Assessing the Effectiveness of the Volcker Rule with Market Proxies for Risk

Jerry Chen

Faculty Advisor: Adam Honig

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Abstract

The Volcker Rule provision of the Dodd Frank Wall Street Reform and Consumer Protection Act of 2010 remains a highly controversial provision of arguably the most comprehensive and extensive US financial regulation to date. The rule sets out to prevent banks with access to government safety nets from engaging in excessively risky trading activities and from maintaining relationships with risky institutions including hedge funds and private equity funds. Thus, the rule can be regarded as a partial reinstatement of the Glass-Steagall Act of 1933 which separated commercial banks and investment banks. While the Volcker Rule has potentially far-reaching effects, I investigate the rule's impact on bank riskiness. Public data on implied volatility for publically traded US banks in addition to VIX data are collected from 2006-2017. The volatility data is combined, by quarter, with bank specific metrics obtained from the Federal Reserve Bank of Chicago's Bank Holding Company database. Using implied volatility as a market proxy for riskiness, I assess the Volcker Rule's effectiveness at reducing the risk-taking of regulated banks. I use specific policy and event dates to break down the span of time from 2006 to 2017 into five distinct time periods. Given the Volcker Rule's focus on restricting risky trading activities, banks engaging in more trading activities should, in theory, be more exposed to the rule. Thus, I also analyze if there exists a differential effect where banks with proportionally larger trading accounts, and thus more Volcker Rule exposure, see larger decreases in risk. I find very little evidence to suggest that the Volcker Rule has reduced bank riskiness and instead find some evidence to suggest that the Volcker Rule actually increased bank riskiness. Further, while some evidence is supportive of differential effects of the Volcker Rule, no strong interaction effect is found.

Keywords: Volcker Rule, Bank Risk, Regulation, Proprietary Trading, Systemic Risk, Volatility, Financial Crisis, Too Big to Fail

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1. Introduction

The severe economic and financial distress caused by the Great Recession of 2007-09 has expectedly generated intense scrutiny of both the US financial sector and the system in place to regulate the sector. It is generally accepted that a widespread failure of financial regulation and supervision played a significant role in the undermining of the US financial system and subsequently the US and global economy during the recession. It comes as no surprise that the regulatory response to the recession has become a major topic of discussion within both political and academic spheres. The Dodd-Frank Wall Street Reform and Consumer Protection Act (Dodd-Frank) of 2010 was the marquee US regulatory response that attempted to overhaul the entire regulatory landscape with ultimate goals of stabilizing the financial system and preventing future crises of similar or worse magnitude.

The immensity of Dodd-Frank cannot be understated as it touches upon nearly every reach of the US financial sector. A particular area of intense scrutiny and focus has been the trading portfolio activities of the largest US banks. The trading operations of these US banks suffered exorbitant losses during the crisis that were largely self-inflicted and the result of tremendous levels of risk-taking that were undertaken by these banks in the lead-up to the crisis. Proprietary trading was one of the common high-risk activities that the banks engaged in pre-crisis that contributed to the undermining of these banks' stability. Proprietary trading is defined as trading of financial instruments with the bank's own capital as opposed to on behalf of clients and with depositors' capital (Chung et al. 2015). It is a form of market speculation that became very appealing to the banks given its potential to generate large, direct gains for the firms.

In this thesis, I will assess the effectiveness of the Volcker Rule, one particularly contentious provision of Dodd-Frank, at limiting the level of risk-taking of the regulated financial institutions via market proxies for bank risk. The Volcker Rule bans proprietary trading activities of the regulated US banks and limits the relationships that the regulated banks can have with other risky financial institutions including private equity firms and hedge funds. Additionally, I will analyze how the Volcker Rule may be impacting different banks' level of risk-taking differently and how differences in business composition amongst the banks can explain these effects. While there is existing literature on the impacts of Dodd-Frank on the financial sector and on bank risk-taking, there is a dearth of literature that directly pertains to the Volcker Rule given that the policy officially went into effect more recently in 2014. Thus, it would be both insightful and interesting to see if heightened regulation and oversight of banks' trading activities, as laid out by the Volcker Rule, do in fact decrease levels of risk undertaken by these banks. Many argue that the rampant risk-taking undertaken by the trading portfolios of the largest US financial institutions was a major cause of the recession and that a regulatory and supervisory failure allowed for such risky activities to take place. I seek to analyze whether or not the Volcker Rule was effective in addressing these concerns in relation to bank riskiness.

This paper provides an important contribution to existing literature on financial regulation given its directed focus on assessing the effectiveness of the Volcker Rule on bank risk-taking in a market context. Chung, Keppo, and Yuan (2016) used a stochastic control model to analyze US banks following the passage of the Volcker Rule. Within the framework of their model, they found that the rule actually raises the banks' default probabilities. They attribute this effect to the reduction in trading book size caused by the Volcker Rule which subsequently raises the illiquid banking book portfolio. The existing literature on the effects of Dodd-Frank have been generally inconclusive and more binary in form by comparing pre- and post-crisis metrics. There is evidence to suggest that Dodd-Frank has reduced the level of risk-taking undertaken by the regulated bank holding companies and that the decline in risk-taking following the passage of Dodd-Frank are not transient, but actually magnified over longer periods of time (Akhigbe et al. 2016). However, it has also been shown that various market proxies for risk have actually increased post-Dodd-Frank (Sarin and Summers 2016). This paper is more granular and attempts to isolate the effects of the Volcker Rule on bank risk-taking by performing a time period analysis based on important event and policy dates pertinent to both the Volcker Rule and Dodd-Frank.

I actually find little to no evidence that suggests that the Volcker Rule has decreased the level of riskiness of the regulated banks. I find instead that the risk levels of these banks remain significantly higher in the time period following the effective date of the Volcker Rule relative to the risk levels in the time period immediately preceding the Great Recession. Moreover, while not significant, the average post-Volcker risk levels are actually found to be higher than the risk levels in the time period immediately preceding the effective date of the Volcker Rule. Some evidence is found in support of differential effects of the Volcker Rule depending on specification, but there is overall not a strong interaction effect.

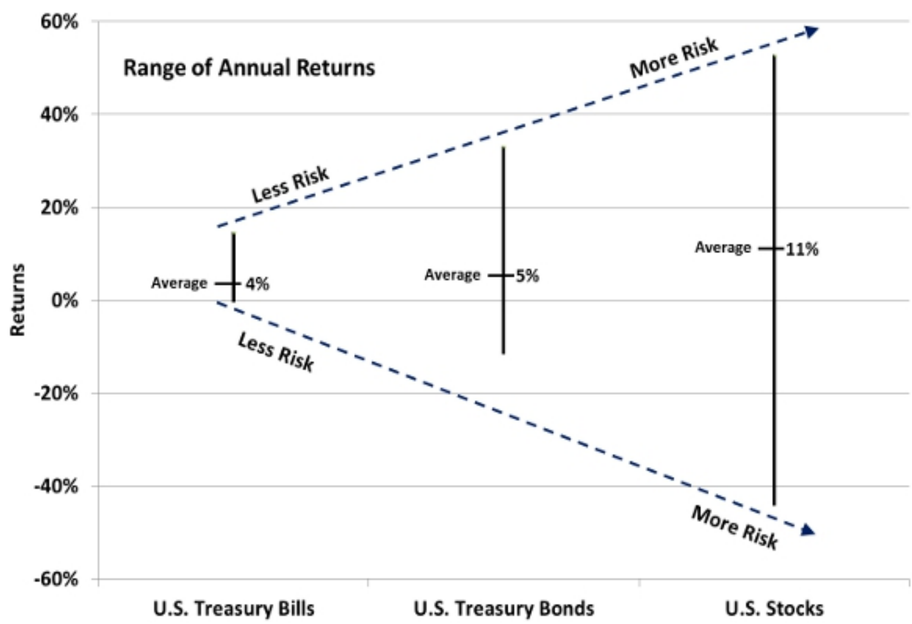
The remainder of this paper is organized as follows. Section 2 provides a background on the moral hazard problem, and the theory and motivations behind Dodd-Frank and the Volcker Rule. Section 3 details the identification strategy and main empirical specifications of the paper. Section 4 describes the data and Section 5 presents the results and main findings. Section 6 is a discussion of results and Section 7 provides concluding remarks.

2. Background

2.1 Too big to Fail – Moral Hazard Problem

Fundamentally, high levels of risk associated with an investment must be compensated for with the potential to produce high levels of returns. There is a risk-return tradeoff in which invested funds can render high returns only if there is a proportionally high probability that the invested funds are lost (Carr and Lee 2009). Risk associated with an investment can be regarded as the amount of uncertainty surrounding the investment. Thus, the only possibility for financial institutions to earn outsize profits given the limitations of

Figure 2.1: Relationship between Risk and Return



Note: Depicts the range of annual returns from 1928 – 2011 stratified by financial instruments with different risk profiles.
Source: Bogleheads.org; data obtained from Federal Reserve Database in St. Louis

their capitalizations is if correspondingly high levels of risk are incurred. We see this relationship played out in Figure 2.1 across three different asset classes. US Treasury bills are an extremely safe money market security which has a very high probability of generating returns to the investor. Thus, the variance of the annualized returns for the US Treasury bill from 1928-2011 is very low. As we move to riskier securities, the variance in the returns of these securities increases. Stocks, generally regarded as the riskiest asset class out of the three shown, have the highest variance in annualized returns. Figure 2.1 succinctly depicts the clear positive correlation that exists between the riskiness of an asset and the corresponding volatility in returns of the asset.

In theory, without any government intervention or support, profit-maximizing financial institutions would balance the tradeoffs between risk and return. Since all costs of a firm's risk exposure is born by the firm itself, an efficient level of risk is produced as the firm attempts to maximize profits. However, in the lead-up to the financial crisis, financial firms were taking on excessive amounts of risk beyond what would be socially optimal. This is due to the existence of explicit and implicit government safety nets. The Federal Deposit Insurance Corporation (FDIC) explicitly provides deposit insurance of up to $250,000 per depositor, per insured bank as a means of maintaining stability within the financial system.[1] The Federal Reserve also acts as a lender of last resort which gives them the authority to lend to domestic banks in times of stress. Implicitly, it was understood that the government will step in and bailout large banks when these banks are faced with insolvency due to financial stress.[2] Firms with access to these government safety nets therefore did not bear the full risk exposure of their actions which thus incentivized these firms to take on excessively high amounts of risk.

In particular, systemically important banks were all but guaranteed a government bailout so as to prevent the failure of such institutions. A bank is deemed to be systemically

[1] For further details on US deposit insurance, refer to https://www.fdic.gov/deposit/deposits/

[2] The government did in fact bailout numerous US financial institutions during the Great Recession. The bailout came in the form of the Capital Purchase Program (CPP) of the Troubled Asset Relief Program (TARP).

important and ‘too-big-to-fail’ if its failure would not only hurt the shareholders and creditors of that specific bank, but send ripple effects throughout the entire financial system and broader economy. Therefore, the failure of a systemically important bank has the potential to cause a chain of other bank failures, potentially resulting in both a banking and financial crisis. The level of risk-taking of the largest, systemically important financial institutions (SIFIs) pre-crisis was substantially magnified by the understanding that the government would provide assistance to these large financial institutions in times of stress. The moral hazard problem arises when these banks know they can take advantage of these government safety nets (Boyd, Chang, and Smith 1998). The implicit government insurance subsidized the risky behavior of the SIFIs, allowing these institutions to elevate their level of risk-taking to the detriment of the stability of the broader financial system.

2.2 Why Financial Regulation?

In general terms, government regulation is needed when a market failure occurs. While market failures can be caused by a variety of different factors, the market failure being addressed by post-crisis regulatory legislation stems from systemic risk, a negative externality. It has been shown through crises of the past that systemic risk emerges as a negative externality when the aggregate capitalization of banks is low. This makes intuitive sense as the amount of financial services that a bank can provide is limited by the amount of capital that that bank possesses. If all banks in aggregate are undercapitalized, the failure of one bank will have extremely pronounced negative effects on the whole system as no other surviving bank is willing and able to step in and readily make up for the shortfall in financial services provided (Calomiris and Richardson 2014, 116-17). As is the case with any negative externality, too much of a 'bad' is produced. In this case, systemically important banks are not adequately internalizing the risks associated with their actions, leading to an excessive production of systemic risk. These banks do not account for the material impacts that their risk-taking behavior will have on other banks.

Financial regulation aims to prevent future crises by reducing the level of riskiness of the largest financial institutions. Ideally, post-crisis regulation should alleviate the negative externality of systemic risk by imposing a tax proportional to the amount of systemic risk a bank generates such that firms internalize the riskiness of their actions and adequately pay for the costs of the riskiness they produce (Calomiris and Richardson 2014, 116-17). If implemented correctly, the regulated firms will willingly reduce the riskiness of their activities which may reduce the overall profitability of the firms, but increase overall social welfare given the reduced likelihood of future crises. In an ideal sense, the regulated financial institutions would become better capitalized and less levered to the point that systemic risk is minimized or even entirely eliminated within the financial system. The variance of the returns of these financial institutions should also decrease in accordance with the decrease in risk.

2.3 Overview of Dodd-Frank

Dodd-Frank, signed into law on July 21, 2010, is a regulatory monstrosity that stands as the lengthiest piece of banking regulation in US history with about 2300 pages and over 400 new rules and mandates. In fact, Dodd-Frank is lengthier than the 1913 Federal Reserve Act which established the US Federal Reserve itself (Barth, Prabha, and Wihlborg 2014). While the legislation touches on essentially every major area of the US banking and financial sector, a couple major goals come to the forefront. One of these goals is to end ‘too big to fail’ amongst the largest US financial institutions while also instituting preventative measures in order to avoid potential crises of similar or worse magnitude in the future. The bulk of these measures focus on increasing the capital requirements of the banks and setting limits on the amount of leverage the regulated institutions can take on. The banks in the lead-up to the crisis took on substantial levels of tail risk[3] that ultimately resulted in the massive losses within the trading portfolios.

The other major goal of Dodd-Frank is to have regulated firms institute formal bankruptcy plans in such a manner that would not pose any systemic risk to the broader financial system. The legislation created an Orderly Liquidation Authority (OLA) to liquidate failing financial institutions that are deemed too-big-to-fail (Jarque and Price 2015). Dodd-Frank requires the largest bank holding companies and non-bank financial institutions with assets greater than $50 billion submit periodic and up-to-date recovery and resolution plans in the case of bank failure. Ultimately, the legislation attempts to prevent future situations where taxpayer funds are needed to ensure the survival of systemically important financial institutions (SIFIs).

Some argue that Dodd-Frank is a second-best policy that acts more like a regulatory Band-Aid than a true remedy for the underlying problem (Barth, Prabha, and Wihlborg 2014). Dodd-Frank’s complexity is often regarded as one of its biggest weaknesses. As described earlier, instead of imposing an appropriate tax in line with the cost of the systemic risk externality and subsequently allowing firms themselves to decide how to optimally produce risk, Dodd-Frank tries to do the firms’ jobs for them by directly imposing capital and

[3] Tail risk refers to the left tail of the normal distribution of expected returns. Therefore, it highlights the risk associated with an unlikely, but severe loss. The Great Recession can be regarded as a tail risk event.

leverage requirements. As regulators are one step removed from the actual activities of the banks themselves, there are obvious lag and informational inefficiencies that thus result. Some form of regulatory response to the crisis was certainly needed, but the approach of Dodd-Frank may not be optimal in addressing the underlying causes of the crisis.

2.4 Rationale of the Volcker Rule

The Volcker Rule provision of Dodd-Frank, named after former US Federal Reserve Chairman Paul Volcker, is defined by Section 619 of the broader Dodd-Frank legislation. The Rule intends to limit risky, speculative trading activity of large financial institutions by prohibiting proprietary trading and limiting the relationships these financial institutions have with other risky institutions including hedge funds and private equity funds. The rule applies to banks with access to either the discount window at the Federal Reserve or to FDIC insurance and to banks with at least $50 billion in trading assets.[4] In line with other Dodd-Frank regulations, the Volcker Rule attempts to directly decide which activities banks can and cannot engage in, instead of imposing some form of per unit tax on risk and letting firms themselves adjust accordingly. The rule officially became effective on April 1, 2014 and by July 21, 2015, the largest banks were to be fully compliant.[5] While proprietary trading in many assets is banned, exceptions are made for certain assets such as U.S. government and agency bonds. Additionally, hedging and market-making activities as well as activities on behalf of clients are still permissible under the rule.

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[4] Banks with trading assets over $50 billion are required to report detailed bank metrics periodically.
[5] There have since been at least two additional extensions of the conformance period for covered funds. Refer to https://www.federalreserve.gov/bankinforeg/volcker-rule/faq.htm for details.

Naturally, the question of why banks in particular should be banned from engaging in proprietary trading and limited in their principal trading[6] activities arises. A variety of activities carried about by banks can be deemed systemically risky, but that doesn't inherently mean that they should be heavily regulated or banned. For example, lending to corporations and households is risky, but is also something really only banks can carry out efficiently. The ability to carry out these activities is essentially what differentiates a bank from other types of corporations (Fama 1985). However, it is unclear as to why banks should carry out principal trading, especially since there a large number of less levered types of firms including mutual funds, hedge funds, and pension funds that can carry out this task and don't have access to any government safety nets. This is why the Volcker Rule serves to regulate the trading activities of banks as it can be argued that these activities are generally considered noncore banking activities.

In concert with the rest of Dodd-Frank, regulators did not want the too-big-to-fail subsidy to extend to proprietary trading activities of banks, allowing banks to speculate with funds obtained at below-market rates. By structurally limiting the activities that a bank can engage in, the rule attempts to reduce the moral hazard problem that incentivizes banks to increase returns by taking very risky positions in the securities markets. In many respects, the Volcker Rule is a re-imposition of the Glass-Steagall Act (Glass-Steagall) of 1933 which divided commercial banks and investment banks, restricting the securities activities of traditional deposit-taking banks. Glass-Steagall was passed in response to the Great Depression of the 1930s and prohibited banking institutions from involvement in both commercial banking and investment banking activities. Interestingly, existing research does

[6] Principal trading in broad terms is defined as the buying and selling of securities.

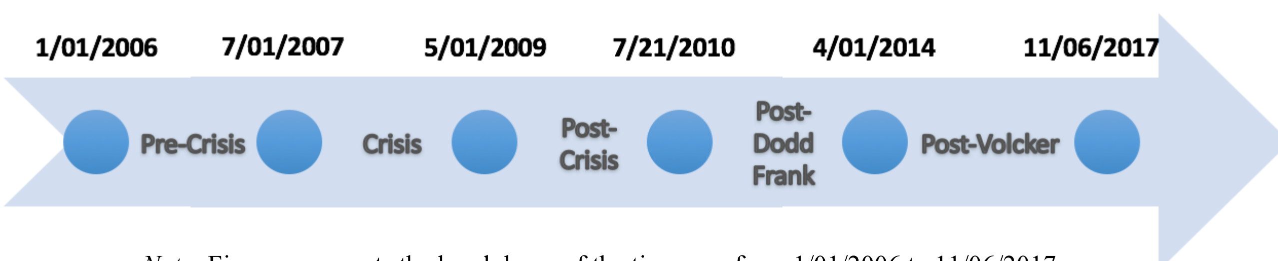
not generally support the effectiveness of Glass-Steagall at achieving its purported goals of increasing stability within the financial industry. Kroszner and Rajan (1994) find that securities underwritten by commercial banks actually defaulted significantly less often than *ex ante* similar investment bank underwritten issues. White (1986) finds that banks with securities operations had statistically significantly higher survival rates during the massive bank failures of 1930-33 which seems go directly against the purported benefits of Glass-Steagall. White explains that it could be possible that particular synergies and complementarities may exist with a more diversified business which results in the higher survival rates (White 1986).

3. Empirical Methodology

3.1 Time Period Analysis

In order to assess the effects of the Volcker Rule on bank riskiness, a time period identification strategy is employed that attempts to isolate the effects of the Volcker Rule. Similar to Bao et al. (2016), the time span of 1/01/2006 – 11/06/2017 is broken down into five periods corresponding to important policy and event dates in relation to the crisis and the subsequent US regulatory response, as represented in Figure 3.1.

Figure 3.1: Time Period Breakdown



Note: Figure represents the breakdown of the timespan from 1/01/2006 to 11/06/2017 according to specific policy and event dates. Adapted from Bao et al. (2016). This is central to my identification strategy.

The crisis period selected, spanning from July 1, 2007 to May 1, 2009, is generally consistent with the National Bureau of Economic Research's (NBER's) classification of the Great Recession which spans between December 2007 and June 2009. Other papers corroborate these dates (Bessembinder et al. 2016; Sarin and Summers 2016). The post-crisis period starts at the conclusion of the crisis period and ends following the passage of Dodd-Frank on July 21, 2010. While the Volcker Rule was originally scheduled to become effective on July 21, 2012, its effective date was pushed back to April 1, 2014. As a result, there exists an approximately four-year period of time following the passage of Dodd-Frank where the Volcker Rule was not in effect. This period is labeled the post-Dodd-Frank time period. The final time period and the period of most interest is the post-Volcker time period that spans from 4/01/2014 to 11/06/2017. This period aims to isolate the effects of the Volcker Rule from other potentially confounding regulatory impacts. Since the Volcker Rule, at the time of this writing, is still in effect, the end date of the post-Volcker period is simply the most recent date in which data was available at the time of the analysis.

3.2 Relative Volatility as a Proxy for Risk

The implied volatility of each individual bank stock indicates financial investors' expectation of the underlying stock's future volatility and is represented as a percentage of the stock price. Thus, implied volatility can be used as a risk measure for each bank and should reflect the riskiness of the activities that the banks are engaging in (Sarin and Summers 2016). The metric is annualized to indicate the expected one standard deviation move of the stock price over the course of a year (Anagnostopoulou and Tsekrekos 2017). As the name suggests, the volatility of the stock is implied by the price of the underlying option on that stock. Options on a stock are financial derivatives that give the buyer the right, but not the obligation, to buy or sell the underlying stock at a predetermined price (strike price). Higher implied volatility indicates that the stock price is less stable, indicating more implied risk. Calculations for implied volatility are calculated iteratively and based on the Black-Scholes pricing model. The inputs for the calculation of implied volatility x_i on a European option[7] include the price of the option, the option's theoretical value at x_i, and the option's vega[8] at each theoretical value (Pacati 2013).

Implied volatility is forward looking and represents expectations of future volatility. Realized, or historical, volatility could be another potential volatility measure that is inherently backwards-looking in nature. There is potential that historical volatility can be used as a risk measure as well. However, it has been shown that implied volatility outperforms historical volatility in predicting future volatility (Christensen and Prabhala 1998). These results have been corroborated by Charles Cao, Fan Yu, and Zhaodong Zhong (2010) in which they show that implied volatility is a better indicator of credit default swap (CDS) spreads than historical volatility as the volatility risk premium is accounted for in the option price. Thus, there is strong reason to suggest that implied volatility would be a better, more accurate, measure of risk than historical volatility.

However, using implied volatility alone still poses some endogeneity concerns given the potential for broad, market-wide shifts during this time span. It would prove fruitful to be able to assess implied volatility relative to the rest of the market. The Chicago Board Options Exchange Volatility Index, with ticker symbol VIX, is commonly referred to as the 'investor

[7] European options, as opposed to American options, can only be exercised at maturity (when the option expires)
[8] The vega of an option expresses the change in the price of the option for every 1% change in underlying volatility

fear gauge' as it captures volatility of the Standard & Poor's (S&P) 500. Therefore, the VIX measure serves as a proxy for overall market volatility. The measure is represented in percentage points and annualized, similar to implied volatility. Both the implied volatility and VIX metrics calculate expected volatility of the underlying stock and the S&P 500, respectively. However, there are some notable differences in the calculation of VIX compared to Black-Scholes implied volatility. The VIX is calculated as 100 times the square root of the expected 30-day variance of the S&P 500 rate of return.

$$VIX = 100\sqrt{var}$$

where *var* = (365/30) * Expected 30-day variance

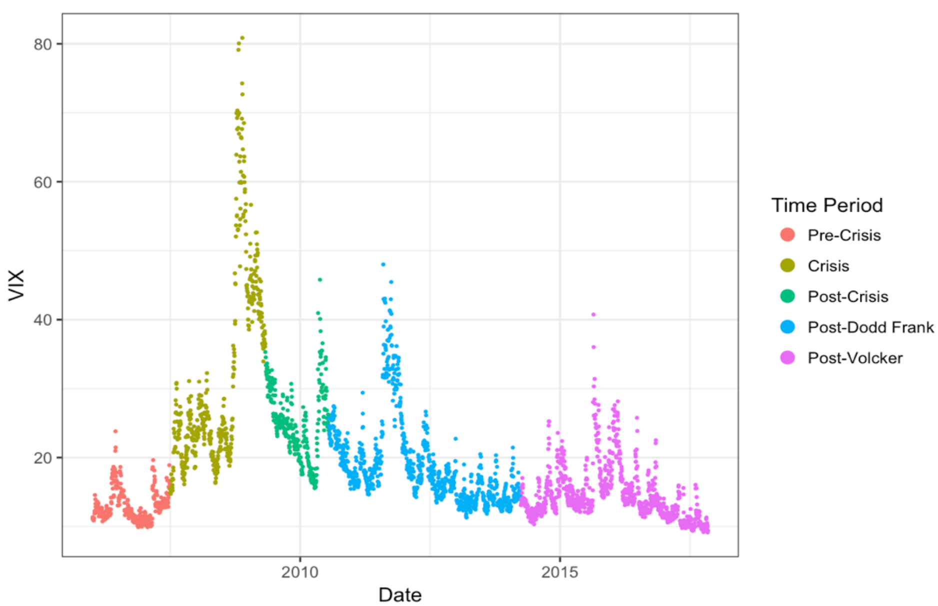
Unlike implied volatility calculated via the Black-Scholes model, the VIX metric does not constrain volatility to be constant. When the underlying volatility is not constant, the Black-Scholes implied volatility of an option with strike price K is approximately equal to the expected volatility over the most probable price path whose ending value at expiration is K ("All About VIX" 2018). This is reflected in the iterative calculation process mentioned above. In comparison, VIX is the square root of the variance over all possible price paths. While there are noticeable differences in the calculations of these two metrics, Carr and Lee (2009) find that Black-Scholes volatility comes closest to expected volatility with at-the-money options, or options where the price is equal to the strike price. Thus, in my sample, the implied volatility numbers for each individual bank stock are calculated based on 100% moneyness (at-the-money) options.

The comparability of the implied volatility and VIX metrics thus allows for the creation of a relative volatility measure that gauges the volatility of the banks relative to the volatility of the overall market. For each bank *i* at time *t* (daily or averaged by quarter), the relative volatility metric is calculated as follows.

$$RelVol_{it} = \frac{ImpliedVol_{it}}{VIX_t}$$

This means that a relative volatility value of 2 for a specific stock on a given day would indicate that investors expect this stock will be twice as volatile as their expectations of overall market volatility over the next 30 days. On the flipside, a relative volatility value of .5 for a stock on a given day would indicate that investors expect the stock will be half as volatile as their expectations of overall market volatility over the next 30 days. Thus, a relative volatility of 1 indicates that investors expect the volatility of the stock will be equivalent to their expectations of overall market volatility over the next 30 days.

Figure 3.2: VIX by Time Period, 2006 - 2017



Note: Daily VIX from 1/01/2006 – 11/16/17
Source: Bloomberg

By using this relative volatility measure as opposed to the implied volatility measure, I am able to address some of the endogeneity that may arise from structural market or economy trends. The Volcker Rule and the broader Dodd-Frank are regulations specifically catered towards and limited to the financial and banking sectors of the US. The time period specification I have presented may pick up trends in the overall economy, independent of the Volcker Rule. These broader trends may manifest themselves in the implied volatility numbers of stocks across various industries, including the stocks of the banks in question. The relative volatility measure can therefore help to better isolate the effects of the Volcker Rule provision on banks. We can see in Figure 3.2 that the VIX has been on a noticeable downward trend following the Great Recession. This trend is also reflected in the implied volatility values for each individual bank. As a result, the time period specification may erroneously identify a result suggesting that the Volcker Rule did decrease bank riskiness when, in fact, the volatility of these bank stocks would have decreased independent of the regulation.

3.3 Controls

Bank-specific control variables are also incorporated into the regressions to control for endogeneity at the bank level. The variables included are total assets, capital ratio (equity capital to total assets), profitability (net income to total assets), deposit ratio (deposits to total assets), cost-income ratio (operating expenses to total income), non-performing loans ratio (non-performing loans to total loans), and real estate loans ratio (real estate loans to total loans). Total assets is included as a proxy for bank size and the capital ratio measures the size of the equity buffer that each bank possesses. Profitability and cost-income ratio serve as indicators of the overall performance and operational efficiency of each bank. The deposit ratio serves as an indicator of the compositional makeup of each bank. Lastly, the non-performing loans ratio and real estate loans ratio provide a gauge for the portfolio composition and portfolio quality of each bank. These set of controls are generally accepted and commonly used within banking literature and is adapted from Keppo & Korte (2016). These variables are available on a quarterly basis.

3.4 Baseline Regression

The following regression will be used to assess the effectiveness of the Volcker Rule based on the time period specification. For bank *i* at time *t* (quarter), the following regression can be calculated.

$$(1)\ RelVol_{it} = \beta_0 + \beta_1\, Crisis_t + \beta_2\, PostCrisis_t + \beta_3\, PostDoddFrank_t + \beta_4 PostVolcker_t + \beta\, BankControls_{it} + \alpha_i + \mu_{it}$$

The dependent variable in this specification is relative volatility. Time period dummy variables are included in the regression as explanatory variables. Bank specific metrics that vary by both time and bank are included as controls. Bank fixed effects α_i are included as well. Quarter fixed effects are not included in this specification as the time period dummy variables would drop out due to collinearity with quarters. There are four time dummy variables that correspond to the time periods represented in Figure 3.1. It is important to note that there are only four time dummy variables shown as the pre-crisis time period is omitted. Therefore, interpretations of the coefficients on the listed time dummy variables should be stated relative to the pre-crisis period.

While relative volatility is available daily given that implied volatility and VIX are collected daily at market close, all the variables on the right hand side of the equation are not granular to the daily level. In particular, the bank-specific control variables are only available quarterly, so it makes sense to transform both the time dummy variables and the relative volatility values such that they vary by quarter as well. The quarterly relative volatility value for each bank is simply calculated as the average of the relative volatility values for each bank over the course of each quarter. Given that the original five period time specification does not line up perfectly with the quarter breakdown, approximations are made according to the table below.

Table 3.1: Time Period Breakdown by Quarter

Time Period	Dates	Quarters
Pre-Crisis	1/01/2006 – 6/31/2007	Q1, 2006 – Q2, 2007
Crisis	7/01/2007 – 4/30/2009	Q3, 2007 – Q1, 2009
Post-Crisis	5/01/2009 – 7/20/2010	Q2, 2009 – Q2, 2010
Post-Dodd Frank	7/21/2010 – 3/31/2014	Q3, 2010 – Q1, 2014
Post-Volcker	4/01/2014 – 11/06/2017	Q2, 2014 – Q4, 2017

Note: The above table matches the each time period by day to the corresponding time period by quarter in order to remain generally consistent with the time period specification outlined in Figure 3.1.

Therefore, with the given specification, we are thus interested in the coefficient β_4. If the Volcker Rule did actually limit the riskiness of the regulated firms relative to the preceding period, β_4 should be expected to be lower than β_3, the coefficient on the preceding post-Dodd Frank time period. If β_4 is found to be statistically significantly lower than β_3, there is reason to believe that the Volcker Rule has actually effectuated a decrease in the riskiness of the regulated firms. The average relative volatility of the regulated firms in the post-Volcker time period should be lower relative to the preceding time period (post-Dodd Frank).

3.5 Differential Effects of Volcker Rule

The prior regression specification identifies the level effects of the Volcker Rule on the regulated banks within the time period specification. This essentially weights every firm equally and looks at the average effects of the Volcker Rule on riskiness of banks altogether. However, the type and composition of business activities across banks vary. In broad terms, banks generally engage in a combination of commercial banking and investment banking businesses. Commercial banking can be thought of as the more traditional business model where firms act as financial intermediaries and lend to and borrow from clients. However, given the Volcker Rule's focus on the speculative trading activities of banks, the scope of the regulation falls outside traditional banking activities and is limited to the investment banking businesses of these firms. Trading activities, in addition to various other activities on behalf of corporations, fall under a firm's investment banking operations. The regulated banks vary in their level of engagement in the investment banking business in relation to their entire business and therefore vary in their exposures to the Volcker Rule. In theory, if the Volcker Rule were effective at reducing the level of risk-taking of these financial firms, the firms with proportionally larger trading operations should see larger declines in relative volatility in relation to the other banks. In the case that I do find an overall decrease in relative volatility in the post-Volcker period, an analysis of the differential effects of the rule can help serve as a robustness check. In more general terms, a study of the differential effects can connect the theoretical foundations of the Volcker Rule with empirical outcomes.

To proxy for the level of exposure each bank has to the Volcker Rule, a measure that captures the size of a bank's trading operations relative to its whole business will be needed. The size of a bank's trading account can serve as the proxy for the size of a bank's trading operations. The size of the entire business operation of a firm as a whole can be represented by the total assets of the bank. Thus, the proportion of a bank's business that is trading is referred to as the trading asset ratio and is calculated as the ratio of the trading account to total assets.

However, both the total assets of a bank and the size of a bank's trading account are not static over time. A very evident endogeneity concern arises given that banks can materially alter and adjust their businesses in direct response to financial regulations including Dodd Frank and the Volcker Rule. These changes would most certainly be reflected in the total assets and trading account variables. Therefore, the measure of a bank's exposure to the Volcker Rule needs to be tethered to a specific date or a specific span of dates, prior to the imposition of any post-crisis regulation. Additionally, since Dodd Frank and the Volcker Rule are ultimately addressing the risky activities of the banks prior to the Great Recession, it would be logical to calculate the trading asset ratio on a time span directly before the onset of the crisis. For obvious reasons, the ratio shouldn't be calculated on a timespan that overlaps with the crisis itself given the breadth and severity of the economic downturn. Thus, the Volcker Rule exposure measure should be calculated on a time span immediately before the onset of both Dodd Frank and the recession. This actually fits nicely within the context of my time period specification as there is a time span aptly labeled as 'Pre-Crisis' and defined as the time period immediately preceding the crisis. Each bank's Volcker Rule exposure measure can thus be calculated as the ratio of the bank's trading account to total assets averaged over the course of the 'Pre-Crisis' period, calculated as follows.

$$Volcker\ Rule\ Exposure_i = \underset{t\,\in\,[2006Q1,\,2007Q2]}{Mean}\left(\frac{Trading\ Account_{it}}{Total\ Assets_{it}}\right)$$

Firms with proportionally larger trading portfolios prior to the crisis should in theory be more exposed to the Volcker Rule than firms with proportionally smaller trading portfolios. If the Volcker Rule were effective in effectuating decreases in risk-taking of the regulated firms, the firms with proportionally larger trading portfolios and thus more exposure to the regulation, should see relatively larger decreases in risk-taking as reflected in lower relative volatility values. To assess the differential impacts of the Volcker Rule, the original specification is modified with interactions between the time period dummy variables and the above measure for Volcker Rule exposure.

$$(2)\ RelVol_{it} = \beta_0 + \beta_1 Crisis_t + \beta_2 PostCrisis_t + \beta_3 PostDoddFrank_t + \beta_4 PostVolcker_t$$
$$+ \beta_5 Exposure_i$$
$$+ \beta_6 (Crisis_t * Exposure_i) + \beta_7 (PostCrisis_t * Exposure_i)$$
$$+ \beta_8 (PostDoddFrank_t * Exposure_i) + \beta_9 (PostVolcker_t * Exposure_i)$$
$$+ \beta\, BankControls_{it} + \alpha_i + \delta_t + \mu_{it}$$

Similar to specification (1), relative volatility is the dependent variable and time period dummy variables are included as explanatory variables. *Exposure* is the aforementioned Volcker Rule exposure variable which is included in the regression as both a level effect and interacted with the time dummy variables. Depending on the specification, α_i and δ_t are included as bank and quarter fixed effects, respectively. *Exposure* is time invariant so it is dropped from the regression when bank fixed effects are included. The time period dummy variables are dropped from the regression when quarter fixed effects are included due to collinearity. The same set of bank specific metrics as in specification (1) are also included. Firms with higher Volcker Rule exposure should see larger decreases in relative volatility in the post-Volcker period compared to the post-Dodd Frank period. This would be reflected in a β_9 coefficient that is statistically significantly lower than the β_8 coefficient shown above. In other words, if the Volcker Rule is deemed effective, it should be more effective for the banks more exposed to the rule.

4. Data

The market data on the daily VIX and implied volatility for each bank at market close were accessed through a Bloomberg Terminal and collected on the timespan ranging from January 1st, 2006 – November 16th, 2017. The specific implied volatility metric used was the 'IVOL_DELTA' metric found in Bloomberg, calculated on a 30 day, at-the-money option.

The initial selected universe of banks is all publicly traded US banks as of January 1st, 2006, the start of my time period specification. These banks were found using the Bloomberg equity screener under the classifications of "Banks", "Diversified Banks", and "Institutional Brokerages". This filter resulted in the selection of 936 publically traded firms. However, of those firms, only 215 had at least some implied volatility data available, and only 57 banks had at least some data in all five time periods. As mentioned in the previous section, the daily data was then converted into quarterly data by averaging the daily data on a quarterly basis. This was done for the 57 banks with at least some data in all periods.

The bank-specific control variables were obtained at the bank holding company (BHC) level through the Federal Reserve Bank of Chicago BHC database which is publically available online.[9] All banks in the US are required to report a variety of metrics on a quarterly or semiannual basis on the FR Y-9C/LP/SP financial forms. The sample pulled from this database spans the period from the first quarter of 2006 to the fourth quarter of 2017. The specific variables pulled can be found in the appendix.

The final comprehensive dataset was created by merging the quarterly volatility dataset of the 57 banks with the FED Chicago database. However, not all banks in the volatility dataset had data in the FED Chicago database. This may be because some firms

[9] This data can be accessed at https://www.chicagofed.org/banking/financial-institution-reports/bhc-data and pulled using the R read table string provided on the website.

within the volatility dataset refer to a bank that is not a BHC or a subsidiary of a BHC. The FED Chicago database only has metrics available at the BHC level. Additionally, for some of the banks that did have data within the FED Chicago database, pre-crisis period data was not available.[10] These banks were subsequently dropped from the dataset as the Volcker Rule exposure measure for those banks could not be calculated. Thus, given the data limitations presented, the final dataset contained a total of 40 firms as these firms had both implied volatility and bank metrics data in the pre-crisis period.

5. Results

5.1 Five Period Analysis

Using the combined dataset described in the previous section, five regressions were run based on the baseline and differential models presented earlier. The estimated regression in Column (1) of Table 5.1 is the rudimentary, baseline time period specification with bank fixed effects and no controls. The only explanatory variables within this model that are of interest are the time period dummy variables. All four time dummy variables are positive and statistically significant at the 1% significance level. No conclusions on bank riskiness can be drawn based on this uncontrolled model, but the results do seem to suggest that the average relative volatilities of the banks in the four periods following the pre-crisis period are all higher than the average relative volatility in the pre-crisis period. The statistically significant coefficient of 0.30 on *Post-Volcker* within this specification indicates that the

[10] Goldman Sachs and Morgan Stanley became BHCs on September 21, 2008, during the height of the crisis. This gave them access to the Federal Reserve discount window, but also subjected them to heightened regulatory scrutiny from the Fed (Schultz 2014).

Table 5.1

All Banks - Five Period Analysis

	Relative Volatility				
	(1)	(2)	(3)	(4)	(5)
Crisis	0.51***	0.39***	0.47***	0.35***	
	(0.09)	(0.07)	(0.09)	(0.08)	
Post-Crisis	0.57***	0.32***	0.54***	0.25**	
	(0.12)	(0.12)	(0.13)	(0.11)	
Post-Dodd Frank	0.27***	0.18	0.24***	0.17	
	(0.07)	(0.13)	(0.09)	(0.11)	
Post-Volcker	0.30***	0.23*	0.28***	0.29***	
	(0.06)	(0.13)	(0.07)	(0.11)	
Exposure			-1.03*	0.21	
			(0.62)	(0.67)	
Crisis * Exposure			1.77	1.37	1.23
			(1.56)	(1.09)	(1.27)
Post-Crisis * Exposure			0.07	0.50	0.21
			(1.41)	(1.14)	(1.31)
Post-Dodd Frank * Exposure			0.29	0.13	0.23
			(1.04)	(0.77)	(1.06)
Post-Volcker * Exposure			-0.65	-0.68	-0.52
			(0.76)	(0.63)	(1.09)
ln(Total Assets)		0.23**		-0.08***	0.05
		(0.10)		(0.03)	(0.12)
Capital Ratio		-0.57		2.44	-1.46
		(2.89)		(2.94)	(2.73)
Profitability		-26.22***		-37.30***	-28.65***
		(5.41)		(5.55)	(7.49)
Deposit Ratio		0.12		-0.27	0.11
		(0.45)		(0.38)	(0.47)
Cost-Income Ratio		-0.16		-0.12	-0.36
		(0.22)		(0.26)	(0.28)
Non-Performing Loans Ratio		125.74**		101.35***	112.90**
		(62.41)		(32.82)	(48.81)
Real Estate Loans Ratio		0.65		0.32	0.89
		(0.45)		(0.39)	(0.55)
Quarter Fixed Effects?					X
Bank Fixed Effects?	X	X			X
Controls?		X		X	X
Observations	1447	1447	1447	1447	1447
R-squared	0.306	0.356	0.060	0.196	0.478

Notes: Estimated regressions on unbalanced panel data set with 40 banks and a total of 1447 observations. Span of time is split into five different time periods according to Table 3.1. Robust standard errors clustered at the bank level are provided in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels respectively.

banks in the post-Volcker period, on average, are considered 0.30 times more volatile than the overall market by financial investors in comparison to the pre-crisis time period. We can conclude that relative volatility amongst these banks remains elevated in the post-Volcker period and has not fallen back down to pre-crisis levels. Furthermore, an F-test[11] comparing the post-Volcker coefficient of 0.30 with the post-Dodd-Frank coefficient of 0.27 results in a p-value of 0.75, indicating that these two coefficients are not statistically different from one another. There is no evidence to suggest that the relative volatility of the banks in the post-Volcker period has decreased in comparison to the preceding post-Dodd Frank period.

Once the bank-specific control variables are added to the baseline regression, the coefficients on the time dummy variables alter considerably. This estimated regression with both bank fixed effects and controls is shown in Column (2) of Table 5.1. However, before addressing the coefficients on the time dummy variables, we can see that the control variables *Profitability*, *ln(Total Assets)*, and *Non-Performing Loans Ratio* are significant at the 1%, 5%, and 10% significance levels respectively. The negative coefficient of -26.2 on *Profitability* indicates that a 0.01 increase in the ratio of net income to total assets, holding all else constant, is associated with a 0.262 decline in relative volatility on average. The negative sign on this coefficient is consistent with intuition. As a bank becomes more profitable and produces profits more efficiently, investors are generally less concerned about the viability of the bank which is reflected in less volatility surrounding the bank's equity. The coefficient on *ln(Total Assets)* is 0.23 which indicates that a 1% increase in the total assets of a bank, holding all else constant, is associated with a 0.0023 increase in relative volatility.[12] *ln(Total*

[11] F-test has H_o: $\beta_3 = \beta_4$ where β_3 is the coefficient on *Post Dodd-Frank* and β_4 is the coefficient on *Post-Volcker* in Column (1) in Table 5.1.
[12] This interpretation is in accordance with a linear-log specification.

Assets) can be regarded as a proxy for systemic risk and its significance suggests that larger banks are deemed more systemically risky (Boyd and Heitz 2016). There could also be more volatility in the equity of larger banks due to the greater public scrutiny these banks face in comparison to smaller institutions. The coefficient on *Non-Performing Loans Ratio* is positive at 125.74 which is also consistent with intuition and serves as the inverse of the coefficient on *Profitability*. A 0.01 increase in the ratio of non-performing loans to total loans, holding all other variables constant, is associated with a 1.26 increase in relative volatility. While the increase in relative volatility seems drastic at first, it does make logical sense given that an increase in the non-performing loans ratio is indicative of direct losses to the firm which should be associated with a direct increase in volatility. Generally, if the non-performing loan ratio increases, the loan portfolio quality of the bank decreases, ultimately increasing the riskiness of the bank.

In Column (2), we see that all the time dummy variables remain positive. The coefficients on *Crisis* and *Post-Crisis* are statistically significant at the 1% significance level. This is unsurprising in many regards as one would expect the average riskiness of the banks during the crisis and the period following the crisis to be higher relative to the pre-crisis period. While volatility for all firms in the market, as captured by the VIX, should increase in both these periods, volatility for banks should be particularly elevated given the severity of the crisis within the financial sector. Interestingly, the coefficient on *Post-Dodd Frank* is positive at 0.18, but not significant. This seems to indicate that the average riskiness of the banks in the post-Dodd Frank time period is not statistically significantly higher than the average riskiness of banks pre-crisis. The riskiness of banks is approaching pre-crisis levels during this period of time. However, the coefficient on *Post-Volcker* remains positive at 0.23

and is significant at the 10% level. This coefficient on *Post-Volcker* indicates that the perceived riskiness of banks, on average, is 0.23 times higher relative to the overall market in comparison to the pre-crisis period. An F-test[13] comparing the coefficient on *Post-Dodd Frank* with the coefficient on *Post-Volcker* results in a p-value of 0.36 which is not significant at 10% level. Given that the estimated coefficient on *Post-Volcker* is larger than the coefficient on *Post-Dodd Frank*, the result of the F-test suggests that the coefficient on *Post-Volcker* is not lower than the coefficient on *Post-Dodd Frank*. Therefore, not only is the relative volatility of the banks elevated in the post-Volcker period in comparison to the pre-crisis period, there is reason to believe that the riskiness of the banks is also elevated in the post-Volcker period in comparison to the pre-crisis period. The results found in Column (2) cast a doubtful shadow on the effectiveness of the Volcker Rule. I have no evidence to suggest that the riskiness of banks has decreased in the post-Volcker period in comparison to the post-Dodd Frank period. Further, the point estimates suggest that the riskiness of the banks in the post-Volcker period actually increased relative to the preceding post-Dodd Frank period.

The remaining three specifications presented in Table 5.1 are based on the differential model presented in Section 3.4. Column (3) shows the estimated regression with the time period dummy variables as well as the interaction terms between the time period dummies and the Volcker Rule exposure variable. The time period dummy variables are all positive and significant at the 1% level, suggesting that the relative volatility of the banks remains elevated in all four subsequent periods in comparison the pre-crisis period. The coefficient on *Exposure*, the Volcker Rule exposure measure calculated as the trading asset ratio, is

[13] F-test has H_o: $\beta_3 = \beta_4$ where β_3 is the coefficient on *Post Dodd-Frank* and β_4 is the coefficient on *Post-Volcker* in Column (2) in Table 5.1.

significant and negative, indicating that a 0.01 increase in the trading asset ratio, holding all else constant, is associated with a 0.01 decrease in relative volatility on average. The negative coefficient seems to suggest that, on average, firms with proportionally larger trading accounts have lower relative volatility, holding all else constant. This seems to run counter to what one might expect given that many trading activities have been deemed risky by regulators. However, I would not put much weight on this interpretation as the coefficient is only significant at the 10% level and no controls are included in this particular regression specification. In order to compare the interaction effect between the post-Volcker period with that of the preceding post-Dodd Frank period, I run another F-test.[14] The resulting p-value of 0.12, while close, is not significant at the 10% level. Even though the coefficient of -0.65 on *Post-Volcker * Exposure* is negative and lower than 0.29, the coefficient on *Post-Dodd Frank * Exposure*, I do not find strong statistical evidence to suggest that these two coefficients are statistically different from one another. The coefficients do have the desired ordinal relationship that would suggest a differential impact of the Volcker Rule, but the lack of statistical significance precludes me from drawing any strong conclusions.

Much of the same results are found in Column (4) which includes the same explanatory variables as in Column (3) with the addition of the bank-specific control variables. The coefficients on *Crisis*, *Post-Crisis*, and *Post-Volcker* all remain significant at the 5% level or lower. However, the coefficient on *Post-Dodd Frank* is 0.17 and no longer significant, as was the case in Column (2). Therefore, once the interaction terms are included in addition to the bank-specific control variables, I once again have reason to believe that the riskiness of the banks in the Post-Dodd Frank period has returned to pre-crisis levels. Further,

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[14] F-test has H_o: $\beta_8 = \beta_9$ where β_8 is the coefficient on *Post Dodd-Frank * Exposure* and β_9 is the coefficient on *Post-Volcker * Exposure* in Column (3) in Table 5.1.

given that the coefficient on *Post-Volcker* is positive at 0.29, I have no evidence suggesting that the perceived riskiness of the banks decreased following the effective date of the Volcker Rule. An F-test[15] comparing the coefficient on *Post-Volcker* with the coefficient on *Post-Dodd Frank* produces a p-value of 0.12 which confirms this finding. In fact, the coefficient on *Post-Volcker* is almost statistically significantly higher than the coefficient on *Post-Dodd Frank*. The coefficient on *Exposure* is no longer significant in specification (4), suggesting that the control variables (mainly *ln(Total Assets)*, *Profitability*, and *Non-Performing Loans Ratio*) explained a significant portion of the variation that was initially explained by the trading asset ratio. While the coefficient on *Post-Volcker * Exposure* is once again negative and lower than the coefficient on *Post-Dodd Frank * Exposure* as in Column (3), an F-test[16] comparing these two results generates a p-value of .16, suggesting that they are not statistically significantly different from one another.

Column (5) represents the estimated regression in Column (4) with the addition of time and bank fixed effects.[17] Results remain very similar. *Profitability* and *Non-Performing Loans Ratio* remain significant at the 1% and 5% levels respectively while *ln(Total Assets)* is now no longer significant. All four coefficients on the time period and *Exposure* interaction terms remain insignificant suggesting no differential effect between the post-Volcker period and the pre-crisis time period. The coefficient on *Post-Volcker * Exposure* is -0.52 while the coefficient on *Post-Dodd Frank * Exposure* is 0.23. The F-test on these two coefficients,

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[15] F-test has H_o: $\beta_3 = \beta_4$ where β_3 is the coefficient on *Post Dodd-Frank* and β_4 is the coefficient on *Post-Volcker* in Column (4) in Table 5.1.

[16] F-test has H_o: $\beta_8 = \beta_9$ where β_8 is the coefficient on *Post Dodd-Frank * Exposure* and β_9 is the coefficient on *Post-Volcker * Exposure* in Column (4) in Table 5.1.

[17] Upon inclusion of time and bank fixed effects, the time period level effects in addition to the *Exposure* variable drop out. *Exposure* is drops out given that it is time invariant, whereas the time period level effects drop out due to collinearity.

carried out in similar fashion to the one's discussed previously for Columns (3) and (4), results in a p-value of 0.15, which once again suggests that there is no statistically significant differential effect of the Volcker Rule.

Thus, I find that the riskiness of banks in the post-Volcker period remain elevated above pre-crisis levels. There is no evidence suggesting that the Volcker Rule was effective in reducing the riskiness of the regulated banks relative to the preceding post-Dodd-Frank period. Further, there is no reason to suggest that the Volcker Rule impacts banks with higher trading asset ratios more given that the coefficient on *Post-Volcker * Exposure* is not statistically significantly lower than the coefficient on *Post-Dodd Frank * Exposure* in Columns (3), (4), and (5). In the context of relative volatility and riskiness, there is little to no evidence to suggest that the Volcker Rule facilitated a decrease in the riskiness of the regulated banks. In fact, the point estimates suggest that the Volcker Rule facilitated an *increase* in the riskiness of the banks, running entirely counter to the intended effects of the legislation.

5.2 Pre and Post Volcker Binary Analysis

While the specificity of the five period specification is useful when assessing the riskiness of the banks in one period relative to the others, it may be more pertinent to take on a more binary approach to the analysis of the Volcker Rule. Thus, the pre-crisis, crisis, post-crisis, and post-Dodd Frank time periods in the original time period specification are now collectively considered pre-Volcker, with the post-Volcker time period remaining equivalent to the original post-Volcker time period.[18] Once these alterations are made, the same set of regressions are run with the results found in Table 5.2.

Column (1) shows results for the simple regression with only the binary *Post-Volcker* time period dummy variable as an explanatory variable, in addition to bank fixed effects. While the coefficient on *Post-Volcker* is negative, there is no reason to suggest that the average relative volatility of these firms in the post-Volcker period is significantly lower than the average volatility of the firms in the pre-Volcker time period given the lack of significance at even the 10% level.

The coefficient on *Post-Volcker* remains insignificantly different from zero, even once the bank-specific controls are added to Column (1). These results can be found in Column (2) of Table 5.2. We do see that the coefficients on the controls of *ln(Total Assets)*, *Profitability*, and *Non-Performing Loans Ratio* are significant at the 1% level and are generally consistent with the findings in Column (2) of Table 5.1. Thus, these results serve to corroborate the results found in the previous section, providing no evidence to suggest that the riskiness of the regulated banks have decreased in the post-Volcker period relative to the pre-Volcker period. Considering that the pre-Volcker period also contains the actual crisis itself in which relative volatility was especially elevated, as shown by the significant coefficient on *Crisis* in Column (2) of Table 5.1, these results further point to a lack of any risk-reducing effects of the Volcker Rule.

We see that the coefficient on the *Post-Volcker * Exposure* interaction term is negative and significant within the all three specifications presented in Columns (3), (4), and (5) of Table 5.2 which differs from the results found in the corresponding estimated

[18] The pre-Volcker time period now spans from Q1,2006 – Q1, 2014. The post-Volcker time period remains defined between Q2, 2014 – Q4, 2017.

Table 5.2

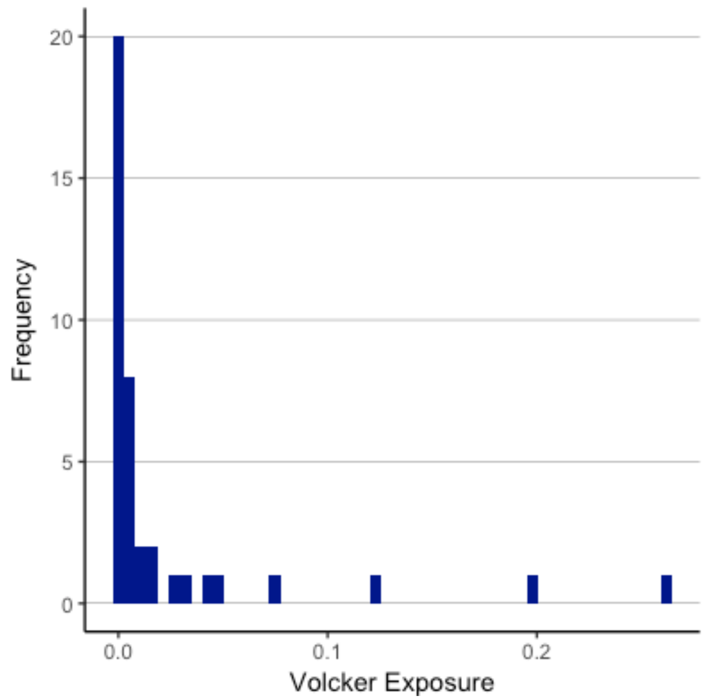
All Banks - Pre and Post Volcker Analysis

	Relative Volatility				
	(1)	(2)	(3)	(4)	(5)
Post-Volcker	-0.02	-0.01	-0.01	0.10	
	(0.07)	(0.07)	(0.08)	(0.07)	
Exposure			-0.52	0.48	
			(0.61)	(0.54)	
Post-Volcker * Exposure			-1.16**	-1.05**	-0.89*
			(0.57)	(0.42)	(0.48)
ln(Total Assets)		0.29***		-0.08***	0.05
		(0.08)		(0.03)	(0.11)
Capital Ratio		0.03		2.48	-1.49
		(2.37)		(2.64)	(2.73)
Profitability		-31.37***		-40.90***	-28.96***
		(5.52)		(5.50)	(7.45)
Deposit Ratio		-0.09		-0.33	0.12
		(0.42)		(0.37)	(0.47)
Cost-Income Ratio		-0.23		-0.15	-0.37
		(0.17)		(0.25)	(0.28)
Non-Performing Loans Ratio		168.71***		113.91***	130.40***
		(59.96)		(29.64)	(45.17)
Real Estate Loans Ratio		0.55		0.32	0.90
		(0.46)		(0.37)	(0.55)
Quarter Fixed Effects?					X
Bank Fixed Effects?	X	X			X
Controls?		X		X	X
Observations	1447	1447	1447	1447	1447
R-squared	0.254	0.333	0.007	0.174	0.477

Notes: Estimated regressions on unbalanced panel data set with 40 banks and a total of 1447 observations. Span of time is split into two time periods based on effective date of Volcker Rule. Robust standard errors clustered at the bank level are provided in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels respectively.

regressions in the five period analysis discussed in the previous section. The coefficient on *Post-Volcker * Exposure* remains negative and significant at the 10% significance level even once time and bank fixed effects are included, as shown in Column (5) of Table 5.2. At face value, these results do seem to indicate that there could be a differential effect where, relative to the pre-Volcker time period, banks with larger trading asset ratios and thus more exposure to the Volcker Rule see larger decreases in risk. However, a closer look into the distribution of the trading asset ratio reveals a heavily right skewed distribution where only a select few banks have significantly large trading operations.

Figure 5.1: Distribution of Trading Asset Ratios



Note: Sample is the 40 banks contained within my dataset.
The width of the graph is defined with 50 bins.

This is quite evident in the distribution of the trading asset ratios shown in Figure 5.1. In fact, in my sample of 40 firms, 12 have a trading asset ratio of 0. Therefore, the significance of the *Post-Volcker * Exposure* coefficients appears to be driven by a handful of firms with very large trading operations. In particular, the three firms with the largest trading asset ratios are J.P. Morgan Chase, Citigroup, and Bank of America with ratios of 0.26, 0.20, and 0.12 respectively. This is of note given that all three of these institutions are considered global systemically important banks (G-SIBS) by the Financial Stability Board (FSB).[19] In fact, these banks are the three largest US banks by total assets, and in combination with

[19] Refer to the 2017 list of G-SIBs found at http://www.fsb.org/wp-content/uploads/P211117-1.pdf

Wells Fargo, Goldman Sachs, and Morgan Stanley, make up the six largest US banks. Collectively, these six banks are often referred to as the 'Big 6'. Given the immensity and systemic importance of these megabanks, the resulting post-recession regulatory scrutiny of these banks have, unexpectedly, been considerable. Thus, it does make sense that the stringent regulatory scrutiny of these large banks, in combination with their large trading operations, would result in these banks being less risky in comparison to other banks within the post-Volcker time period.

To look at this effect closer, I examine the full effect of the Volcker Rule on a hypothetical bank with a proportionally large trading portfolio. To illustrate my point, I will assume that this bank has a trading asset ratio of 0.26. This is equivalent to the trading asset ratio of J.P. Morgan Chase, the bank with the largest trading asset ratio in my sample. I then run an F-test to test for the total effect of the Volcker Rule (both level effect and differential effect) on this hypothetical bank with a trading ratio of 0.26.[20] The F-test results in a p-value of 0.04 which is significant at the 5% significance level. This suggests that the Volcker Rule did in fact lower the riskiness of this hypothetical bank, holding all other variables constant. However, if the same test is re-run on a hypothetical bank with a trading asset ratio of 0.20, the same ratio as the bank with the next largest trading asset ratio in my sample (Citigroup), I find a p-value of 0.10 which is just insignificant at the 10% level. As the trading asset ratio decreases further and further, the resulting F-test can only get more and more insignificant. This means that while I do find a significant interaction term in this binary pre- and post-Volcker specification suggesting a differential effect, only one bank in my sample has a

[20] F-test has H_o: $\beta_{Post\text{-}Volcker} + .2619*\beta_{Post\text{-}Volcker*Exposure} = 0$ and is run on the estimated regression in Column (4) since the *Post-Volcker* time period dummy is dropped in the fixed effects model in Column (5) in Table 5.1.

trading asset ratio that is high enough such that the Volcker Rule actually significantly decreased the riskiness of the bank overall.

Overall, the results of the regressions based on this binary time period specification are consistent with the results found in the prior five period analysis. On average, the Volcker Rule did not decrease the riskiness of the banks. However, there is some evidence suggesting that there is a differential effect of the rule, suggesting that banks with more Volcker exposure decreased their riskiness more. However, further analysis of the distribution of trading asset ratios within my sample reveals that, even when differential effects are considered, only one bank had a trading asset ratio that was large enough such that the full impact of the Volcker Rule significantly decreased the riskiness of the bank. In a sense, this is consistent with the coefficients on the time period level effects, suggesting that the Volcker Rule, on average, did not effectuate any significant decrease in the riskiness of the banks.

6. Discussion

The results presented certainly do not bode well for the effectiveness of the Volcker Rule. On the surface, there is very limited evidence suggesting that the regulated, publically traded banks in my sample have seen any decreases in riskiness following the effective date of the Volcker Rule. I find that bank riskiness still remains elevated above pre-crisis levels and are not significantly different than post-Dodd Frank levels. However, these results are not entirely surprising when analyzed in the context of previous work on the Volcker Rule and its historical predecessor, Glass-Steagall. In particular, the effects of risk-targeting and less diversification could have potentially outweighed any direct decreases in risk brought about by the Volcker Rule. The growing selection of literature highlighting the economic costs of the Volcker Rule could serve to explain these results, further bolstering the arguments held by critics and opponents of this legislation.

6.1 Risk-Targeting

One possible explanation for the lack of any noticeable decrease in risk following the imposition of the Volcker Rule is the existence of internal risk targets within banks. The ban of risky activities such as proprietary trading should theoretically decrease banks' riskiness under the assumption that these banks do not alter any of their other operations. However, there is no reason to suggest that banks wouldn't respond dynamically to restrictions imposed by the Volcker Rule. Firms may have specified risk-targets or a certain tolerance for risk which correlates with their expected profits. In order to attain certain profit targets, firms may have the incentive to maintain similar levels of risk, even following the imposition of the Volcker Rule. Given that high-risk activities including proprietary trading are no longer permitted under the rule, firms may respond by engaging in less hedging while also increasing the riskiness of permitted activities in order to reach their risk targets (Keppo and Korte 2016).

There is evidence of this phenomenon occurring for banks that received government assistance following the crisis. In particular, the banks that received federal funds under the Capital Purchase Program (CPP) of the Troubled Asset Relief Program (TARP) issued riskier loans and increased capital allocation to riskier, higher-yielding securities as compared to banks that were denied federal funds (Duchin and Sosyura 2014). Most notably, the majority of the increase in risk occurred within the same asset class which subsequently went undetected by regulatory capital ratios. In fact, in terms of regulatory capital ratios, banks appeared safer, even when it was shown that both volatility and default risk increased for the banks that received federal assistance. While these past findings certainly highlight the existence of moral hazard caused by government safety nets, they also suggest that a similar phenomenon might be occurring in response to the Volcker Rule. In broad terms, trading on behalf of clients, hedging, and market-making activities are explicitly permitted under the Volcker Rule. This creates a big implementation problem for regulators given that it can oftentimes be difficult to identify which activities are Volcker-prohibited and which are simply for market-making. Banks may exploit these regulatory limitations by engaging in higher-risk activities under the guise of one of the permitted activities. The difficulties associated with implementing the Volcker Rule may present avenues through which banks can still maintain higher levels of trading risk. This could serve as a potential explanation for the lack of any observed decrease in riskiness.

6.2 Less Diversification

Previous research by Keppo and Korte (2016) find that while banks overall did not decrease their trading asset ratios, banks with a heavy focus on trading did significantly reduce the size of their trading accounts relative to their whole business in response to the Volcker Rule. This is of note when considered in the context of business diversification. Banks may have responded to the Volcker Rule by reducing their trading operations, thus becoming overall less diversified as a firm. White (1986) hypothesizes that the observed increases in bank riskiness following the passage of Glass-Steagall could be explained by less diversification. Following WWI, commercial banks were able to aggressively enter into investment banking businesses by establishing security affiliates. These affiliates essentially became the investment banking arms of the commercial banks. Using data from 1931, the year in which the most banks with securities operations closed, White finds that commercial banks with a security affiliate had a lower likelihood of failing in comparison to commercial banks without a security affiliate. This suggests that firms with an investment banking operation were sounder institutions. While there are certainly conflicts of interest concerns with housing commercial banking and investment banking operations under one roof, banks that engage in both businesses may be more diversified and thus less risky.

There are two main channels in which business diversification can improve the soundness and reduce the riskiness of a bank. The first such channel is the ability for the different businesses of a bank to act as hedges for one another. The trading operations of a bank can serve as a hedge for the interest-generating, commercial banking operations of the bank. There is evidence in support of this notion that different lines of businesses within a bank can hedge one another. Using a sample of 719 US BHCs, Gandhi and Kiefer (2013) find that the correlation between interest income generated by traditional commercial banking and income from trading activities is negative. This suggests that the existence of a trading operation within a bank can act as a natural hedge for the commercial banking activities of the bank. In fact, Gandhi and Kiefer (2013) go one step further and find that banks with a negative correlation between trading and interest income are able to maintain more stable lending policies as compared to banks with a positive correlation between trading and interest income.[21] This could be a direct product of the lower earnings volatility brought about by being a more diversified bank. Ultimately, the natural hedging of trading

[21] While unconfirmed, one proposed channel for this effect is that diversified banks with lower income volatility may be able to benefit from lower funding costs. This may allow them to provide credit to customers at lower costs (Gandhi and Kiefer 2013).

may make bank earnings less cyclical, reducing the overall volatility of a bank's equity. Therefore, if the Volcker Rule both directly and indirectly reduces the size of the regulated banks' trading operations, the impacted banks will be less hedged and their earnings will be more cyclical. This could help to explain why I observed that the riskiness of banks actually increased following the effective date of the Volcker Rule (although not significant).

The other channel through which business diversification can be beneficial relates to the complementarities and synergies that exist between commercial banking and investment banking activities. The widespread adoption of security affiliates by commercial banks following WWI may have been driven by the potential synergies that exist between those two lines of business. Security affiliates of commercial banks may have had a competitive advantage over the smaller investment banks given the differences in the type and size of the client and distribution networks that these banks possessed. The traditional investment banks generally had smaller networks consisting of wealthier clientele. In comparison, commercial banks were able to establish large and extensive retailing networks amongst depositors during WWI that the security affiliates could exploit. Thus, the security affiliates of the commercial banks were in a better position to obtain funding in the underwriting of securities. The difference in clientele was also attractive to the issuing companies as the securities underwritten by security affiliates of commercial banks were more likely being purchased by investors who wanted to own these securities and earn dividends, as opposed to merely speculators attempting to make a quick profit. The commercial banking operations also benefited from the larger and more specialized research staffs of these security affiliates as they could better analyze the purchases and loans made on their own accounts (Neal and White 2010).

There is reason to believe that the complementarities that exist between investment banking and commercial banking businesses still exist when considered in the context of proprietary trading and the Volcker Rule. It can be argued that the existence of proprietary trading within a bank can allow the bank to better serve its clients. For example, if a bank is already engaging in permitted, core banking activities including lending and underwriting with a corporate client, it can be assumed that the bank already has a good understanding of the client's financial portfolio and the types of risks the client may be facing. The bank is thus best positioned to help the client in the case that the client wants to alter their risk exposure. Prior to the Volcker Rule, banks can efficiently carry out the hedging of risks for their clients by establishing ad hoc deal teams dedicated to tracking and serving these clients. The best people for these deal teams would be the proprietary traders as they possess the most knowledge about the various financial instruments that they trade. These traders have had success trading these instruments for profit, and in some cases, helped to design the financial instruments themselves. However, the imposition of the Volcker Rule strips away this source of human capital from banks. There is a clear loss of efficiency as it will cost more for third parties to provide this service given the lack of a pre-existing understanding of the financial portfolio and strategies of the client (Calomiris and Richardson, 2014, 127-29).

There are currently no concrete studies on the existence and size of the synergies between proprietary trading and the other client-based services within banks as studies of this nature require confidential and sensitive bank-level data that can only be made available with permission by the banks themselves. The potential existence of these synergies would suggest that the existence of proprietary trading operations may not only increase overall bank profitability, but reduce the riskiness of the banks as well.[22] Thus, the ban on proprietary trading imposed by the Volcker Rule could make the impacted banks less diversified, rendering them unable to employ the aforementioned synergies when serving clients. The reduction of these complementarities between commercial banking and investment banking could be another explanation for the higher risk observed following the enactment of the Volcker Rule.

6.3 Concerns with Time Period Specification

There are concerns that the specified post-Volcker time period does not capture potential anticipatory and lag effects of the provision given that the Volcker Rule's official effective date is used. It had been reported that many large, regulated firms spun off and closed many proprietary trading desks following the passage of Dodd-Frank in anticipation of a ban of some form on proprietary trading.[23] Other similar activities carried out by regulated banks prior to the effective date of the Volcker Rule may be reflected in the volatility numbers prior to the post-Volcker period. Lag effects may also exist and may not be fully accounted for by this particular time period specification. A conformance period was put into effect following the April 1, 2014 effective date of the rule that initially ended on July 21, 2015. By that date, large banks were required to be fully complaint with the rule. Additional conformance period extensions for legacy investment funds, accounts dealing with hedge funds and private equity funds, were put in place by the Board of Governors of

[22] While proprietary trading is inherently risky and profitable, the profit synergies that proprietary trading may have with other banking services will be far more stable than direct gains made from proprietary trading.
[23] JP Morgan Chase is relocating its proprietary trading unit out of the investment bank and into the asset management unit (https://dealbook.nytimes.com/2010/09/27/jpmorgan-is-shifting-its-prop-trading-desk/). Citigroup shuts down its equity principal strategies desk in response to the Volcker Rule (https://dealbook.nytimes.com/2012/01/27/citigroup-to-close-prop-trading-desk/).

the Federal Reserve, with the final extension to July 21st, 2017.[24] Thus, the current post-Volcker period may not be able to isolate the entirety of the potential effects of the rule, especially with regards to the anticipatory effects.

Given that the current post-Volcker period may not capture the full effects of the Volcker Rule on bank risk, there is a bias against finding significant results. In order to test for the potential that anticipatory effects reduced bank risk prior to the post-Volcker time period, I re-run the regressions in Table 5.2 on a modified time period specification. Specifically, I create a new post-Dodd Frank period which is a combination of the original post-Dodd Frank time period and the original post-Volcker time period. The original pre-crisis, crisis, and post-crisis time periods are considered as pre-Dodd Frank.[25] The prior results that did not find any risk-reducing effects of the Volcker Rule may have been due to the fact that the majority of the risk reductions occurred in the time period immediately preceding the effective date of the Volcker Rule. This new time period specification should help to test this.

The results of the regressions are presented in Table 6.1. The *Post-Dodd Frank* level effect dummy is insignificantly different from zero in Columns (1) - (4).[26] This indicates that the riskiness of banks in the post-Dodd Frank period is not significantly different than the riskiness in the pre-Dodd Frank period, on average. Even if the time period that attributed to the Volcker Rule is broadened (spanning roughly from 2010 – 2017) in order to capture anticipatory effects of banks in response to the rule, I still find no evidence to suggest that the

[24] The extension to July 21st, 2017 for covered funds is the final of three one-year extensions that the Board of Governors of the Federal Reserve is allowed to grant. Official press release found at https://www.federalreserve.gov/newsevents/pressreleases/bcreg20160707a.htm.

[25] The pre-Dodd Frank time period now spans from Q1,2006 – Q2, 2010. The post-Dodd Frank time period remains defined between Q3, 2010 – Q4, 2017.

[26] *Post-Dodd Frank* and *Exposure* are once again dropped since *Post-Dodd Frank* is collinear with quarter and *Exposure* is time invariant.

Table 6.1

All Banks - Pre and Post Dodd-Frank Analysis

	Relative Volatility				
	(1)	(2)	(3)	(4)	(5)
Post-Dodd Frank	-0.07	-0.11	-0.07	0.02	
	(0.06)	(0.10)	(0.06)	(0.09)	
Exposure			-0.33	0.70	
			(0.61)	(0.60)	
Post-Dodd Frank * Exposure			-0.87	-0.92**	-0.63
			(0.57)	(0.41)	(0.49)
ln(Total Assets)		0.36***		-0.08***	0.06
		(0.09)		(0.03)	(0.12)
Capital Ratio		0.80		2.84	-1.64
		(2.67)		(2.74)	(2.72)
Profitability		-29.07***		-39.46***	-28.84***
		(5.84)		(5.43)	(7.43)
Deposit Ratio		-0.04		-0.36	0.07
		(0.42)		(0.38)	(0.47)
Cost-Income Ratio		-0.12		-0.08	-0.35
		(0.21)		(0.25)	(0.27)
Non-Performing Loans Ratio		162.50***		110.82***	142.17***
		(59.68)		(30.37)	(46.40)
Real Estate Loans Ratio		0.39		0.31	0.88
		(0.37)		(0.38)	(0.56)
Quarter Fixed Effects?					X
Bank Fixed Effects?	X	X			X
Controls?		X		X	X
Observations	1447	1447	1447	1447	1447
R-squared	0.257	0.336	0.010	0.172	0.476

Notes: Estimated regressions on unbalanced panel data set with 40 banks and a total of 1447 observations. Span of time is split into two time periods based on effective date of Dodd-Frank. Robust standard errors clustered at the bank level are provided in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels respectively.

rule effectuated any significant decreases in risk. Admittedly, by broadening the time period, there are confounding effects related to the imposition and implementation of the numerous other regulations as part of Dodd Frank that fall outside the scope of the Volcker Rule. The major regulations that have an impact on bank risk relate to capital and leverage requirements. However, higher capital requirements and limits on leverage, according to standard financial theory, would suggest that these effects should decrease bank volatility, and thus bank risk (Sarin and Summers 2016). These effects should therefore bias the coefficient *Post-Dodd Frank* downwards, in effect strengthening the statistically insignificant results found in Table 6.1. Therefore, estimating my regressions on this new, modified time specification serves as a robustness check. The results, in fact, further bolster my findings suggesting that the Volcker Rule, on average, did not significantly decrease bank risk.

7. Conclusion

In this paper, I find very little evidence suggesting that the riskiness of publically traded banks, as proxied with implied volatility, has decreased as a result of the Volcker Rule. In fact, I find evidence, albeit insignificant, suggesting that the Volcker Rule is responsible for an increase in the riskiness of the banks in my sample. Furthermore, while results vary depending on specification, evidence in favor of any differential effect of the Volcker Rule is generally weak. I argue that the decrease in bank diversification and the opportunity for firms to exploit implementation difficulties of the Volcker Rule can explain the results I found.

Needless to say, there are a number of costs, both direct and indirect, associated with the Volcker Rule that most certainly need to be discussed when holistically assessing a policy of this nature. My thesis merely addresses the effects that the Volcker Rule have on bank riskiness whereas a tradeoff analysis between the pros and cons of such a legislation must be carried out to make a better assessment on the viability of the Volcker Rule going forward. Additionally, if the Volcker Rule does improve the stability of the financial system, are these benefits large enough to outweigh the immense regulatory and implementation costs produced by the rule itself? Is there a better, more efficient manner in which the Volcker Rule could be implemented? Many questions remain answered.

Critics say that the "Volcker Rule highlights the dangerous tendency of Washington to react boldly to crises based on superstitious or ill-informed beliefs" while proponents, such as Paul Volcker himself, stand by the need for such a legislation to address systemic risk within the financial system (Calomiris and Richardson 2014, 128-29). The evidence I present does cast doubt on the effectiveness of the Volcker Rule at reducing bank risk, but the verdict is still out on the success of the legislation as a whole.

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Appendix

Table A: Universe of Banks

1	JPMORGAN CHASE & CO	21	SVB FNCL GRP
2	CITIGROUP	22	U S BC
3	BANK OF AMER CORP	23	SYNOVUS FC
4	FIRST HORIZON NAT CORP	24	CULLEN/FROST BKR
5	WACHOVIA CORP	25	MARSHALL & ILSLEY CORP
6	SUNTRUST BK	26	WEBSTER FNCL CORP
7	VALLEY NAT BC	27	BANCORPSOUTH
8	PNC FNCL SVC GROUP	28	TCF FC
9	KEYCORP	29	ASSOCIATED BANC CORP
10	WELLS FARGO & CO	30	BOSTON PRIVATE FNCL HOLD
11	BANK OF HI CORP	31	EAST W BC
12	REGIONS FC	32	FIRSTMERIT CORP
13	BB&T CORP	33	FULTON FNCL CORP
14	NATIONAL CITY CORP	34	GLACIER BC
15	HUNTINGTON BSHRS	35	NATIONAL PENN BSHRS
16	FIFTH THIRD BC	36	NEW YORK CMNTY BC
17	CITY NAT CORP	37	PROVIDENT FNCL SVC
18	COMERICA	38	PRIVATEBANCORP
19	M&T BK CORP	39	UNITED BSHRS
20	ZIONS BC	40	WESTAMERICA BC

Note: The 40 US publically traded banks that are included in the final dataset. Ordered by trading asset ratio, from highest to lowest.

Table B: Variables Reference

Variable	Definition
Relative Volatility	Daily implied volatility divided by daily VIX, averaged by quarter
Crisis	Dummy variable that equals 1 in crisis time period
Post-Crisis	Dummy variable that equals 1 in post-crisis time period
Post-Dodd Frank	Dummy variable that equals 1 in post-Dodd Frank time period
Post-Volcker	Dummy variable that equals 1 in post-Volcker time period
Exposure	Average trading asset ratio in pre-crisis time period
ln(Total Assets)	Natural logarithm of total assets
Capital Ratio	Equity capital divided by total assets
Profitability	Net income divided by total assets
Deposit Ratio	Deposits divided by total assets
Cost-Income Ratio	Operating expenses divided by total income
Non-Performing Loans Ratio	Non-performing loans divided by total loans
Real Estate Loans Ratio	Real estate loans divided by total loans

Note: A reference table for the variables, with corresponding descriptions, used within the regressions. All variables vary by quarter.

Table C: FED BHC Reference

Bank Metric	Item Name	Series/Number
Short Name	Entity Short Name	RSSD/9010
Legal Name	Legal Name	RSSD/9017
Total Assets	Total Assets	BHCK/2170
Trading Account	Quarterly Average of Assets Held in Trading Accounts	BHCK/3401
Equity Capital	Quarterly Average of Equity Capital	BHCK/3519
Net Income	Net Income	BHCK/4340
Total Loans	Total Loans and Leases; Net of Unearned Income	BHCK/2122
Deposits	Quarterly Average of Interest-Bearing Deposits	BHCK/3517
Operating Expenses	Total Noninterest Expense	BHCK/4093
Total Interest Income	Total Interest Income	BHCK/4107
Total Noninterest Income	Total Noninterest Income	BHCK/4079
Non-Performing Loans	Total Non-Performing Loans	BHCK/3508
Real Estate Loans	Loans Secured by Real Estate	BHCK/1410

Note: Reference table that matches each bank metric used to the corresponding entry in the Federal Reserve Bank of Chicago Bank Holding Company dataset
Source: Federal Reserve Bank of Chicago's Bank Holding Company Dataset