were implemented. They argue

that it is most likely due to increased transparency because OTC derivatives markets used to be opaque as very little information was shared with public institutions. Increased transparency with the public could have counteracted negative effects on liquidity that were caused by limiting the participation of banks. Duffie (2012) illustrates that limiting the participation of proprietary traders in OTC derivatives markets leads to adverse consequences on liquidity. Financial institutions have the abilities to absorb imbalances in demand and supply by holding their own inventory, thus enabling sellers and buyers of securities to buy and sell without moving the prices against themselves. However, little to no research has been done regarding impacts of the Volcker Rule on liquidity after Dodd-Frank in OTC derivatives markets. Also, it is unclear whether financial institutions with less than 10 billion dollars in assets are able to provide additional liquidity in OTC derivatives markets, something that this research will explore.

1.4 Social Relevance

Implementation of Dodd-Frank has brought significant costs not only to banks and its affiliates, but also to various market participants, which participation was facilitated by services provided by the financial institutions (Thakor, 2012). Therefore, understanding whether liquidity has improved to facilitate efficient trading after the implementation of the exemption to the Volcker rule is important for policy makers. The policy makers believe that the failure of small to mid-size banks would not bring recession to the US economy, and the deregulations could improve profitability of these banks as well as facilitate efficient trading in various markets (Anderson, 2019). The banks will have abilities to use customer deposits for proprietary trading purposes. Moreover, the exemption to the Volcker rule could further facilitate distrust in smaller regional banks in the US. For instance, after the financial crisis of 2008, the public perceives proprietary trading in OTC derivatives markets as one of the causal reasons of the crisis (Anderson, 2019). Therefore, considering that the public assumes that proprietary trading in OTC derivatives markets will make the banks susceptible to similar risks as throughout the Financial Crisis of 2008, little is known whether liquidity has improved after the deregulations were implemented. This research can help the policy makers understand whether banks with less than 10 billion dollars in assets are capable of implementing significant changes in OTC derivatives markets.

1.5 Preview of Results

This paper investigates whether liquidity had increased in OTC derivatives markets by studying changes in transaction costs and price impacts on all vanilla interest rate swap (IRS) trades

executed from January 2nd, 2018 to August 10th, 2018. Thakor (2012) suggests that before Dodd-Frank regulations, banks were the most prominent liquidity providers in OTC derivatives markets. As a result of the Volcker Rule, other financial institutions have additional opportunities to collect higher premiums due to diminished competition. Therefore, the first hypothesis of this paper test whether enabling banks with less than 10 billion dollars in assets to participate as market makers in OTC derivatives markets leads to lower transaction costs for the executed trades. Using daily Roll measures as proxies for transaction costs, opposite effect is observed. For the period after the exemption to the Volcker Rule was implemented, mean value of daily Roll measures is higher than the mean value for the period before the exemption came into effect. This illustrates that transaction costs have increased rather than decreased after the implementation of the exemption to the Volcker Rule. As a result, the first hypothesis is rejected.

Duffie (2012) further suggests that the Volcker Rule will reduce abilities and quality of the market making services because decreasing competition between the market makers at OTC derivatives markets will lead to distorted security prices. He mentions that for each executed trade, the prices of the following trades will fluctuate more. Therefore, the second hypothesis of this paper test whether enabling the banks to participate as market makers in OTC derivatives markets leads to lower price impacts for the executed trades. Daily Amihud estimates are used as proxies to establish relative price impacts for the executed trades. For the period after the exemption came into effect, mean value of daily Amihud estimates is lower than for the period before. This indicates that the price impacts on the executed trades have decreased. However, the difference is not significant, considering the significance level of 5%. As a result, the second hypothesis is rejected. The results of this paper suggest that liquidity has not been improved after the deregulations were implemented since both transaction costs and price impact proxies do not illustrate reductions by statistically significant levels.

1.6 Structure

This paper is structured as follows. First, the current state of research regarding liquidity in OTC derivatives markets will be discussed and two hypotheses will be developed using the relevant literature. Afterwards, data from DTCC (Depository Trust and Clearing Corporation), which were also disseminated by Bloomberg, are discussed. Following that, suitable methodology for the data is determined and introduced. In this paper, Amihud and Roll measures are utilized, which are price impact and transaction cost measures, respectively. The

differences between the measures are tested by independent samples t-tests. Lastly, results are provided, which are followed by conclusion and discussion of the results.

2. Theoretical Background

2.1 Market Makers

For the rest of this paper, market making is defined as a form of proprietary trading. A market maker facilitates trading by holding a particular security in its own inventory. As a result, it provides liquidity to the market by ensuring that the market participants trade at existing prices, thus allowing the participants to be less concerned about moving the price of a trade against themselves. Moreover, since market makers can also execute transactions from their own inventory, buyers or sellers of a security are not required to wait for a buyer or seller to appear, but rather can trader with a market maker (Thakor, 2012).

2.2 Transparency Effects on Liquidity

Before the implementation of Dodd-Frank, OTC markets were characterized with little to no post-trade transparency. This has changed because information regarding real-time reporting and public dissemination of transactions must be readily available to the public now (Loon & Zhong, 2016). Economic theory highlights three reasons why liquidity improves in a more transparent market. First, Pagano and Roell (1996) suggest that in markets where market makers have more opportunities to observe the actual order flow, it is harder for better-informed participants to take an advantage over the uninformed participants. Also, Bessembinder and Maxwell (2008) mention that increased transparency in markets prevents the market participants from selling or buying securities at prices that do not reflect fundamental values of these securities. Moreover, Naik, Neuberger, and Viswanathan (1999) illustrate that in more transparent markets the cost of trading is reduced because dealers have more opportunities to share risks, which, in turn, decrease their inventory costs.

2.3 Counterparty Risk Externality

It is important to note that OTC derivates markets are defined by specific characteristics. Acharya and Bisin (2014) mention that a counterparty risk externality exist in OTC derivatives markets, which refers to “the effect that the default risk on one contract will be increased if the counterparty agrees to any contract with another agent which increases the probability that the counterparty will be unable to perform on the first one” (p. 154). This means that likelihood that a particular contract will default depends on what else has been done in the market. The

risk arises when information sharing in the market is not transparent, meaning that the markets cannot recognize the associated risks, and charge corresponding prices to the risk levels involved. To illustrate this, Acharya and Bisin (2014) use an example regarding A.I.G's inadequate liquidity positions during the financial crisis of 2008. The company offered CDS contracts that insured against default on mortgage-backed financial instruments. However, with each additional customer, value of A.I.G.'s insurance was diminished as it kept insuring more financial assets. This illustrates that markets, such as OTC derivatives markets, can be subject to the counterparty risk externality.

Acharya and Basin (2014) further mention that this externality is diminished when trades occur within centralized locations that enable public to observe the trades, and thus, rationally estimate the risks. As a part of Dodd-Frank reform, centralized locations were created for OTC derivatives markets. Benos, Payne and Vasios (2020) mention that Dodd-Frank created multilateral trading venues, swap execution facilities (SEF), where market participants can request quotes from multiple dealers. SEFs increased transparency in OTC derivatives markets and also reduced searching costs for the market participants. To estimate the impact of SEFs in OTC derivatives markets on liquidity, Friewald, Jankowitsch and Subrahmanyam (2017) show that the OTC trades executed in trading venues exhibit lower transaction costs, price impact, and price dispersion, which are all indications of higher liquidity.

2.4 Effects of TRACE and Dodd-Frank on Liquidity

Before the Dodd Frank Act was implemented, Bessembinder and Maxwell (2008) illustrate that the U.S. corporate bond market had already underwent similar changes in transparency increases with introduction of Transaction Reporting and Compliance Engine (TRACE) in July 2002. TRACE requires bond dealers to report details of their trades to National Association of Security Dealers, an organization, which gathers data on all OTC bond transactions and makes the data publicly available. Edwards, Harris and Piwowar (2007) looked into whether liquidity had increased in the OTC corporate bonds market after the implementation of TRACE. Their results indicate that liquidity has increased because transaction costs and price impacts of the bonds are significantly diminished when information became publicly available.

Similarly, after the implementation of Dodd-Frank, all OTC derivatives markets became more transparent when key trade information, such as volume and price, became publicly available. To illustrate this, Loon and Zhong (2016) examined how liquidity in index CDS market has

been affected after Dodd-Frank. After examining average relative effective spread of the CDS trades, they determined that liquidity has increased after Dodd-Frank was implemented, suggesting that additional transparency has resulted in more liquidity in the OTC derivatives market.

2.5 Explanations of the Hypotheses

Dodd-Frank has not only implemented mandatory public dissemination of trade reports in OTC derivatives markets, it has also implemented the Volcker Rule. Concern was raised before the implementation of Dodd Frank that the Volcker Rule might negatively affect liquidity and thus, increase price impacts and transaction costs of trades executed in OTC derivatives markets. Thakor (2012) mentions that market makers conduct majority of OTC transactions. Before the implementation of Dodd Frank, large banks were the most significant market makers within OTC derivatives markets because the traded financial instruments exhibit relatively low trade frequency and relatively large trade size. This suggests that banks facilitated trading for many securities that were not traded on organized exchanges, often due to large trade sizes. As a result of the Volcker Rule, the market makers that are not affected by the regulation will have additional opportunities to collect higher premiums due to diminished competition. Therefore, after enabling banks with less than 10 billion dollars in assets to participate as market makers in OTC derivatives markets, the premiums that market makers can collect from the executed trades should decrease because of additional competition. Therefore, first hypothesis is as follows:

H1: Exemption of banks with less than 10 billion dollars in assets from complying with the Volcker Rule leads to lower transaction costs for OTC derivative trades.

Duffie (2012) further suggests that the Volcker Rule will reduce abilities and quality of market making services because decreasing competition between the market makers in OTC derivatives markets will lead to distorted security prices. He mentions that for each executed trade, the prices of the following trades will fluctuate more. This suggests that limiting participation of the market makers would lead to higher and more persistent price impacts for each trade. Therefore, after the implementation of the exemption to the Volcker Rule, price impacts of individual trades should decrease as more financial institutions can participate as proprietary traders, and capitalize from distorted prices that do not reflect the fundamental values. As a result, the second hypothesis is as follows:

H2: Exemption of banks with less than 10 billion dollars in assets from complying with the Volcker Rule leads to lower price impacts for OTC derivative trades.

3. Data

3.1 Data Selection

Dodd-Frank Act has made OTC derivatives markets more transparent because US government has established clearing houses, such as Depository Trust and Clearing Corporation (DTCC), where information on all OTC trades is publicly accessible (Loon & Zhong, 2016). This means that all OTC derivative trades must be publicly reported and disseminated. On May 24th, 2018, the partial repeal of Dodd-Frank was signed into law, allowing some banks to trade in OTC derivatives markets. To understand possible consequences of the implemented changes, 92,944 individual trade reports of vanilla interest rate swaps (IRS) executed between January 2nd, 2018 and August 10th, 2018 are used in this study. Vanilla interest rate swaps refer to financial instruments contracted in the OTC derivatives market with which a floating interest rate can be exchanged for a fixed rate (Benos, Paybe & Vasios, 2020).

Duffie and Zhu (2011) define central clearing houses as entities that guarantee terms of trade for both sellers and buyers. Central clearing reduces the counterparty risks in OTC derivatives markets. Loon and Zhong (2016) illustrate that liquidity increases in OTC derivatives markets if the trades are executed at the clearing houses as participants can better estimate the counterparty risks. Moreover, Wooldridge (2016) observes an increasing trend that more IRS and CDS contracts are centrally cleared each year. Nonetheless, as compared to the other derivatives markets, central clearing is the most prevalent in IRS derivatives market. Therefore, this makes the IRS market the most suitable one for this study. IRS market can better isolate positive liquidity effects stemming from the increasing trend of more derivatives being executed at the central clearing houses. Moreover, all IRS trades involving a U.S. counterparty must take place on SEFs. Therefore, the selected data already accounts for the increased liquidity effects due to increased transparency, which was a result of Dodd-Frank reforms (Benos, Paybe & Vasios, 2020).

3.2 Description of Data

IRS trades used in this study were disseminated by Bloomberg and posted on the official DTCC website, which is publicly accessible. Data disseminated by Bloomberg are selected because

the data were disseminated more precisely as compared to the other data source posted on DTCC website. Bloomberg data have no duplicates, or trades with inconsistent information. Each trade was reported at a second precision, including its transaction price and trade size, among other things. Moreover, trade sizes of IRS trades can be denoted in multiple currencies. As a result, Bloomberg data converts the trades denoted in foreign currencies to US dollar equivalents using exchange rates at the time of the trades. Descriptive statistics of the data used is as follows:

Table 1 Descriptive statistics of the data used in this study. Prefix (pre) refers to the period before the implementation of the exemption to the Volcker Rule while prefix (post) refers to the period after the implementation.

	Mean	**SD**	**Min**	**Max**	**Median**
Transaction price (PRE)	2.531	0.590	0.100	9.750	2.770
Notional Amount traded (Pre)	51,880,789	99,265,576	61,000	3,000,000,000	25,000,000
Transaction price (Post)	2.581	0.603	0.110	7.823	2.894
Notional Amount traded (Post)	56,550,100	104,789,533	48,000	2,100,000,000	28,000,000

Note. Transaction price is in percentages, and notional amount traded is in US dollars.

Table 1 illustrates that both distributions of transaction price and notional amount traded before and after the implementation of exemption to the Volcker rule are relatively similar. For both distributions notional amount traded of IRS are skewed to the right, meaning that the distributions have relative more observations that are relatively smaller. Moreover, transaction prices for both distributions indicate that their medians and means are relatively similar to each other, indicating that the distributions are relatively symmetric. However, all distributions indicate the existence of outliers.

3.3 Block Trades

It is discussed in theoretical framework that additional transparency measures promote liquidity in OTC derivatives markets. However, Wyman (2011) also mentions that some forms of transparency have negative consequences on market liquidity. For instance, if a dealer aims to purchase a large notional amount of financial instruments, then it will be more costly for the dealer to purchase the financial instruments. Other market participants can anticipate the trades, and adjust their bid-ask spreads. As a result, to counteract the negative consequences of transparency on liquidity, block trades are performed under certain conditions. Block trades refer to purchases or sales of relatively large number of securities in OTC derivatives markets by dealers of those securities. Block trades need to be consistent with the appropriate minimum block size requirements, among other regulations that are defined by Federal Register. If a trade is considered as a block trade, when it is not necessary to report the exact size of transaction, but rather a volume dissemination cap. As a result, the actual size of each reported block trade is always larger.

In this study, 3.81% of the executed IRS trades are block trades. As a proxy to notional amount traded, a volume dissemination cap is used. To understand the differences in the data between block and non-block trades, following regressions with a dummy variable are performed.

Table 2 Regression analyses to test the difference between block and non-block trades. Block Trade is equal to 1 when a trade is the block trade, and 0 otherwise.

	Model 1	Model 2
	Notional Amount Traded	**Transaction Price**
Block Trade	222,000,000**	0.064**
	(6,313,416)	(0.017)
Constant	60,300,000**	2.818**
	(1,232,270)	(0.004)
R^2	0.124	0.002

Note. Robust standard errors are in parentheses; ** $p < 0.01$; notional amount traded is in US dollars, and transaction price is in percentages.

Table 2 illustrates that block trades have significantly higher notional amounts traded and transaction prices on average, keeping all the other things constant. As mentioned before, the volume dissemination caps are used as proxies for the notional amounts traded. Therefore, the actual notional amounts traded of IRS block trades are higher than what is reported in Table 2.

4. Methodology

4.1 Correct Sequencing of Trades

Friewald, Jankowitsch and Subrahmanyam (2017) illustrate that liquidity proxies that are based on aggregate trading activity are not sufficient proxies for market liquidity. On the other hand, utilizing actual prices and volumes of each individual trade improves the accuracy of liquidity measures. As a result, two measures, Roll estimate and Amihud measure, are used to calculate relative transaction costs and price impacts of the trades, respectively. These measures require correct sequencing of trades. Therefore, block trades are used in this research as well despite the lack of precise information on the notional amounts traded.

4.2 Roll Estimate (Transaction cost)

To measure actual trading costs requires a lot of information, such as negotiated brokerage commissions, which, in turn, depend on the size of transactions, and the time of a day, among other things. However, Roll (1984) presents a method to estimate effective bid-ask spread using a times series of market prices. This method requires that two assumptions must be met. First one is that the underlying asset must be traded in an informationally efficient market to ensure that successive transactions have the same chance of being a sale or a purchase, meaning that traders can agree on the price randomly, and not because of new information. This is a strong assumption; however, Duffie (2012) mentions that OTC derivative trades usually occur in large quantities, meaning that the participants have strong incentives to negotiate. Jankowitsch, Nashikkar and Subrahmanyam (2011) further support the argument, suggesting that particularly in the OTC markets, prices are determined based on bilateral negotiations between the dealers and investors. Moreover, after the implementation of Dodd-Frank, OTC derivatives market has become much more transparent (Loon & Zhong, 2016). The second assumption is that a probability distribution of the observed price changes is stationary. Nelson (1990) suggests that a time series is stationary when its statistical properties, such as mean, are constant over time. To test whether the distribution of the data used in this study is stationary, the following figure is drawn:

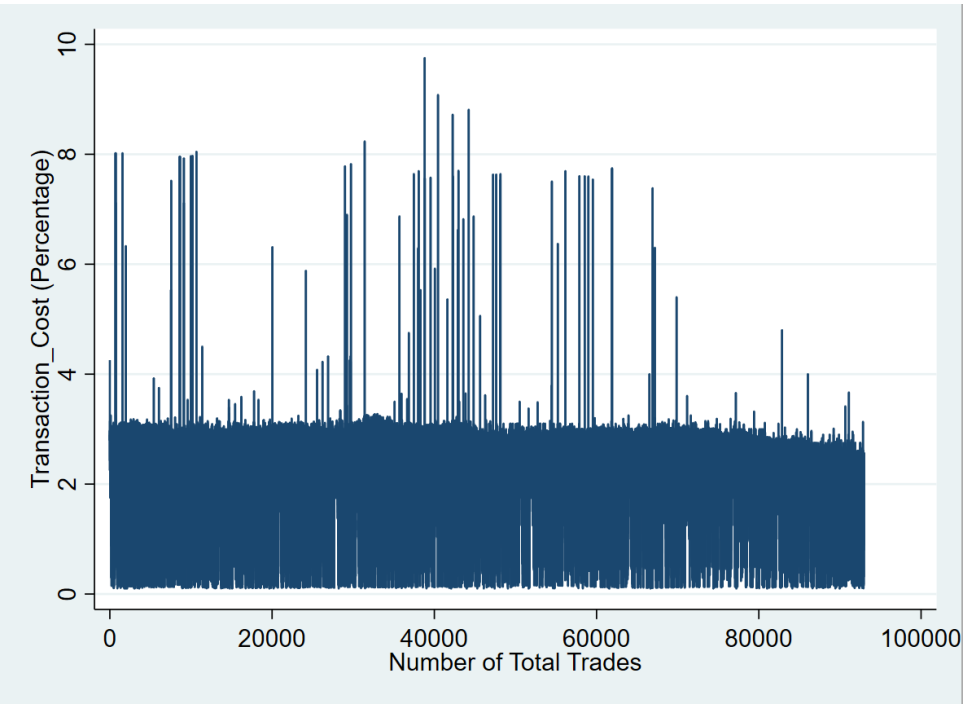

Figure 1 Transaction costs as a percentage of each trade for all consecutive IRS trades from January 2nd, 2018 to August 10th, 2018.

Figure 1 does not illustrate that the distribution is non-stationary. Nonetheless, Dickey Fuller test with a drift is performed because it is clear that the intercept is not equal to zero. Value of the test statistic is -184.53. It is lower than a critical value of 1%, which is -2.33. This ensures that the time series can be considered as stationary.

Under the previously mentioned conditions, successive price movements can be interpreted as a bid-ask bounce. Friewald, Jankowitsch and Subrahmanyam (2017) further suggest that in the context of OTC derivatives markets, Roll measure is a transaction cost measure, which is based on observed trade prices, and it is best to calculate Roll measure daily.

(1) $$Roll = 2\sqrt{-cov(\Delta p_n, \Delta p_{n-1})}$$

where *cov* means covariance, Δp_n and Δp_{n-1} refers to changes in transaction prices from trades n to n-1. This method only requires data on the prices themselves which are readily available at the DTCC database. Bloomberg database disseminated each trade at a second precision, meaning that it has a correct sequencing of trades necessary for the correct estimate of Roll measure.

4.3 Amihud Measure (Price impact)

Amihud (2002) developed a measure of illiquidity, which is the ratio of return to its volume and averaged over a certain time period, usually a day, which provides an estimate of a price impact. Amihud measure is based on assumption that market makers cannot differentiate between uninformed and informed traders. As a result, they will set higher prices as an increasing function given the higher transaction volume, which is a manner that indicates informed trading. As a result, Amihud measure serves as an estimate of a positive relationship between the price change and volume. This suggests that larger Amihud estimate indicates that trading particular IRS contracts cause their prices to move more given their volume, which, in turn, indicates lower liquidity. Loon and Zhong (2016) suggest Amihud measure for OTC swap contracts, which is as follows:

(2) $$Amihud = \frac{1}{N}\sum_{k=1}^{N}\frac{|r_k|}{TdSz_k}$$

$$r_k = 100\ (\frac{p_k - p_{k-1}}{p_{k-1}})$$

Where N refers to the total daily number of IRS trades, p_k (p_{k-1}) is the trade price for k (k-1) trade, and $TdSz_k$ refers to the size of k trade. Correct sequencing of trades is present due to the nature of the collected data. To diminish the influence of outliers, Log (Amihud) will be calculated as well.

4.4 Independent Samples t-tests Assuming the Difference in Variances

Calculated daily Roll and Amihud estimates from January 2nd, 2018 until August 10th, 2018 can be found in Table 5 and Table 6 in the appendix. To estimate whether the distributions of daily Roll and Amihud estimates have changed after the exemption to the Volcker came into effect, the difference in means of the daily measures will be tested using independent sample t-tests as suggested by Loon and Zhong (2016). Rasch, Kubinger and Moder (2011) mention that the independent sample t-test requires that two assumptions are met. First is that a sample used in the t-test is an independent random sample. This is a strict condition. Nonetheless, the sample of this study includes all the daily measures from all trading days between January 2nd, 2018 and August 10th, 2018. The sample itself is large enough to establish relative means and study the possible differences in means after the Volcker rule came into effect on May 24th, 2018. Moreover, the second condition tells that the t-test can only establish credible

relationships from normally distributed populations. As a result, the following histograms are drawn to check whether the calculated daily Roll and Amihud measures follow the normal distributions.

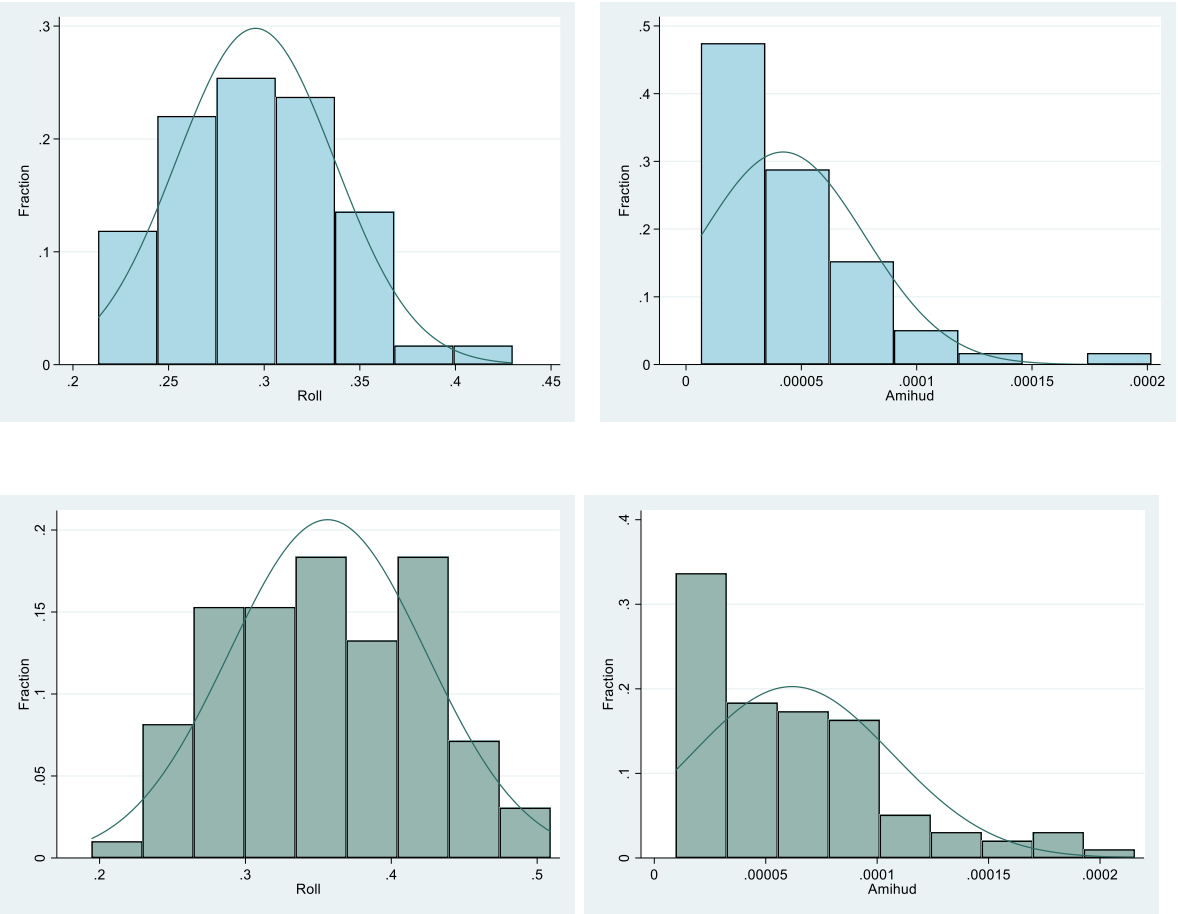

Figure 2 Histograms of the daily measures of Roll and Amihud estimates. Light blue indicates the period before the exemption to the Volcker rule came into effect, and light green indicates the estimates for the period after the implementation.

Figure 2 indicates that daily Roll measures of both distributions follow approximately normal distributions while Amihud measures do not follow them because they are skewed to the right. As a result, logarithm of Amihud measure is applied to adjust the distributions.

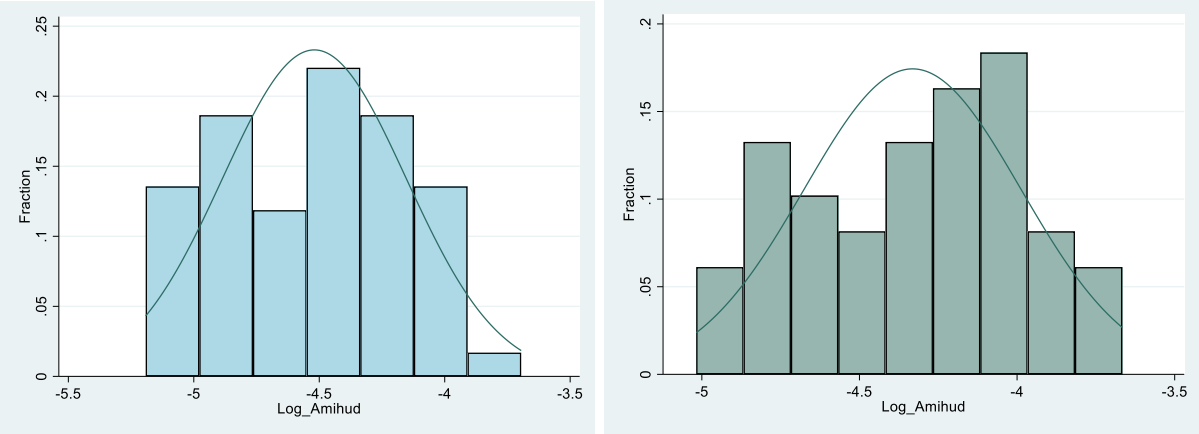

Figure 3 Histograms of the daily measures of logarithmic Amihud estimates. Light blue indicates the period before the exemption to the Volcker rule came into effect, and light green indicates the estimates for the period after the implementation.

Under the previously mentioned conditions, the formula for the t-test to study the differences in means is as follows:

(3) $$t = \frac{(\bar{x}_1 - \bar{x}_2)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

Where $\bar{x}$ refers to mean, *s* to standard deviation, and *n* to the number of daily measures used to establish the mean. Variables denoted with 1 refer to the period before the implementation of the exemption, and variables denoted with 2 refer to the period after.

4.5 Independent Samples t-tests Assuming the Equality in Variances

Bhattacharyya (2013) mentions that a pooled variance independent sample t-test performs significantly better than an unpooled variance independent sample t-test in a setting where the variances of the two samples are equal. The benefit of using the pooled variance t-test is that it produces an exact t-distribution while the unpooled t-test produces an approximate t-distribution. However, the pooled variance t-test requires an additional assumption that the variances of the two samples are equal. Therefore, to check whether the variances are equal between the samples of the daily measures before and after the implementation of the exemption to the Volcker rule, an F-test is performed under a null hypothesis of equal variances and an alternative hypothesis of unequal variances.

(4) $$F = \frac{s_2^2}{s_1^2}$$

Where s_1 refers to the standard deviations of Roll and Amihud measures before the implementation of the exemption to the Volcker rule and s_2 refers to the period after. Under the null hypothesis of equal variances, the variances of the Roll measures should not be considered as equal between the periods because its F-value of 2.07 is greater than the critical value of 5%, which is 1.49. On the other hand, logarithmic measure of Amihud estimate can be considered for the pooled variance independent sample t-test as its F-value of 1.13 is lower than the critical value of 5%, which is 1.46. As a result, the pooled variance independent sample t-test is described as follows:

(5) $$t = \frac{(\bar{x}_1 - \bar{x}_2)}{s_p\sqrt{\frac{1}{n_1}+\frac{1}{n_2}}}$$

$$s_p^2 = \frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}$$

Where $\bar{x}$ refers to mean, s to standard deviation, and n to the number of daily logarithmic Amihud measures used to estimate the means. Variables denoted with 1 refers to the period before the implementation of the exemption to the Volcker rule, and variables denoted with 2 refer to the period after.

5. Results

5.1 First Hypothesis

Roll, Amihud and logarithmic Amihud daily estimates are calculated for each trading day from January 2nd, 2018 until August 10th, 2018. The results can be found in Table 5 and Table 6 in the appendix. Following the calculations of the daily estimates, independent sample t-tests for the difference in means assuming unequal variances are performed for the daily Roll and logarithmic Amihud measures as described in methodology section, and the results are as follows:

Table 3 Independent sample t-tests for the difference in means assuming unequal variances for daily Roll and logarithmic Amihud measures before and after the implementation of the Volcker Rule.

		Before	After	(Before – After)
Roll measure	Mean	0.296	0.356	-0.060
		(0.053)	(0.071)	
	Count	100	57	
Log (Amihud)	Mean	-4.431	-4.519	0.088*
		(0.344)	(0.366)	
	Count	100	57	

Note. Standard deviations are in parentheses; * $p < 0.1$.

The first hypothesis suggests that the exemption of banks with less than 10 billion dollars in assets from complying with the Volcker Rule will lead to lower transaction costs for the executed IRS trades. To estimate the relative transactions costs, Roll measure is utilized. Higher Roll estimate indicates that transactions costs are higher under the assumptions mentioned in methodology section. Opposite effect is observed than the first hypothesis suggests. For the period after the implementation of the exemption to the Volcker rule, mean of daily Roll measures is 0.356, which is higher than the mean for the period before the implementation, which is 0.296. The results illustrate that transaction costs did not increase after the deregulations were implemented. Therefore, the first hypothesis, which states that the exemption to the Volcker Rule leads to lower transaction costs for OTC derivative trades, is rejected.

5.2 Second Hypothesis

The second hypothesis suggests that the exemption of banks with less than 10 billion dollars in assets from complying with the Volcker Rule will lead to lower price impacts for IRS trades. Logarithmic Amihud measure is used to estimate the relative price impacts. After the implementation of the exemption to the Volcker rule, mean value of the daily logarithmic Amihud measures is lower than the mean value for the period before the implementation, which are -4.519 and -4.431, respectively. Lower estimate indicates that after the deregulations were implemented, the lower price impacts of IRS trades can be observed. However, while performing a one-side hypothesis test with an alternative hypothesis that the price impacts are

lower for the period after the implementation of the deregulations, difference is only significant at the significance level of 10%. The p-value of the difference is 0.069.

The difference in means between the periods can be also studied utilizing the assumption of equal variances as it was suggested in methodology section. As a result, independent sample t-test for the difference in means assuming equality in variances is as follows.

Table 4 Independent sample t-test for the difference in means assuming equality in variances for daily logarithmic Amihud measures before and after the implementation of the Volcker Rule.

		Before	**After**	**(Before – After)**
Log (Amihud)	Mean	-4.431	-4.519	0.088*
		(0.344)	(0.366)	
	Count	100	57	
	Pooled SD	0.352		

Note. Standard deviations are in parentheses; * $p < 0.1$.

The difference in means of logarithmic Amihud measures between the two periods is also significant at 10% under the independent sample t-test assuming equal variances. The p-value of the test reduces from 0.069 to 0.066. Nonetheless, considering the confidence level of 5%, the second hypothesis, which suggests that the exemption to the Volcker rule will lead to lower price impacts for the OTC derivative trades, is rejected.

6. Conclusion

6.1 Answer to the Research Question

The exemption to the Volcker Rule states that banks with less than 10 billion dollars in assets are no longer required to comply with the rule. This means that the banks can participate as market markers in OTC derivatives markets. Therefore, the aim of this research is to understand whether the exemption to the Volcker Rule improves liquidity in OTC derivatives markets. Two hypotheses are formulated to answer the research question. The hypotheses suggest that the exemption would lead to lower transaction costs and price impacts in OTC derivatives markets, respectively. Lower transaction costs and price impacts of trades serve as indications of higher liquidity in OTC derivatives markets. To test the hypotheses, 92,944 individual trade

reports of IRS trades executed between January 2nd, 2018 and August 10th, 2018 are used. IRS trades are selected for this study because IRS market is characterized by transparency and the highest share of centrally cleared trades (Wooldridge, 2016).

To estimate transaction costs and price impacts, Roll and Amihud measures are selected, respectively. These measures are selected because they utilize high frequency data, which are necessary to obtain accurate results about liquidity in OTC derivatives markets (Friewald, Jankowitsch & Subrahmanyam, 2017). To test the differences in liquidity estimates before and after the deregulations came into effect, independent sample t-tests are utilized. The tests do not illustrate statistically significant evidence supporting that liquidity measures for transaction costs and price impacts have improved after the implementation of the exemption to the Volcker Rule. As a result, this paper does not establish any statistically significant relationships, suggesting that the exemption to the Volcker Rule has improved market liquidity in OTC derivatives markets.

6.2 Contribution to the Existing Literature

The results of this paper add on the extensive academic literature that studies the effects of Dodd-Frank regulations. While the most studies focus on how increase in transparency has affected liquidity in OTC derivatives markets, this paper focuses on the effects of competition on liquidity. It has been established that the transparency measures introduced by Dodd-Frank have increased liquidity in OTC derivatives markets (see Loon and Zhong (2016); Friewald, Jankowitsch, and Subrahmanyam, (2017)). However, it had been difficult to access how limiting the competition among the market makers had affected liquidity in OTC derivatives markets because the reforms were implemented simultaneously. Nonetheless, Duffie (2012) and Thakor (2012) both argue that the Volcker rule should have detrimental effects on liquidity. Therefore, the exemption to the Volcker rule provides an opportunity to access the possible effects regarding how liquidity has been affected by the increase in a number of institutions participating as the market makers. The results of this paper suggest that liquidity has not been improved in OTC derivatives markets when the exemption was implemented. This suggests that the competition among the market makers might not be as significant determinant of liquidity in OTC derivatives markets as suggested by Duffie (2012) and Thakor (2012).

6.3 Discussion

The results of this paper do not support the notion that limiting the number of market makers negatively affect liquidity in OTC derivatives markets. However, it is important to mention that before the implementation of Dodd-Frank, large banks served as the most prominent market makers in OTC derivatives markets (Thakor, 2012). This research only shows that relatively smaller banks, in particular, banks with less 10 billion dollars in assets, do not improve liquidity. It has not been established whether banks with less than 10 billion dollars in assets were prominent market makers before the Dodd-Frank era. It could be the case that relatively smaller banks are unable to become efficient market makers due to their size. For instance, IRS trades used in this study are executed in relatively large quantities. The median notional amounts of executed IRS trades before and after the deregulations, were 25 million and 28 million dollars, respectively. As it was mentioned in theoretical framework, market making requires owning inventory to enable the banks to absorb the imbalances in supply and demand. Since IRS trade sizes are relatively large, owning the IRS securities can make up a large portion of assets of banks that have less than 10 billion dollars in assets. As a result, price fluctuations in the value of the IRS securities, for example, could serve as a significant deterrent from the participation as the market makers.

6.4 Limitations

There are limitations of this research that might have affected the conclusions. The sample period after the implementation of the Volcker rule only includes first 57 trading days. Larger sample size could be more beneficial. It might take longer for banks with less than 10 billion dollars in assets to build the expertise and become efficient market makers. Also, the accuracy of Amihud measure is negatively affected by block trades. Due to the regulations, only information on a volume dissemination cap is available for block trades, rather than the actual notional amount traded. As a result, volume dissemination cap is used as a proxy for trade size. 3.81% of the executed IRS trades used in this study are block trades, and daily Amihud measures can be more accurate if the actual national amount traded is used rather than the volume dissemination cap to estimate them. Moreover, one of the assumptions of the independent sample t-test is that the sample needs to be normally distributed. Figure 2 and Figure 3 indicate that the distributions of daily Roll and logarithmic Amihud measures are only approximately normal. As an alternative, Wilcoxon rank sum test can be considered because it does not require the assumption of normally distributed populations.

Liquidity proxies can also be improved. Roll and Amihud measures only account for changes in the bid-ask spreads of IRS trades. Jankowitsch, Nashikkar, and Subrahmanyam (2011) developed a liquidity measure, price dispersion, that considers that the traded prices may deviate from the actual valuations because of inventory, search, and fixed costs. The benefit of this measure is that it can account for the significant price dispersion effects that cannot be accounted by the bid–ask spreads only. As a result, Loon and Zhong (2016) suggest how to apply the price dispersion measure for OTC swap trades, which is as follows:

$$(6) \qquad Dispersion = \sqrt{\sum_{k=1}^{N} \frac{1}{TdSz_k} \sum_{k=1}^{N} TrdSz_k \left(\frac{p_k - CV_k}{CV_k} * 100\right)^2}$$

Where p_k is the transaction price for k trade, $TdSz_k$ refers to the trade size of k trade, and CV_k refers to the consensus valuation of k trade. Higher dispersion estimate would illustrate that the prices of IRS trades deviate relative more from their actual valuations, thus illustrating lower liquidity. It is evident from Formula 6 that the dispersion estimate requires additional information, which is a consensus valuation of the executed trades, as compared to Amihud and Roll measures. The consensus valuation of IRS trades can be obtained from Markit database. However, it requires to pay subscription fees as this database is not publicly available.

6.5 Suggestion for Future Research

Future research could look into how the composition of market makers in OTC derivatives markets has changed after the Dodd-Frank regulations, and how it has affected the OTC markets in terms of individual trade sizes and transaction prices. Before the implementation of Dodd-Frank regulations, large banks were the most prominent market makers in OTC derivatives markets (Thakor, 2012). This has changed after Dodd-Frank, and it is still unclear how the composition of the market makers have affected OTC derivatives markets. Moreover, further research could also study the impacts of foreign competition on liquidity in OTC derivatives markets. Benos, Payne and Vasios (2020) illustrate that the growing share of interdealer trading is being executed by the non-US trading desks. The researchers suggest that avoidance of SEF trading mandates is the most likely reason for the observed trend. This illustrates that foreign competition affect OTC derivatives markets; however, the effects on liquidity corresponding to this competition are yet unknown.

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8. Appendix

Table 5 Daily Roll, Amihud, and Logarithmic Amihud measures before the exemption to the Volcker Rule came into effect.

	Roll Measure	Amihud measure	Log (Amihud)
2-Jan	0.274908	0.000082	-4.084389
3-Jan	0.354869	0.000202	-3.695165
4-Jan	0.311158	0.000011	-4.940058
5-Jan	0.264244	0.000016	-4.802444
8-Jan	0.285238	0.000022	-4.651500
9-Jan	0.241915	0.000083	-4.078678
10-Jan	0.314949	0.000010	-5.020452
11-Jan	0.281195	0.000012	-4.914353
12-Jan	0.261789	0.000011	-4.947691
16-Jan	0.337678	0.000013	-4.901010
17-Jan	0.290188	0.000009	-5.043351
18-Jan	0.272708	0.000011	-4.960189
19-Jan	0.260642	0.000006	-5.191789
22-Jan	0.291509	0.000008	-5.097997
23-Jan	0.266727	0.000008	-5.080399
24-Jan	0.346330	0.000016	-4.797512
25-Jan	0.286779	0.000009	-5.027334
26-Jan	0.344393	0.000015	-4.838632
29-Jan	0.429925	0.000016	-4.785951
30-Jan	0.317718	0.000013	-4.894149
31-Jan	0.324544	0.000019	-4.723538
1-Feb	0.298370	0.000066	-4.183604
2-Feb	0.308080	0.000035	-4.451731
5-Feb	0.247443	0.000039	-4.409524
6-Feb	0.315944	0.000071	-4.151802
7-Feb	0.335217	0.000022	-4.657127
8-Feb	0.268931	0.000091	-4.041608
9-Feb	0.252002	0.000045	-4.342343
12-Feb	0.308880	0.000036	-4.441391
13-Feb	0.277570	0.000019	-4.711264
14-Feb	0.373325	0.000043	-4.366591

15-Feb	0.314018	0.000039	-4.407117
16-Feb	0.326206	0.000018	-4.752530
19-Feb	0.262721	0.000123	-3.911592
20-Feb	0.351003	0.000080	-4.095299
21-Feb	0.289899	0.000071	-4.148364
22-Feb	0.256623	0.000010	-5.019733
23-Feb	0.257700	0.000047	-4.323381
26-Feb	0.233884	0.000038	-4.424939
27-Feb	0.231210	0.000082	-4.084063
28-Feb	0.304950	0.000041	-4.386845
1-Mar	0.349110	0.000026	-4.581205
2-Mar	0.350704	0.000045	-4.348331
5-Mar	0.304347	0.000014	-4.860376
6-Mar	0.285754	0.000009	-5.033023
7-Mar	0.290407	0.000043	-4.371013
8-Mar	0.243527	0.000049	-4.311971
9-Mar	0.213155	0.000050	-4.297746
12-Mar	0.296587	0.000094	-4.028612
13-Mar	0.313124	0.000034	-4.472935
14-Mar	0.298952	0.000043	-4.366104
15-Mar	0.348999	0.000023	-4.630078
16-Mar	0.321051	0.000071	-4.146274
19-Mar	0.278134	0.000102	-3.991687
20-Mar	0.231905	0.000032	-4.492945
21-Mar	0.310392	0.000070	-4.155136
22-Mar	0.335547	0.000061	-4.217766
23-Mar	0.245860	0.000049	-4.314033
26-Mar	0.242102	0.000057	-4.243314
27-Mar	0.378693	0.000069	-4.158639
28-Mar	0.338173	0.000015	-4.393041
29-Mar	0.431355	0.000040	-4.829953
2-Apr	0.298962	0.000034	-4.466958
3-Apr	0.366850	0.000088	-4.055036
4-Apr	0.372826	0.000097	-4.015202
5-Apr	0.393030	0.000141	-3.851685
6-Apr	0.320991	0.000173	-3.762180

9-Apr	0.354214	0.000125	-3.902948
10-Apr	0.417573	0.000098	-4.009396
11-Apr	0.366494	0.000056	-4.248211
12-Apr	0.355578	0.000023	-4.646882
13-Apr	0.376611	0.000014	-4.859168
16-Apr	0.387178	0.000115	-3.940880
17-Apr	0.233441	0.000010	-5.017801
18-Apr	0.322713	0.000064	-4.196980
19-Apr	0.404745	0.000077	-4.112790
20-Apr	0.275091	0.000048	-4.321570
23-Apr	0.390830	0.000041	-4.384894
24-Apr	0.322616	0.000054	-4.269876
25-Apr	0.258060	0.000024	-4.620064
26-Apr	0.355393	0.000027	-4.568770
27-Apr	0.194475	0.000063	-4.202110
30-Apr	0.358136	0.000011	-4.957133
1-May	0.295058	0.000073	-4.139540
2-May	0.321080	0.000010	-4.979051
3-May	0.250092	0.000042	-4.375408
4-May	0.308921	0.000114	-3.944928
7-May	0.269057	0.000076	-4.120038
8-May	0.261362	0.000120	-3.920987
9-May	0.430076	0.000012	-4.913800
10-May	0.381787	0.000016	-4.797484
11-May	0.301737	0.000091	-4.041587
14-May	0.287392	0.000216	-3.666253
15-May	0.429993	0.000139	-3.855619
16-May	0.331577	0.000036	-4.437795
17-May	0.235881	0.000052	-4.279990
18-May	0.296631	0.000017	-4.774698
21-May	0.344939	0.000081	-4.090079
22-May	0.361504	0.000028	-4.557610
23-May	0.358686	0.000074	-4.132834

Note. Log(Amihud) refers to a logarithm of Amihud measure.

Table 6 Daily Roll, Amihud, and Logarithmic Amihud measures after the exemption to the Volcker Rule came into effect.

	Roll Measure	**Amihud measure**	**Log (Amihud)**
24-May	0.317305	0.000055	-4.257708
25-May	0.377153	0.000153	-3.815867
28-May	0.295207	0.000077	-4.115937
29-May	0.423745	0.000065	-4.188363
30-May	0.293024	0.000025	-4.601022
31-May	0.459883	0.000080	-4.099332
1-Jun	0.333555	0.000014	-4.868189
4-Jun	0.433617	0.000121	-3.917355
5-Jun	0.288837	0.000067	-4.171657
6-Jun	0.345060	0.000015	-4.817317
7-Jun	0.398809	0.000081	-4.093660
8-Jun	0.364363	0.000026	-4.589542
11-Jun	0.410594	0.000018	-4.742866
12-Jun	0.404420	0.000048	-4.315107
13-Jun	0.309658	0.000086	-4.065650
14-Jun	0.231037	0.000067	-4.172725
15-Jun	0.460688	0.000094	-4.026111
18-Jun	0.261236	0.000021	-4.670993
19-Jun	0.409180	0.000088	-4.057094
20-Jun	0.360583	0.000035	-4.451608
21-Jun	0.466086	0.000015	-4.813363
22-Jun	0.344747	0.000039	-4.413454
25-Jun	0.453894	0.000094	-4.025766
26-Jun	0.268247	0.000049	-4.305774
27-Jun	0.426924	0.000017	-4.779510
28-Jun	0.423010	0.000093	-4.030883
29-Jun	0.361853	0.000046	-4.340649
2-Jul	0.444294	0.000187	-3.727706
3-Jul	0.243959	0.000156	-3.807810
4-Jul	0.310581	0.000018	-4.752203
5-Jul	0.435921	0.000081	-4.089129
6-Jul	0.317433	0.000076	-4.117157

9-Jul	0.285996	0.000101	-3.997126
10-Jul	0.509295	0.000068	-4.166416
11-Jul	0.432032	0.000056	-4.251662
12-Jul	0.266089	0.000092	-4.033934
13-Jul	0.385509	0.000027	-4.565431
16-Jul	0.333211	0.000019	-4.712198
17-Jul	0.507575	0.000119	-3.925184
18-Jul	0.358467	0.000043	-4.366532
19-Jul	0.298193	0.000082	-4.086716
20-Jul	0.323410	0.000020	-4.705534
23-Jul	0.278862	0.000013	-4.885389
24-Jul	0.388960	0.000179	-3.746953
25-Jul	0.335603	0.000033	-4.482936
26-Jul	0.432347	0.000076	-4.122053
27-Jul	0.305614	0.000028	-4.548982
30-Jul	0.405338	0.000064	-4.192059
31-Jul	0.395397	0.000017	-4.757707
1-Aug	0.417716	0.000017	-4.777804
2-Aug	0.405808	0.000016	-4.800245
3-Aug	0.448625	0.000025	-4.606600
6-Aug	0.479054	0.000019	-4.721704
7-Aug	0.456873	0.000020	-4.697669
8-Aug	0.364696	0.000044	-4.355168
9-Aug	0.398753	0.000043	-4.364014
10-Aug	0.295481	0.000027	-4.563201

Note. Log(Amihud) refers to a logarithm of Amihud measure.