Examining the Influence of the Volcker Rule On Post-Crisis Credit Risk Management Conditions in the U.S. Financial Institutions

by

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Abstract:

After the financial crisis in 2008, risk management for financial institutions has become an extremely important issue. Especially for large banks which are "Too Big Too Fail." In this paper, we examined the influence of the Volcker Rule over the U.S. banks' risk management conditions. With the implementation of the Volcker Rule in 2014, financial institutions in the U.S. are no longer permitted to engage in proprietary trading. As a result, their profitability has decreased gradually. We argue that this decreasing profitability will make banks lend to riskier borrowers as a compensation. Moreover, in areas where interbank competition is high, banks are more likely to do this.

1. Introduction：

Financial risks, which usually include market risk, credit risk, management risk and liquidity risk, refer to those risks which are caused by market volatility and other administrative factors that may generate losses to the financial institutions (FIs)[1]. FIs are special because they perform very important functions including transmission of monetary policy, credit allocation, intergenerational wealth transfers and so on which are essential to the whole economy[2]. Financial risks pose a great threat over the FIs and therefore lead to instability of the whole economy. Among all the financial risks, credit risk, which refers to the risk caused by default on a debt that may arise from a borrower failing to make required payments to the FIs, is one of the biggest risks that almost every FIs are suffered from since the primary service of a bank is to accept deposits and provide loans. Moreover, credit risk can result in large financial crises if not dealt with well. For instance, in 2008, the U.S. subprime mortgage crisis was caused by credit risk and it led

[1] Saunders, A., & Cornett, M. M. *Financial markets and institutions: A modern perspective.* (Boston, 2004)
[2] Ibid.

to a global financial crisis ultimately. Hence, understanding the credit risk management conditions in FIs can help us develop precautions for future crises.

Risk management in financial institutions is the process of identifying and controlling potential financial risks[3]. It is influenced by many factors within and outside the FIs. Particularly, the changing nature of the regulatory framework has constantly affected how FIs manage their risks. In this paper, we focused on studying the U.S. financial system. In the U.S., the regulatory framework is best characterized by an oscillating force between the two opposing poles of greater and less regulation. During some periods, there were more regulation due to the fear of financial instability while in some other periods, there were less regulation because of the desire for greater economic freedom.[4] All of these have made the risk management conditions in the U.S. FIs more difficult to understand. And it is the same for the post-crisis period starting from 2008 till now. The Obama government has passed the Dodd-Frank Wall Street Reform and Consumer Protection Act (the Dodd-Frank Act) in 2010 as a response to the 2008 financial crisis[5]. Starting from its being put into effect, the debates over the Dodd-Frank Act has never quieted down. And recently, the Trump government has pledged to repeal parts of the Dodd-Frank Act, which has made the situation even more complex.[6]

In this paper, we examined the credit risk management condition in the U.S. FIs during the post-crisis period. Particularly, we studied how the Volcker Rule, the key part of the Dodd-Frank Wall Street Reform and Consumer Protection Act, has influenced FIs' credit risk management conditions. We believe that since the Volcker Rule restricted banks from engaging in proprietary trading behaviors, banks' profitability has decreased

[3] Ibid.
[4] Johnston, M. *A Brief History of U.S. Banking Regulation.* (2019, March 12)
[5] Kenton, W. *Dodd-Frank Wall Street Reform and Consumer Protection Act.* (2019)
[6] Ibid.

gradually. Therefore, in order to compensate for this, banks tend to lend to riskier borrowers. Moreover, in areas where interbank competition is high, banks are more likely to do this.

The first section of this paper provides a brief history of the U.S. financial system regulation and deregulation, as well as some details of the Volcker Rule. The second section provides a literature review on this topic. The third section is the empirical analysis including data description, theory background and model setup, regression analysis and result interpretation, and robustness check. The last part of the paper provides the conclusion and points out several directions for future research.

2. Research Background:

(1) History of U.S. Financial Institution Regulation

U.S.FI regulation has a long history. In 1914, the central bank was established under the Federal Reserve Act. It was aimed to regulate banks and conduct monetary policy. All of the member banks were required to register and hold reserves at the Federal Reserve, which until 2009 earned no interest.[7] However, without a comprehensive understanding of the whole financial system, the Fed failed to prevent the 1929 stock market crash, which ultimately led to a worldwide economic crisis known as the Great Depression. After the Great Depression, great emphasis has been put on the regulation of financial system, particularly on risk management condition of FIs. As a result, many changes have been made, including the famous Glass-Steagall Act conducted in 1933.[8] Regulation Q, which was one of the provisions of this act, placed limits on the interest rates banks could offer on deposits. FDIC was also established under the Glass-Steagall

[7] Johnston, M. *A Brief History of U.S. Banking Regulation.* (2019, March 12)
[8] Ibid.

Act. FDIC guaranteed that the deposit insurance for consumers is up to a certain level so that it helped to decrease the “bank run” under the fear of bank failures. Moreover, regulations have been passed to prohibit banks from “principally” engaging in non-banking activities and restrict FIs’ participation in securities market, along with the establishment of SEC aimed to regulate the investment banking sector.[9]

Most of these early regulations has made the U.S. financial market experience a long period of financial stability and economic expansion. But it has also been recognized that the regulation has made the U.S. banks “far less innovative and competitive than they had previously been.”[10]. For instance, the interest rate ceiling posed by the Regulation Q has become an important constraint when the inflation has made the market interest rate higher in the 1970s. As a result, many FIs sought for alternative such as money market mutual funds[11]. Hence, a number of deregulation policies have been conducted throughout the last two decades of the twentieth century. In 1980, Congress passed the Depository Institutions Deregulation and Monetary Control Act, which allowed depository institutions to offer accounts with competitive rates of return in the market[12]. Also, restrictions on the opening of bank branches across states that had been posed by the McFadden Act in 1927 were removed under the Riegle-Neal Interstate Banking and Branching Efficiency Act of 1994. And most importantly, in 1999, the Gramm-Leach-Bliley Act of 1999 allowed a bank to offer commercial banking and invest banking services at the same time.

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[9] Ibid.
[10] Sherman, M. *A Short History of Financial Deregulation in the United States. Center for Economic and Policy Research 7.* (2009).
[11] Ibid.
[12] CLIMO, B., & EVANS, R. *Interest Rate Deregulation. The Business Lawyer*. (1982)

Although these deregulations helped to stimulated the banking industry as well as the whole economy, it also caused many problems. Without the restrictions over inter-state branches, FIs mergers increased rapidly. There were over 15,000 banks in the early 1980s while this number decreased to under 8000 right before the 2008 financial crisis[13]. A larger bank not only means that each bank is now providing much more complex financial services which may increases financial risks, but also means that the "Too Big to Fail" problem is more serious. Moreover, with the swift development of the derivatives markets, more and more banks have become speculators to some degree. All of these have increased the systematic risk of the financial industry gradually. The 2008 financial crisis finally has caused the government to change the current regulatory framework. As a response, the Dodd-Frank Wall Street Reform and Consumer Protection Act were passed in 2010 in order to regulate the financial system.

(2) The Dodd-Frank Act and the Volcker Rule:

The Dodd-Frank Wall Street Reform and Consumer Protection Act (the Dodd-Frank Act) was a financial reform legislation conducted by the Obama government in 2010 as a response to the 2008 financial crisis. The main goal of it is to control various financial risks in the financial system. Important components of the Dodd-Frank Act include (1) establishing the Consumer Financial Protection Bureau (CFPB) which is aimed to help consumers better understand the terms of different mortgages and regulate the consumer lending behaviors; (2) establishing the Financial Stability Oversight Council and Orderly Liquidation Authority, which monitors those FIs that are considered "Too Big To Fail"[14].

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[13] Sherman, M. *A Short History of Financial Deregulation in the United States. Center for Economic and Policy Research 7.* (2009).
[14] Kenton, W. *Dodd-Frank Wall Street Reform and Consumer Protection Act.* (2019, March 12).

The key part of the Dodd-Frank Act is the Volcker Rule (Title VI of the Act), which restricts FIs from engaging in proprietary trading and limits FIs' speculating behaviors. Also, banks are not allowed to be involved with hedge funds or private equity firms. In short, the Volcker Rule is aimed to prevent banks from participating into risky investment behaviors. All of these restrictions are based on the assumption that FIs' involvement in these activities will not bring about large benefits to consumers but instead will increase FIs' credit risk exposure[15]. The Volcker rule went into effect on April 1, 2014. In July 2015, all banks are required to fully comply.

3. Literature Review:

The criticisms to the Volcker Rule have come out from different angle even before it was fully implemented. In 2012, a report by the U.S. chamber's center for capital market competitiveness has pointed out several potential consequences of the Volcker Rule such as decreasing market-making benefits, reduced liquidity and distorted security prices[16]. It also argued that efficient risk management in financial institutions will also be interfered and there will be a reduction in the value of financial services sold by the banks[17]. After it being put into effect, the Volcker Rule has been widely criticized. In 2014, the U.S. Chamber of Commerce claimed that "a cost-benefit analysis was never done", and that "the costs associated with the Volcker Rule outweigh its benefits"[18]. Also, in 2017, the International Monetary Fund's top risk official said that "regulations to prevent speculative bets are hard to enforce" and that the Volcker Rule could unintentionally diminish liquidity in the bond market[19]. This indicates that the efforts of

[15] Chen, J. *Volcker Rule.* (2019, March 12).
[16] Thakor, A. V. *The economic consequences of the Volcker rule*. (2012).
[17] Ibid.
[18] Lynch, S. N. *Critics claim Volcker rule skirts cost-benefit laws.* (2014, February 12)
[19] Mayeda, M. *IMF Calls Volcker Rule Hard to Enforce and Threat to Liquidity.* (2014, April).

the Volcker Rule to reduce FI's risk exposure more bring about new risks. The Federal Reserve's Finance and Economics Discussion Series (FEDS) made a similar argument in October 2017, arguing that the Volcker Rule will reduce liquidity due to a reduction in banks' market-making activities. And Bao, Ohara and Zhou found that the illiquidity of stressed bonds has increased after the Volcker Rule as a result of banks which are regulated by the Rule have decreased their market-making activities[20].

Moreover, in October 2017, a Reuters report revealed that the European Union had scrapped a drafted law, which was considered as EU's response to the Volcker Rule, "citing no foreseeable agreement in sight"[21]. Meanwhile, several reports have cited a lighter-than-expected impact on the revenues of big banks in the years following the rule's enactment — although ongoing developments in the rule's implementation could affect future operations[22].

4. Theory Background and Hypothesis:

In this paper, we want to analyze the impact of the Volcker Rule on post-crisis credit risk management conditions in the U.S. financial institutions. A traditional model to measure credit risk of a given financial institution is to calculate the probability of default (PD) and loss given default (LGD) for each of the loans the financial institution lent. Then we multiply the PD and LGD for individual loans and sum them up to get the total credit risk exposure for this financial institution[23]. LGD is generally difficult to estimate since we did not have the details of all the borrowers of a given financial institution. However, if we assume that the bank is large, then due to the "Too Big To Fail" problem, we can argue that the LGD is zero since the Fed would perfectly protect

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[20] Bao, J., Ohara, M., & Zhou, X. *The Volcker Rule and Market-Making in Times of Stress.* (2016).
[21] Jones, H. *EU scraps its answer to U.S. Volcker Rule for banks.* (2017, October 24).
[22] Chen, J. *Volcker Rule.* (2019, March 12).
[23] Saunders, A., & Cornett, M. M. *Financial markets and institutions: A modern perspective.* (Boston, 2004)

debt holders, and even equity holders as we have seen in the crisis[24]. And since most banks which have engaged in proprietary trading are large banks, our analysis will use PD to measure the credit risk of a given FI. We believed that with the implementation of the Volcker Rule, FIs' profitability has decreased since they are no longer allowed to participate in risky speculating behaviors. As an alternative, they might tend to lend to more risky borrowers to compensate for their loss on the revenue of speculating behaviors. Moreover, we also believed that this is also related to the degree of banking market competition. In areas where the interbank competition is high, banks are more likely to lend to risky borrowers and hence have a higher PD.

There are generally two approaches to measure PD. One is the historical approach and another is the credit scoring model approach. Most FI prefer historical approach since it does not make a lot of assumptions about the financial condition of a FI[25]. However, in order to use the historical approach, the minimum data period required is 5 years for each FI. Also, we need the details of banks' loan as well. Since our analysis is on the national level, using historical approach to measure PD is not realistic. Hence, we will use the credit scoring model in our analysis. More specifically, we will use the Altman Z-Score Model, which was proposed by Edward I. Altman in 1968. The original model was designed to estimate manufacturing firms[26]. Altman later proposed a model to estimate nonmanufacturing firms by adjusting the original model. Moreover, by adding a constant to the adjusted model, Altman made his model applicable for financial institutions (particularly in emerging market) as well[27]. However, there are still a lot of doubts on whether Altman Z-Score model can be applied to FIs. A simple argument is that the idea

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[24] Ibid.
[25] Ibid.
[26] Altman, Edward I. *Financial Ratios, discriminant analysis and the Prediction of Corporate Bankruptcy.* (1968).
[27] Altman E.I. Hartzell J. Peck M. *Emerging Markets Corporate Bonds: A Scoring System.* (1995).

of working capital is difficult to calculate for FIs. FIs, like banks, usually do not distinguish between current liabilities and noncurrent liabilities since their liabilities are mainly composed by deposits which does not have a clear due date. In our research, we assume that all the noninterest-bearing deposits fall into the category of current liabilities. The Altman Z-Score model for banks is stated as follows:

$$Z - Score = 6.56\frac{Working\ Capital}{Total\ Assets} + 3.26\frac{Retained\ Earnings}{Total\ Assets} + 6.72\frac{EBIT}{Total\ Assets} + 1.05\frac{Book\ Aalue\ of\ Equity}{Total\ Liabilities} + 3.26$$

We use this Z-Score as the main way to estimate the PD of a given FI. However, from the above equation of Z-Score, it is not difficult to see that it is affected by working capital, retained earing, EBIT and many other financial variables which are highly correlated with the market condition. Therefore, it might be good idea to control the market condition for each FI. We solve this problem partially by (1) calculate the 3 digits zip-code level average Z-Score and then aggregate it using the 3 digits zip-code level demographic data; (2) we used a fixed effect model within a panel data to control for regional market conditions.

In order to test our second hypothesis, which is that in areas where the interbank competition is high, banks are more likely to lend to risky borrowers and hence have a higher PD, we need to measure the degree of interbank competition. A commonly accepted measure of market concentration is using the Herfindahl-Hirschman Index (HHI). HHI is calculated by squaring the market share of each firm competing in a market and then summing the resulting numbers[28]. It is a number ranging from zero to 10,000. The higher the number is, the more concentrated the market is. The regulators of banks in the U.S. uses HHI as well to deal with merge & acquisition issues.

[28] Hayes, A. *Herfindahl-Hirschman Index - HHI Definition.* (2019, March 25).

5. Data Description:

We mainly use data from the Reports of Condition and Income (the Call Report) from the Federal Reserve Board to analyze the FIs' credit risk exposure, as well as to construct our measures of the PD. A call report is a report that required by the Fed to be filed by all the banks in the U.S. on a quarterly basis. It contains the detailed information of the balance sheet and income statement of a given bank. We used the fourth quarter Call Report data filed by the FIs during the period of 2011 to 2017. Each year there are around 5500 – 7000 individual FI filed the Call Report. In order to merge this Call Report data with the demographic data, we aggregated this bank-level data into a 3 digits zip-code level data by calculating the average Z-Score for each 3 digits zip-code area.

We complemented the Call Report data with branch level deposit data from the Federal Deposit Insurance Corporation. This can help us to estimate the bank market concentration. Again, we calculated the HHI for each 3 digits zip-code area and aggregated the data into a 3 digits zip-code level.

We have also looked for extra demographic data from the National Historical Geographic Information System (NHGIS) and the U.S Census.

6. Summary Statistics:

We first constructed a bank-level panel data from the Call Report. Since the Call Report data represents all the variables in a code format, it is very important identify relevant variables beforehand. In order estimate the credit risk exposure of a FI using the Altman Z-Score model, we need the book value of total assets, book value of total liabilities, book value of equity, EBIT (earnings before interests and taxes), retained earnings and working capital of a given FI. Apart from those which can be directly found in the Call Report, for EBIT, we constructed it as rcon4301-rcon4074. For working capital, by definition it is the difference between current assets and current liabilities. We constructed it as:

(rcon0081+rcon1773+rcon5369+rcon3545) - (rcon6631+rcon3548+rconb993)

Note that this estimation of working capital is not that accurate. As we have discussed above, FIs do not have a clear definition of current liabilities since they do not know the time when consumers will get their deposits out. We assumed that all the interest-bearing deposits are noncurrent liabilities and noninterest-bearing deposits are current liabilities.

Then we used the formula to calculate Z-Score for each individual FI. And Table 1 below summarizes the calculated individual bank-level Z-Score for each year. It is not difficult to see that the average Z-Score of FIs has decreased from 2010 to 2017 year by year.

Table 1: Summary of Z-Scores

Years	Mean	Std. Dev.	Frequencies
2010	3.8919218	1.4927261	6,866
2011	3.9692521	1.5213451	6,663
2012	3.9572004	1.6250623	7,030
2013	3.8969349	1.6110959	6,756
2014	3.8230905	1.6379551	6,459
2015	3.7378541	1.6192643	6,134
2016	3.6718032	1.6287634	5,870
2017	3.6159296	1.6943949	5,637
Total	3.82911	1.6067118	51,415

Since we want to analyze the impact of the Volcker Rule over banks' credit risk management conditions, it is important to identify which bank is influenced by the regulations as not all the banks are engaging in proprietary trading. We used the variable rcon3545, which is the number of trading asset value, from the call report to construct a controlled group. For those banks who have zero trading asset value, it is impossible for them to engage in proprietary trading. And for those banks whose trading asset value is larger than zero, although we did not know whether they have done some proprietary trading before, but they are more likely to be influenced by the Volcker Rule directly since many of them are large banks at the same time.

We then merged the Call Repot data with the 3 digits zip-code level demographic data. In order to do this, we need to aggregate the bank-level Call Report data to the 3 digits zip-code level. We calculated the average Z-score for each 3 digits zip-code area and then merged it with the demographic data. Also, we calculated the sum of the trading asset value in each 3 digits zip-code area to separate areas where have banks engaged in trading behaviors from areas where does not.

Then we used the branch deposit data from FDIC to calculate the 3 digits zip-code area HHI and merged it with the Z-Score data we got. Table 2 are the descriptive statistics for the main variables used in our research. Table 3 shows a full list of the variables.

We also plotted the geographic distribution of Z-Score among different states in year 2010 and year 2017 (Figure 1a and Figure 1b) in order to see how the Z-Score has changed from 2010 to 2017 geographically.

Table 2: Summary of Variables

Years	Observations	Mean	Std. Dev.	Min	Max
z-mean	5,797	3.903116	2.046648	-0.8653618	56.55382
trading-adj	5,797	0.3569226	4.82286	0	122.732
male	5,797	0.4944415	0.0119445	0.419951	0.5841542
population	5,797	366711.8	390367.1	8339	3155878
white	5,797	0.8017451	0.1529766	0.205394	0.9880996
black	5,797	0.0983826	0.1238479	0.0002393	0.707167
asian	5,797	0.0302683	0.0492949	0	0.5342246
income	5,797	27249.58	7844.967	13014.17	115463.8
unemploy	5,797	0.0796705	0.0263044	0.0103639	0.2507715
hhi	5,797	637.7592	1002.6	40.48199	9603.975

Table 3: Variables list

Variable	Explanation
z-mean	Average Z-score in each 3 digits zip-code region
Volcker	A dummy variable is 0 before 2014 and 1 after 2014
trading-adj	Total number of trading assets value in each 3 digits zip-code region divided by 1000000
population	Population number in each 3 digits zip-code region
male	Percentage of male population in each 3 digits zip-code region
white	Percentage of the white population in each 3 digits zip-code region
black	Percentage of the black population in each 3 digits zip-code region
asian	Percentage of the Asian population in each 3 digits zip-code region
income	Average annual personal income in each 3 digits zip-code region
unemploy	Unemployment rate in each 3 digits zip-code region
hhi	Herfindahl-Hirschman Index in each 3 digits zip-code region

Notes: We have 1,088 out of the 5,797 3 digits zip-code regions where the total trading asset value is not zero.

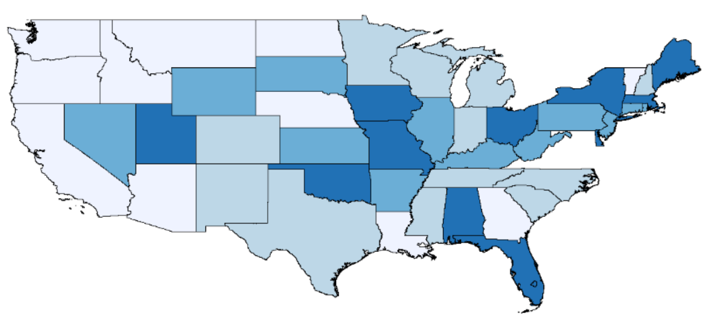

Figure 1a

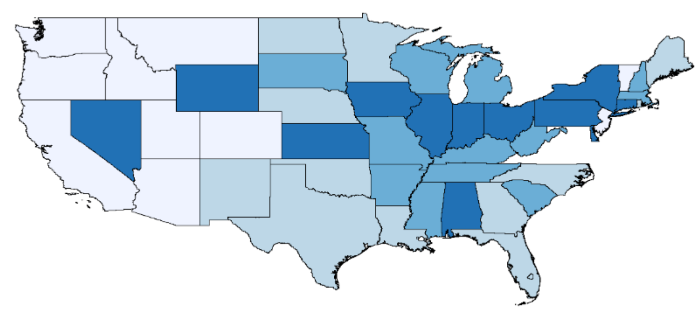

Figure 1b

Figure 1a: State average Altman Z-Score in year 2010
Figure 1a: State average Altman Z-Score in year 2017

There are mainly two observations got from the above graphs. Firstly, the cross-area Z-Score variation is high. This indicates that it is possible to conduct a regression analysis to study what has caused this variation. Secondly, it is not difficult to see that the geographic distribution of average Altman Z-Score changes a lot from 2010 to 2017. For instance, Indiana, Pennsylvania, Illinois, Wyoming and Nebraska experienced a increase in average Z-Score from 2011 to 2017 while Utah, Oklahoma, Florida and Maine experienced a decrease in average Z-Score during this period.

Table 4: Correlation Matrix

Variable	z-mean	trading-adj	hhi	population	income	unemploy	male	white
z-mean	1	0.0236	0.1143	-0.0515	0.0670	0.0028	-0.0719	0.0105
trading-adj	0.0236	1	0.3135	0.0211	0.1124	-0.0386	-0.0144	-0.0506
hhi	0.1143	0.3135	1	-0.0736	0.1682	-0.0258	-0.0128	-0.1424
population	-0.0515	0.0211	-0.0736	1	0.2046	0.1924	-0.2122	-0.3734
income	0.0670	0.1124	0.1682	0.2046	1	-0.3615	-0.1445	-0.0920
unemploy	0.0028	-0.0386	-0.0258	0.1924	-0.3615	1	-0.2581	-0.4309
male	-0.0719	-0.0144	-0.0128	-0.2122	-0.1445	-0.2581	1	0.3344
white	0.0105	-0.0506	-0.1424	-0.3734	-0.0920	-0.4309	0.3344	1

We also checked the correlation among different variables. Table 4 shows the pairwise correlation while Figure 2 shows the pairwise scatter plot. We can see from the table that Altman Z-Score does not correlate with other demographic variables a lot in the 3 digits zip-code level.

Table 5 shows the percentile distribution for the 3 digits zip-code level Z-Scores. According to Altman's standard, for a nonmanufacturing company, if the Z-Score is above 2.6, then it is in the "Safe" Zone. If the Z-Score is between 1.1 and 2.6, then it is in the "Grey" Zone and a Z-Score below 1.1 implies the company is in the "Distress" Zone. Then in our data, over 90% of the 3 digits zip-code area has an average Altman Z-Score in the "Safe" Zone and only less than 5% of the zip-code area has an average Altman Z-Score in the "Distress" Zone. This is reasonable since the regulation of banking system has increased a lot in the post-crisis period. Also, according to the FDIC (Figure 3), the number of bank failures has kept decreasing during the post-crisis period. There were 140 bank failures in 2009 and 157 bank failures in 2010 while there were only 8 bank failures in 2017 and 5 bank failures in 2016.

Table 5: z-mean distribution

	Percentile
1%	1.77853
5%	2.447809
10%	2.789468
25%	3.274634
50%	3.711928
75%	4.165235
90%	4.739237
95%	5.262922
99%	10.1145

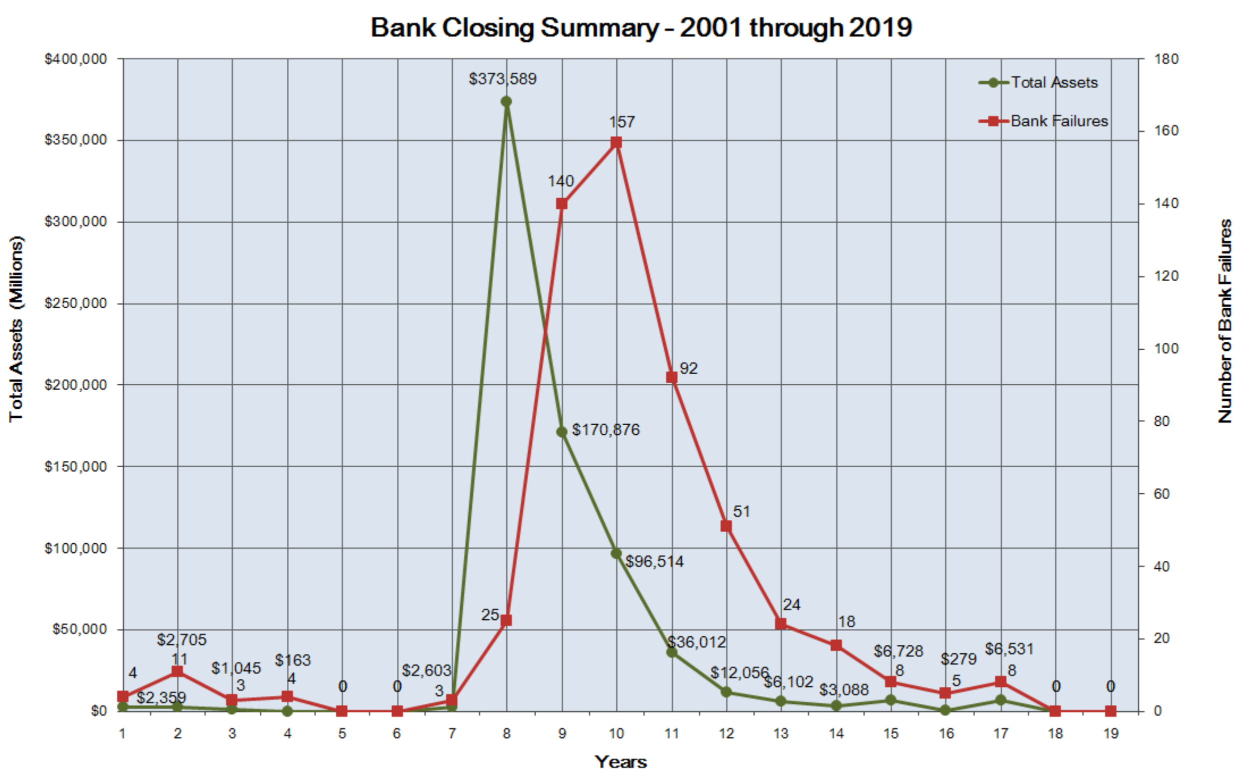

Figure 3: U.S. Bank Failures Summary

7. Empirical Specification:

In order to analyze the effect of the Volcker Rule over the average Z-Score of FIs. It is necessary to control for any omitted variables. There are generally two approaches to estimate the influence of a policy. One is using the regression discontinuity design to analyze influence of a policy, which sets a cutoff over some continuous variables, over our target variables. To conduct a regression discontinuity design, we need a continuous underlying variable and we do not have it in our research.

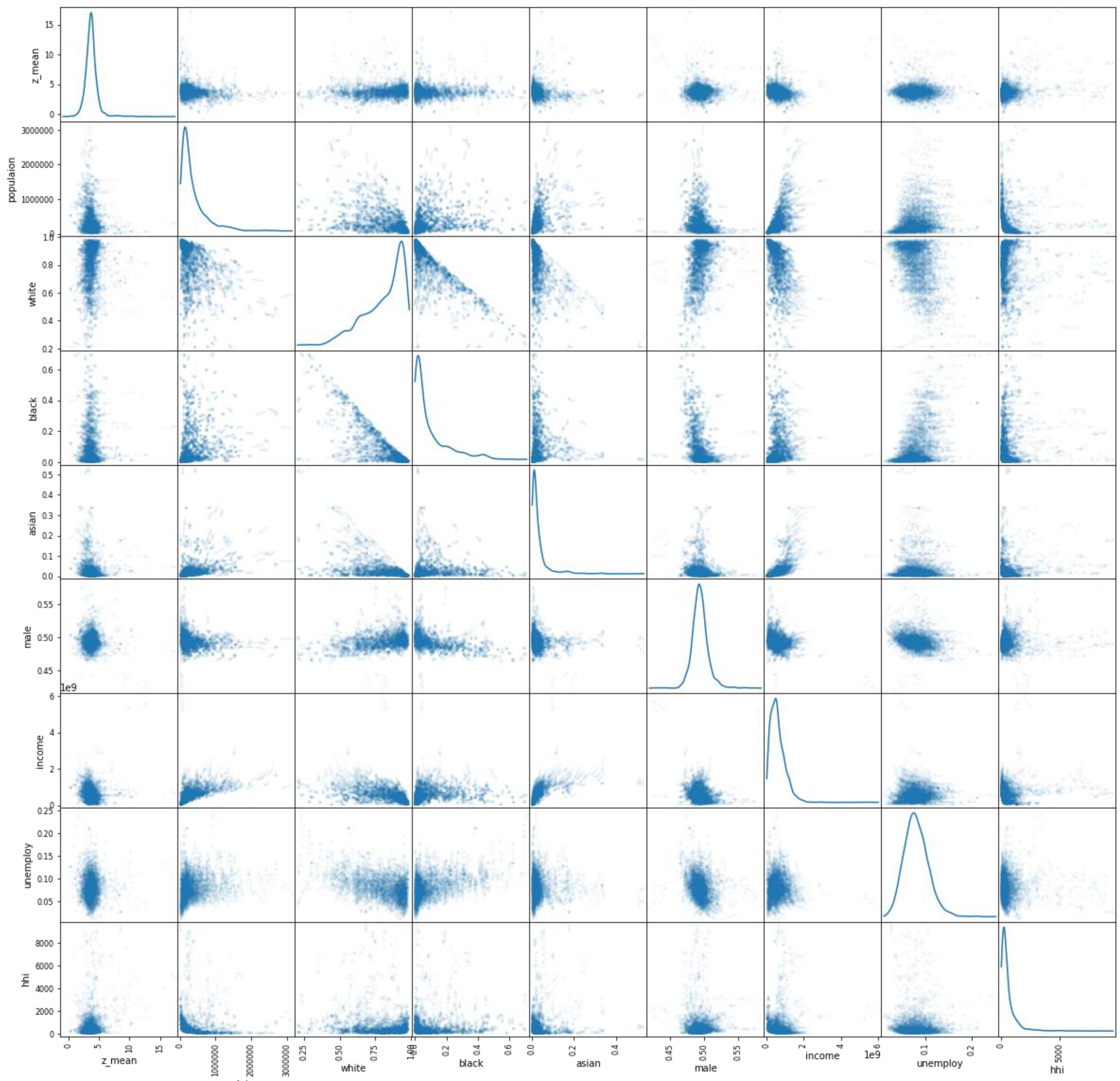

Figure 2: Correlation plot between variables

Another approach is to use the difference-in-difference method. We used the second approach to construct our regression analysis. Difference-indifference model requires us to have a policy cutoff dummy as well as a controlled group dummy. The basic assumption of a difference-in-difference model is that it assumes that the dependent variable for the control group and the treatment group shows similar trend without the policy cutoff. In our analysis, we used a dummy variable *Volcker*, which is 0 before 2014 and 1 for the rest, to indicate the policy cutoff. Also, we used the variable *trading_adj*, which is the number of trading asset value, to control between groups. For those regions where the trading asset value is zero, it is clear that they were not influenced by the Volcker Rule a lot since they were not engaged in any trading behaviors. By adding an interaction term between *Volcker* and *trading_adj*, we can control for those omitted variables which influenced each bank uniformly during this time period (like macro market condition, other policies and regulations.) The model is stated as below:

$$Z\_Score_{i,t} = \alpha_i + \beta_1 volcker + \beta_2 trading\_adj + \beta_3 volcker * trading\_adj + \beta_4 hhi + \beta_5 hhi * volcker$$

$$+\beta_6 income + \beta_7 unemploy + \beta_8 population + \beta_9 male + \beta_{10} white + \beta_{11} black + \beta_{12} asian + \epsilon_{i,t}$$

where αi is the 3 digits zip-code area fixed effect, *trading_adj* is the total number of trading asset value divided by 1,000,000, *Volcker* is a dummy variable, *hhi* is the Herfindahl-Hirschman Index and the rest are demographic variables. It can be seen from the model that by adding the interaction term between *Volcker* and *trading_adj*, we could estimate the influence of the Volcker Rule over regional average Z-Score using $\beta 3$.

Before the Volcker Rule being put into effect, the difference in the regional average Z-Score between an area where has banks engaging in trading behaviors with an area where does not have, is measured by $\beta 2$**trading_adj*. After the Volcker Rule being put into effect, the difference in the regional average Z-Score between an area where has banks engaging in trading behaviors with an area where does not have is measured by $\beta 2$**trading_adj+*$\beta 3$**Volcker*trading_adj*. Then taking the difference of these two differences, we get *β3*Volcker*trading_adj*, which measures the influence of the Volcker Rule specifically on the region where has bank engaging in trading behaviors.

8. Regression Result & Robustness Check:

The regression result is shown in Table 6 below. Note that we used the robust standard error in this regression model so the standard error is adjusted for 846 different 3 digits zip-code groups. The overall R-Square of our regression model is 0.6699, which is acceptable. The coefficient in front of the interaction term between *Trading_adj* and *Volcker* is -0.0170569 and it is statistically significant. This number indicates that after the Volcker Rule being put into effect, the average financial institutions' Z-Score for a 3 digits zip-code area would experience a 0.0170569 decrease in average when the total trading asset value increases by 1,000,000 thousand dollars. This is consistent with our hypothesis that the implementation of the Volcker Rule may lead to higher credit risk exposure.

Moreover, we can see that the coefficient in front of *hhi* is -0.0005597 and it is statistically significant as well. This indicates that in areas where have higher market concentration, the average Z-Score will be lower. This is consistent with our intuition. However, an interesting thing is that the coefficient in front of the interaction term between *Volcker* and *hhi* is 0.0001821, which means that after the Volcker Rule being put into effect, Z-Score decreases less in areas with high interbank competition compared to the period before the Volcker Rule being put into effect. This actually indicates that with higher interbank competition (lower HHI), financial institutions' Z-Score increase less after the implementation of the Volcker Rule. This is consistent with our hypothesis that interbank competition somehow influences banks' lending decisions.

Table 6: Effect of the Volcker Rule over Z-Scores

Dependent variable: z-mean	
Volcker	-0.2618962***
	(0.0720424)
Trading_adj	0.0170295
	(0.0235607)
Volcker*Trading_adj	-0.0170569**
	(0.0076979)
Male	9.201746
	(8.574969)
Population	-6.32e-07
	(2.58e-06)
White	1.752105
	(4.682406)
Black	-7.307283
	(8.026206)
Asian	-5.258126
	(28.26497)
Personal Income	0.0000197
	(0.0000491)
Unemployment Rate	6.055837
	(3.81334)
HHI	-0.0005597*
	(0.0002901)
HHI*Volcker	0.0001821**
	(0.0000907)
Constant	-1.524494
	(5.430305)
N	5,797
R^2	0.6699

Standard errors in parentheses. Two-tailed test.

Std. Err. adjusted for 846 clusters in zip_g

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

We now consider the case that if we did not use the robust standard error, will the significance level of our estimators change? Table 7 shows the results of our original model without adjusting the standard error. We can see that the coefficients in front of in *Volcker*Trading_adj* and *Volcker*HHI* is still significant.

Table 7: Effect of the Volcker Rule over Z-Scores

	Dependent variable: z-mean
Volcker	-0.2618962***
	(0.0509941)
Trading_adj	0.0170295
	(0.0249391)
Volcker*Trading_adj	-0.0170569**
	(0.0087031)
Male	9.201746
	(7.949514)
Population	-6.32e-07
	(1.49e-06)
White	1.752105
	(2.330931)
Black	-7.307283
	(6.154002)
Asian	-5.258126
	(8.073898)
Personal Income	0.0000197
	(0.0000231)
Unemployment Rate	6.055837***
	(2.139233)
HHI	-0.0005597***
	(0.000082)
HHI*Volcker	0.0001821***
	(0.0000364)
Constant	-1.524494
	(4.534758)
N	5,797
R^2	0.6699

Standard errors in parentheses. Two-tailed test.

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

9. Conclusion:

The debate over the influence of the Volcker Rule has come out constantly before and after its implementation. Scholars has shed light on the decreasing FIs' profitability and increasing risk exposure as potential consequences of the Volcker Rule. And that's one of the biggest reasons why the financial institutions have sought for deregulation from the President Trump's government recently. While many papers discussed the influence of the Volcker Rule over banks' market making ability and therefore led to higher liquidity risk, we analyzed the impact of the Volcker Rule with a focus on financial institutions' credit risk exposure.

By conducting a difference-in-difference model, we tried to figure out how the implementation of the Volcker Rule affected banks' Altman Z-Score. Moreover, we are also interested in whether this effect is associated with the degree of interbank concentration. Our result suggested that after the Volcker Rule being put into effect, the average financial institutions' Z-Score for a 3 digits zip-code area would experience a 0.0170569 decrease in average when its total trading asset value increases by 1,000,000 thousand dollars. Also, while high market concentration increases banks' credit risk exposure in general both before and after the implementation of the Volcker Rule, we also observed that the difference of the average Z-Scores between high interbank competition areas and low interbank competition areas is smaller after the implementation of the Volcker Rule.

Of course, due to the limit of our data, there may exist potential omitted variables (like regional regulatory differentiation). Future research can explore more about the regional differentiation in the influence of the Volcker Rule over banks' credit risk exposure as well as how it is related to the interbank competition.

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