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Risk Targeting and Policy Illusions—Evidence from the Announcement of the Volcker Rule

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We analyze the Volcker Rule's announcement effects on U.S. bank holding companies. In line with the rule and the banks' public compliance announcements, we find that those banks that are affected by the Volcker Rule already reduced their trading books relative to their total assets 2.34% more than other banks. However, the announcement of the rule did not reduce the banks' overall risk taking. To keep their risk targets, the affected banks raised the riskiness of their asset returns. We also find some evidence that the affected banks raised their trading risk and decreased the hedging of their banking business.

Data, as supplemental material, are available at https://doi.org/10.1287/mnsc.2016.2583.

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1. Introduction

In the wake of the 2008 financial crisis, many observers have commented that the crisis happened partly because of the lack of regulation or the lack of implementation and enforcement of different rules and regulations (see, e.g., Campbell et al. 2011, Acharya et al. 2010, Agarwal et al. 2015). Consequently, subsequent to the crisis, we have seen a flurry of regulation (e.g., the Dodd–Frank Act; the Credit Card Accountability, Responsibility, and Disclosure Act; and Basel III) and the creation of new regulatory agencies (e.g., the Bureau of Consumer Financial Protection and the Federal Housing Finance Agency). The Volcker Rule has emerged as one of the most debated pieces of regulation among regulators, academics, and bankers. Banks argue that the Volcker Rule significantly decreases their profitability and, on the other hand, many policy makers and regulators feel that it is too weak.

The Volcker Rule was put into law in July 2010 as a central part of what was probably the most important overhaul in U.S. financial regulation over the past decades, the Dodd–Frank Act (DFA). By restricting banks' business models and prohibiting allegedly risky activities, the Volcker Rule explicitly aims to shield the banking sector from nonbanking risks, reducing risk taking by banks, volatility of bank earnings, and therefore threats to financial stability. More specifically, this is done by limiting proprietary trading and investments in hedge funds, venture capital, and private equity by banks and bank holding companies. Five years after the enactment of the Dodd–Frank Act, this paper analyzes whether the Volcker Rule has already had major implications on the affected banks' business models and risk taking. While there are many other alleged motivations and consequences of the Volcker Rule, such as the liability for deposit insurance or the complexity and resolvability of banks, we focus on the announcement effects of the rule that are clearly identifiable and testable for a broad set of banks. More specifically, we analyze the changes in banking and trading activities as well as in overall bank risk after the introduction of the rule. We also study related issues such as changes in liquidity holdings and dividend and recapitalization policies.

Why could the effect of the Volcker Rule be dubious so far? First, the Volcker Rule is not yet fully implemented, i.e., the rule is not yet fully binding for banks. Second, since banks can take risk in different ways (e.g., leverage, riskiness of the banking book and the trading book), limiting the size of the trading book or its activities does not necessarily decrease the risk. That is, banks might comply with the rule and keep their risk target unchanged by increasing the riskiness of the permitted trading activities or the banking book or by taking more leverage. Since the Dodd–Frank Act stipulates a long list of exemptions to the Volcker Rule, there are many

permitted trading activities and, therefore, the banks could keep the risk target by simply raising the riskiness of these permitted activities. Further, regulators may find it difficult—some claim even impossible—to differentiate between prohibited proprietary trading and permitted activities such as trading on behalf of customers, market making, or hedging. Moreover, when it comes to restricting investments into funds, it might be difficult to effectively delineate, for example, a private equity fund investment from a permitted small business investment fund engagement. Hence, it could be that the banks have kept their risk targets without any major changes in their business model. Our results indicate that this has happened.

Motivated by several banks' self-declared compliance,[1] in this paper we analyze whether the Volcker Rule has had an announcement effect. We also investigate whether this compliance results in some of the intended effects. For this, we construct a comprehensive data set of all bank holding companies (BHCs) in the United States covering a time span of Q1 2002 till Q2 2015 on a quarterly basis. We employ a straightforward identification framework that relies on the differential affectedness of bank holding companies by the Volcker Rule. We rely on the assumption that those BHCs that have traditionally had their business models geared toward activities now banned or limited by the Volcker Rule (institutions with large trading books) are affected most and should hence show the strongest reactions. Employing accounting and regulatory data, we test for several changes in portfolios, risk taking, and hedging, and also compare affected banks' trading books with hedge funds.

We find several results. First, banks—on average—reduce the size of their trading books relative to total assets after the passing of the Volcker Rule. More important, however, is that those bank holding companies that are presumably most affected by the Volcker Rule (in terms of larger exposure to banned activities in the period before the introduction of the Volcker Rule) show the strongest reduction of their trading books. This result is robust to various specifications, alternative affectedness definitions, variations in timing, and a propensity score matching approach. Also, we do not find significant results when using a different time as placebo treatment instead of the introduction of the Volcker Rule, which corroborates our interpretation. Further, the reduction of the trading books is sizable; the affected BHCs' average trading book before the passing of the Volcker Rule was around 11% of total assets and after that the affected BHCs reduced their trading books relative to their total assets 2.34% more than other BHCs, controlling for other potential explanations and fixed effects. Moreover, when comparing with hedge funds, we do not find a similar trend; instead, hedge fund assets have been rising after the recent financial crisis and the passage of the Dodd–Frank Act. The reduction of banks' trading books is quite an intuitive reaction and also corresponds with the self-declared compliance announcements by banks affected by the Volcker Rule.

Since the trading books of the affected banks have decreased significantly, we extend our model toward the changes in risk taking of the institutions. While overall bank risk measured by the *z-score* has decreased after the enactment of the Volcker Rule, we do not find a pronounced effect on the BHCs that are particularly affected. If anything, the affected banks got riskier than the unaffected banks in terms of the *z-score*. We further examine the components of the *z-score* (return on assets, capital asset ratio, and asset return volatility). First, the return on assets decreased significantly for all the banks. However, we do not find a significant difference between the affected and unaffected banks. Second, we find some evidence indicating that the affected banks have increased their capital asset ratio, although this finding is not robust. Third, the asset return volatility of affected banks increased significantly and this result is robust. Thus, the overall risk of the affected banks has not decreased because their volatility of asset return has increased. There are three possible channels raising the asset return volatility: banking book volatility, trading book volatility, and the correlation between the banking and trading books. We find that, if anything, on average the affected banks' banking book volatility has decreased relative to the unaffected banks' volatility after the enactment of the Volcker Rule. On the other hand, the affected banks have raised their trading risks and decreased the hedging of their banking business, although those findings are not robust. These findings imply that, on average, the affected banks have been able to keep their risk targets without raising the riskiness of the banking book. This is consistent with Duchin and Sosyura (2014), who find that banks can change their risk taking within the same asset class while complying with the regulation. Further, we also analyze banks' behavior around the repeal of the Glass–Steagall Act and, consistent with our Volcker Rule results, we find opposite effects: affected banks' trading asset ratios rose significantly after the repeal of the Glass–Steagall Act, and their overall risk level did not change relative to unaffected banks (although we find that the affected banks significantly reduced their banking book risk).

We interpret our results as evidence that banks started to comply with the Volcker Rule by reducing their trading portfolios. However, consistent with banks' risk targeting, this did not imply lower overall risk levels. This should be expected since their risk-taking incentives have not changed. Apparently there

[1] See, for example, Craig (2012) and Roose (2012).

are levels of risk that banks find optimal (whether they are from a societal perspective is a different question) and that they manage to sustain, at least so far, without raising the banking book risk. This is consistent with Chung et al. (2016), who find that the Volcker Rule does not decrease the default probability of the banks. Banks' objective is to maximize their value, and to do that they not only minimize risks but also maximize the expected returns. If the reduction of banks' overall risk was an essential target of the Volcker Rule, our findings suggest that the rule has so far not been effective.

To be fair, though, the Volcker Rule is not yet fully implemented and will only be fully effective from July 2016 or most likely July 2017 onward.[2] Nevertheless, this paper highlights that banks do not necessarily need to change their risk targets. These findings have important implications for banking regulators, for example, in the European Union, who are currently debating the introduction of proprietary trading bans. For instance, regulators might want to analyze the unintended consequences of the Volcker Rule in more detail, especially since its implementation is expensive. Thus, after the Volcker Rule is effective, we might observe a drop in affected banks' earnings because of its implementation costs.[3] Falling profitability might raise the banks' default probability.

The remainder of this paper is organized as follows. Section 2 introduces the institutional framework of the Volcker Rule and relates our paper to the literature. Section 3 describes the data and introduces our baseline identification framework. Section 4 reports and discusses the results of our analyses and provides robustness tests. Section 5 concludes.

2. The Volcker Rule and Its Implications—Institutions, Literature, and Initial Evidence

2.1. The Institutional Framework

What is the Volcker Rule and when does it become effective? The Volcker Rule is mandated as one of the core elements in the larger financial reform legislation of the Dodd–Frank Act that was signed into law on July 21, 2010. Laid down in Title VI of the Act, the Volcker Rule prohibits banks from engaging in certain nonbanking activities such as proprietary trading or hedge fund and private equity investing. While it was originally proposed by former Federal Reserve Chairman Paul Volcker as an answer to over boarding nonbanking and speculative activities presumably contributing to the recent financial crisis, the rule has a historical precedent in the Glass–Steagall Act of 1933.[4] The central idea is to protect the banking system from nonbanking capital market risks and to contain the liability of the banking system's deposit insurance by restricting the activities permissible to banks. Hence, the Volcker Rule as a separation of financial activities can be seen in the spirit of the Glass–Steagall Act (Richardson et al. 2010, Thakor 2012).

While the Volcker Rule is widely regarded as one of the most critical provisions of the Dodd–Frank Act, it is not yet fully implemented. Originally, the Dodd–Frank Act envisaged a deadline of two years after its passing, i.e., July 2012, for the rule to become effective. However, the implementation of the rule involves several regulatory agencies[5] and was only agreed upon at the end of 2013. Moreover, as compliance to these rules is subject to at least two (potentially up to five) additional years of a transition period, the Volcker Rule is unlikely to be fully effective anytime before 2016 (see, e.g., Anand 2011, CCH Attorney-Editor 2010, DavisPolk 2010).

Which activities are prohibited and what are the exemptions? The Volcker Rule as laid down in Section 619 under Title VI of the Dodd–Frank Act explicitly prohibits two types of nonbanking activities: (a) proprietary trading and (b) investing in hedge funds and private equity funds, subject to a list of permitted exceptions. With regard to proprietary trading, the Volcker Rule prohibits engaging as a principal for trading accounts, i.e., taking positions in any security, derivative, futures, or options contract in order to profit from short-term price movements. However, Section 619 also stipulates a long list of permissible activities, such as trading in U.S. government obligations, market making or trading on behalf of customers, hedging activities, or other trading activities that regulators determine as conducive to financial stability.

With regard to hedge funds and private equity funds, the Volcker Rule prohibits any equity investments into or sponsorship of (i.e., being general or managing partner or otherwise controlling) such entities that would be an investment company or a similar fund. Again, a list of exceptions is laid down in

[2] The Federal Reserve Board has extended the Volcker Rule's conformance period for "legacy covered funds" until July 21, 2016, and has indicated that it will likely extend the period further to July 21, 2017 (Board of Governors of the Federal Reserve System 2014).

[3] JPMorgan Chase, for instance, estimates that the direct costs of the Volcker Rule for them will be $400 million–$600 million annually (*The Economist* 2012).

[4] The Glass–Steagall Act introduced a strict separation between commercial and investment banking activities and was essentially repealed by the Gramm–Leach–Bliley Act of 1999.

[5] The writing of the final version of the Volcker Rule and its implementing rules requires the collaboration and the final consent of five regulators: the Commodity Futures Trading Commission (CFTC), the Federal Deposit Insurance Corporation (FDIC), the Federal Reserve, the Office of the Comptroller of the Currency (OCC), and the Securities and Exchange Commission (SEC).

the Dodd–Frank Act. These explicitly permitted activities include investments in small business investment companies, seed investments for the purpose of establishing a fund, and de minimis investments, i.e., less than 3% of the total ownership of a fund provided that the aggregate does not exceed 3% of the banking entity's Tier 1 capital.

Who is affected? The provisions of the Volcker Rule apply to "any banking entity," which is defined as any insured bank or thrift, any BHC or any other company controlling an insured bank or thrift, and any affiliate or subsidiary of such a company. Systemically important nonbank financial companies, while not immediately affected by the prohibitions of the Volcker Rule, are subject to additional capital and quantitative requirements to be stipulated by the regulatory authorities.[6]

2.2. Literature and Hypotheses

While there is already some recent research on various provisions of the Dodd–Frank Act (e.g., Acharya et al. 2010, Ignatowski and Korte 2014, Kroszner and Strahan 2011), the literature evaluating the impact of the Volcker Rule is relatively scarce, presumably because it is not yet fully implemented. There are, however, a few very recent exceptions. The contribution by Chung et al. (2016), for example, builds on the calibration of a structural model to evaluate the impact of the Volcker Rule and finds that the rule raises banks' default probability and reduces their equity value. Schaefer et al. (2013) find somewhat similar effects in an event study evaluating market reactions around the announcement[7] and enactment of the Volcker Rule, with banks' stock market returns decreasing and credit default swap spreads increasing. Motivated by the inception of the Volcker Rule and its ban of proprietary trading, King et al. (2013) investigate the impact of bank holding companies' trading activity on their performance, finding that trading is positively related to bank risk and systemic risk and negatively related to profitability and stock returns, particularly during the financial crisis. Motivated by these studies and banks' self-declared compliance (Online Appendix A, available as supplemental material at https://doi.org/10.1287/mnsc.2016.2583, gives one example), in Section 4 we analyze whether the affected banks have reacted to the announcement of the Volcker Rule. To do that, we make the following testable hypothesis on the banks' trading asset ratios.

Hypothesis 1. *The affected banks started to reduce their trading asset ratios after the announcement of the Volcker Rule.*

We discuss this hypothesis in detail in Subsection 2.3 and then formally test it in Section 4.

The discussion around, and research into, bank activity restrictions and a separation of commercial and investment banking activities is hardly new. A large amount of both theoretical and empirical research was conducted particularly in the late 1990s and early 2000s, when the historical precedent to the Volcker Rule, the Glass–Steagall Act, was repealed. Hence, we also relate our paper to this literature and might extend its predictions to the effects of the Volcker Rule. Most of the research centers around the viability of three main reasons brought forward for or against a separation of commercial banking and investment banking/securities trading, namely, (1) potential conflicts of interest, (2) the potential impact on default probability, and (3) bank profitability.

With regard to the first argument, John et al. (1994) show in a theoretical model that the combination of both activities in one banking entity may result in a conflict of interest in which commercial banks mislead customers to invest in poor securities. Empirical evidence, however, is mixed with several authors finding no evidence for conflicts of interest when assessing the quality and performance of securities issued by commercial banks and nonbanks (Ang and Richardson 1994; Kroszner and Rajan 1994, 1997; Puri 1994). A notable exception is analyzed by Kang and Liu (2007), who find evidence for conflicts of interest of commercial banks with securities business in Japan.

Regarding the impact on bank risk and probability of default, there are theoretical arguments supporting an increase in risk because of the combination of moral hazard and additional opportunities to engage in risky activities (Boyd et al. 1998). It is also argued that diversification of banks' business into nonbanking activities might reduce overall risk and the probability of default (Benston 1994, Saunders and Walter 1994). Several empirical analyses find evidence for increased risk and low or no diversification benefits if commercial banks are allowed to combine more activities such as investment banking and securities trading (Akhigbe and Whyte 2004; Geyfman and Yeager 2009; Stiroh 2004, 2006). This increase in risk is mostly driven by nonbanking activities as measured, for example, in the noninterest income ratio (DeJonghe 2010, DeYoung and Roland 2001). On the other hand, several studies find diversification benefits and a decrease in banks' risk (Barth et al. 2004, Cornett et al. 2002, Goetz et al. 2015, Jorion 2005, Saunders and Walter 1994). Trading off the increased risk-taking opportunities and the diversification effects, Freixas et al. (2007) suggest that the cost of risk increase is greater than the diversification benefits. Further, Barth et al. (2000) and Stiroh

[6] Compare Title VI, Section 619, of the Dodd–Frank Act.

[7] In the wider finance literature, there are several papers that have studied announcement effects, for example, Asquith and Kim (1982) and Franks et al. (1991).

and Rumble (2006) find in their empirical analyses that while there might be positive effects from diversification, these are outweighed by an increase in volatility and risk. The effect of activity extensions or diversification on banks' profitability is also unclear. While Cornett et al. (2002) and DeYoung and Roland (2001) find an extension of banks' business into nontraditional activities to generally increase profitability, other empirical papers find no effect or even a negative effect of diversification and conglomeration on bank returns and market valuation (Laeven and Levine 2007, Schmid and Walter 2009, Stiroh 2006). Motivated by these studies, we give the following two testable hypotheses.

Hypothesis 2A. *Because of the trading constraints of the Volcker Rule, affected banks became less risky after the announcement of the rule.*

Hypothesis 2B. *The affected banks' risk level did not change significantly after the announcement of the Volcker Rule, indicating that the banks kept their risk targets.*

Consistent with banks' risk targeting, it may be that the announced trading constrains of the rule did not imply lower overall risk levels. Duchin and Sosyura (2014) find that banks can change their risk taking within the same asset class while complying with the regulation. Motivated by this paper, we hypothesize that the affected banks responded to the rule as below, if Hypothesis 1 holds and Hypothesis 2B dominates Hypothesis 2A.

Hypothesis 3. *The affected banks' remaining trading activities became riskier and were used less in the hedging of banking books after the announcement of the Volcker Rule.*

Taken together, despite ample research, there is no clear consensus to be found in the literature regarding the impact of a separation of commercial and investment banking on risk and profitability. Because of this conflicting evidence and the work-in-progress implementation, we do not presume any effect of the Volcker Rule yet, but rather start with analyzing whether and how banks are already complying to the rule and whether this possible compliance results in any of the intended effects.

2.3. Have Banks Already Reacted to the Volcker Rule?

Although full compliance is not required before 2017, major affected banks in the United States have repeatedly announced reconfigurations of their business models, allegedly in an effort to comply with the Volcker Rule. For instance, the banks have declared they have shut down proprietary trading desks and sold their shares in hedge funds.[8] And indeed, the top 10 trading bank holding companies that were presumably most affected by the Volcker Rule significantly reduced their trading accounts, as shown in Figure 1.[9]

Moreover, as we will see in Section 4, the banks with high trading asset ratios (defined as 3% or more of total assets) reduced their trading assets to a greater degree when compared to banks with low trading asset ratios after the introduction of the Volcker Rule. One might argue that there was a general reduction in the trading asset ratio because of a value effect or a general tendency away from trading after 2008. If that was the case, it would not be meaningful to compare banks with active trading operations to banks with low trading activity. Therefore, in Figure 2 we compare the trading book of BHCs with high trading activity to hedge funds' total assets under management in the Credit Suisse Hedge Fund Index.[10] While the figure presents only indicative evidence, it does not support the view of decreasing trading assets in financial institutions. Note that hedge funds' assets increased from 2010 onward. This evidence is consistent with Hypothesis 1.

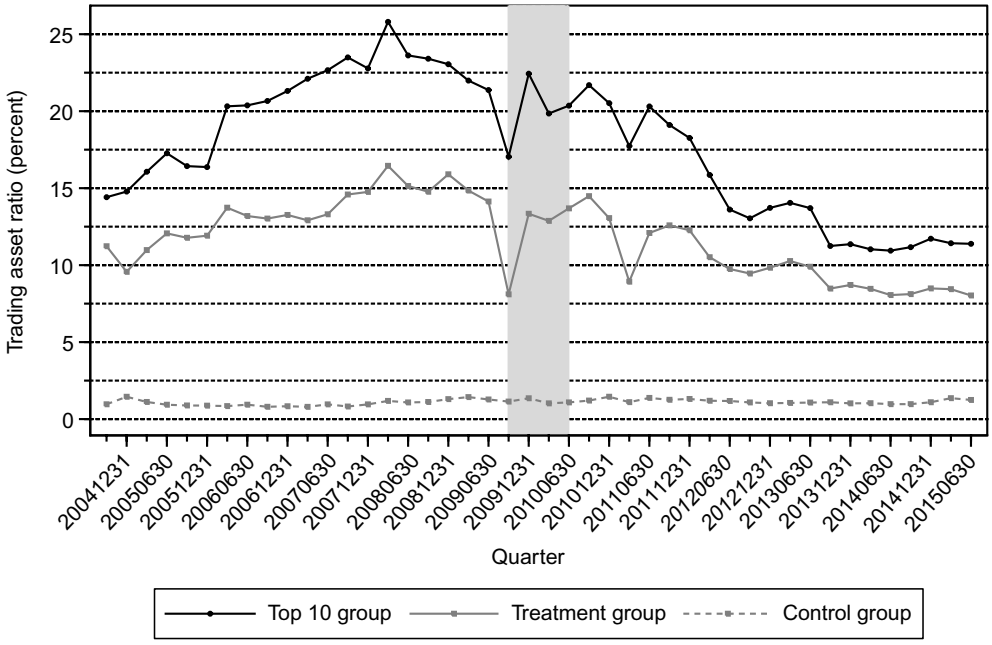
Is this already evidence for the Volcker Rule to have its intended effects of reducing allegedly risky activities and thereby increasing financial stability? There is ample reason to remain skeptical, since, as we have discussed earlier, there is no reason to assume that banks' risk-taking incentives have changed and they can take risk in different ways (leverage, riskiness of the banking book and the trading book). Further, both the ban of proprietary trading as well as the limitation on hedge fund and private equity activities are subject to a vast list of permitted exceptions. With regard to proprietary trading, for example, it will be extremely hard—some claim even impossible—for regulators to differentiate between prohibited proprietary trading and permitted activities such as trading on behalf of customers, market making, or hedging. When it comes to restricting investments into funds, it might be difficult to effectively delineate, for example, a private equity fund investment from a permitted small business investment fund engagement. Consequently, Kroszner and Strahan (2011) and Richardson et al. (2010) argue that the effect of the Volcker Rule on bank business models, overall risk, and systemic stability might be rather limited or eventually even contrary to the intended effect.

[8] See, for example, Craig (2012), Roose (2012), and Tracy and Rudegeair (2015).

[9] Figure C1 of Online Appendix C plots the average quarterly trading asset ratio of the banks in the top 10 group, treatment group, and control group with 95% confidence intervals.

[10] Figure C2 of Online Appendix C plots the average quarterly scaled trading assets of the banks in the top 10 group and treatment group with 95% confidence intervals. The quarterly assets under management in hedge funds in the Credit Suisse Hedge Fund Index are given as a comparison.

Figure 1 **Trading Asset Ratio of Banks in Three Different Groups**



Notes. This figure plots the average trading asset ratio of the 10 bank holding companies with the highest trading asset ratio in the 15 quarters before 2007. Banks with average trading asset ratio greater than 3% during the same period are in the treatment group. Banks with nonzero but less than 3% average trading asset ratio with the closest propensity score with the banks in treatment group are in the control group. The vertical gray area is the Volcker Rule's announcement time period, 2009 Q3–2010 Q2.

These initial analyses are supported by anecdotal evidences on compliance with the Volcker Rule that were reported in the financial press. In Online Appendix A, we report one such example, Goldman Sachs,[11] and related comments that are insightful and exemplary, suggesting the existence of creative compliance. Moreover, Online Appendix A indicates that banks do not necessarily need to raise leverage or the riskiness of banking book to keep their risk targets. This is consistent with Hypothesis 3.

3. Data Set and Identification Strategy

3.1. Data Set, Variable Definitions, and Descriptive Statistics

We construct our data set assembling data on the BHCs level. In the United States, BHCs are required to file quarterly (or half-yearly) financial reports on a consolidated and parent-only level (FR Y-9C/LP/SP), which are available from the Federal Reserve Bank of Chicago (FED Chicago). We construct a sample that contains the full set of BHCs (i.e., up to 8,128 individual institutions) and selected financial data (i.e., mainly balance sheet and income statement data) for the period covering the first quarter of 2002 to the second quarter of 2015. In addition, we use data from Thomson Reuters Datastream and the U.S. Department of the Treasury to complement the data set. Table 1 lists the used variables, and Table 2 provides the summary statistics of the data.

Dependent Variables. As we conduct statistical tests and robustness checks for several effects of the Volcker Rule, we define various dependent variables. To analyze how the Volcker Rule affected the nonbanking business, we start with an evaluation of the *trading asset ratio*. The *trading asset ratio* is defined as the ratio of the trading account to total assets. As the majority of BHCs do not have large trading accounts, this ratio is below 1% on average. However, for some banks the trading accounts represent a large share of their business, comprising 40% and more of the total assets. Table D1 of Online Appendix D lists the top 10 bank holding companies with the highest *trading asset ratio*.[12]

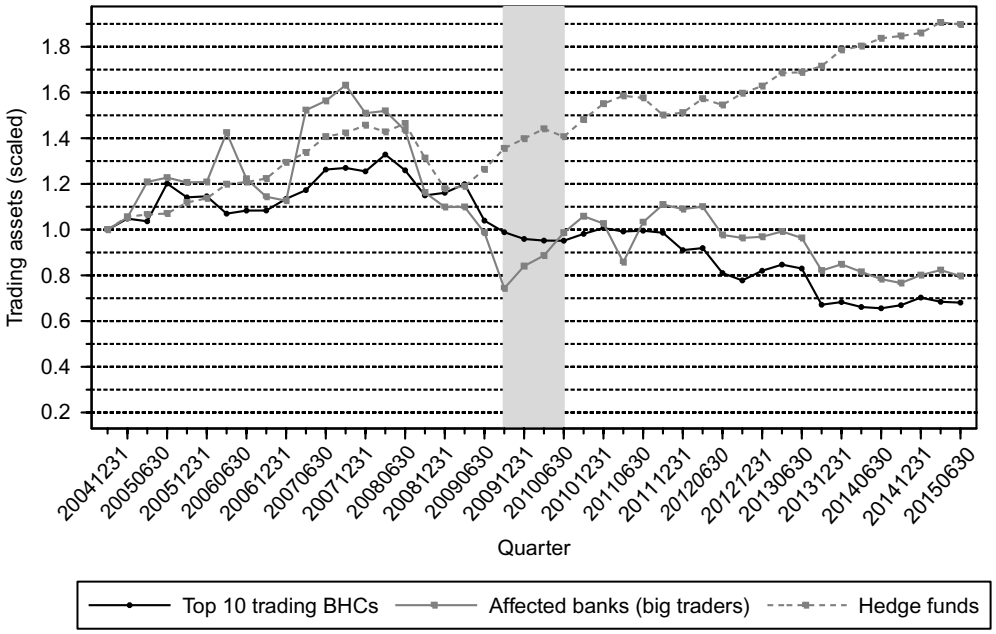
In a second step, we evaluate the announcement effect of the Volcker Rule on overall bank risk. To conduct a series of robustness checks, we use several measures of risk taking. Our primary measure is the *z-score*, which is defined as

$$z\text{-}score = (RoA + CAR)/\sigma RoA,$$

[11] Note that this is not the only financial firm about which similar reports have been given in the financial press. We selected this example, as it seems to be well documented.

[12] Note that some of the large investment banks are not to be found in the pre-2007 list as they only became bank holding companies following the financial crisis.

Figure 2 Trading Assets of Trading Banks and Hedge Funds



Notes. This figure plots the average trading assets of banks in the top 10 group (top 10 trading BHCs) and banks in the treatment group (affected banks) separately. The quarterly assets under management in hedge funds in the Credit Suisse Hedge Fund Index are given as a comparison. The 10 BHCs with the highest average trading asset ratio during the 15 quarters before 2007 are in the top 10 group, and banks with an average trading asset ratio greater than 3% during the same period are in the treatment group. The assets are scaled to one in 2004 Q3. Among all 35 banks in the treatment group, six banks have a trading ratio less than 3% at the end of this period.

where RoA is the return on assets, CAR is the capital asset ratio, and σRoA is the estimated standard deviation of the return on assets. [13] We estimate the volatility σRoA by using a seven-quarter period and require at least three observations over this period. The *z-score* has been widely used in the empirical literature as a proxy for overall bank risk (Dam and Koetter 2012, Gropp et al. 2014, Laeven and Levine 2009, Roy 1952). Essentially, the *z-score* captures two channels through which a reduction in overall bank risk can take place (i.e., asset quality and leverage), measuring the number of standard deviations by which a bank's return on assets would have to fall to deplete the available capital. If we define default as losses exceeding capital, the *z-score* can be interpreted as a measure for distance to default or the inverse of the default probability (Laeven and Levine 2009, Roy 1952). We also analyze the components of the *z-score* separately to better understand the affected banks' risks. In addition, we use the volatility of trading returns (σ *trading returns*) and the volatility of banking returns (σ *banking returns*) as alternative risk measures.[14] We estimate σ *trading returns* (or σ *banking returns*) as the standard deviation of trading returns (banking returns) over a seven-quarter period and require at least three observations. While the *z-score* and its components are available for most of the BHCs, the σ *trading returns* can only be computed for a subsample of banks that report information on their trading accounts.

As a third step, we test for the implication of the Volcker Rule on the correlation between BHCs' banking and trading returns. To do so, we use the correlation of banking and trading returns (ρ) over a seven-quarter period as the dependent variable (as before, we require at least three observations). Correlation ρ can be estimated only for 318 individual institutions. It is interesting to note that there is a wide range of correlations across banks, ranging from strongly negative to strongly positive correlations and averaging around zero. This indicates that, on average, the trading book's main purpose is not the hedging of the banking returns.

Finally, we analyze the changes in dividends, recapitalization, and liquidity holdings in terms of cash

[13] We follow Laeven and Levine (2009) in computing the natural logarithm of the *z-score* and use it throughout our analyses. Because the *z-score* is highly skewed, its natural logarithm is assumed to be approximately normally distributed. Further, we use the net operating income to average total assets as the return on assets (RoA) and average equity to average total assets as the capital assets ratio (CAR). Later in this paper, we use natural logarithm also with RoA, σRoA, σ *banking returns*, σ *trading returns*, dividends ratio, recapitalization ratio, stock price volatility, and liquidity ratio.

[14] We use net gains from trading accounts divided by average total trading assets as the trading returns and the difference between net operating income and net gains from trading accounts divided by the difference between average total assets and average trading assets as the banking returns.

Table 1 Variable Sources and Definitions

Variable	Source	Definition
		Panel A: Dependent variables
Trading asset ratio	BHC	Ratio of trading assets to total assets
z-score	BHC	Composite measure approximating the distance to default, computed as natural logarithm of ratio of the sum of return on assets and capital asset ratio to asset return volatility, where return on assets, capital asset ratio, and asset return volatility are without natural logarithm
Return on assets, RoA	BHC	Natural logarithm of ratio of net operating income to average total assets
Leverage ratio, capital asset ratio, CAR	BHC	Average equity divided by average total assets
Asset return volatility, σ RoA	BHC	Natural logarithm of standard deviation of return on assets (*RoA*)
Volatility of banking returns, σ banking returns	BHC	Natural logarithm of the standard deviation of banking returns
Volatility of trading returns, σ trading returns	BHC	Natural logarithm of the standard deviation of trading returns
Correlation of banking and trading returns, ρ	BHC	Correlation of banking book returns and trading book returns
Dividends ratio	COM	Natural logarithm of ratio of dividends to average total assets
Recapitalization ratio	COM	Natural logarithm of ratio of change in total capital to average total assets
Liquidity ratio	BHC	Natural logarithm of ratio of cash and balances at other depository institutions to average total assets
Stock price volatility, σ stock prices	CRSP	Natural logarithm of the average daily idiosyncratic volatility of stock price returns in a quarter
		Panel B: Explanatory variables and controls
After DFA	BHC	Dummy variable that equals one for all quarters between the third quarter of 2010 and the second quarter of 2015, and zero for all quarters from the third quarter of 2004 to the second quarter of 2009
Affect	BHC	Average trading asset ratio from the third quarter of 2004 to the second quarter of 2009
Affect (*pre*-2007)	BHC	Average trading asset ratio from the second quarter of 2003 to the fourth quarter of 2006
Affected BHC	BHC	Dummy variable that equals one if the average trading asset ratio during the pre-DFA period (Q3 2004–Q2 2009) was equal to or larger than 3%, and zero otherwise.
Total assets	BHC	Natural logarithm of total assets
Leverage ratio	BHC	Average equity divided by average total assets
Profitability	BHC	Net income divided by average total assets
Liquidity ratio	BHC	Cash and balances at other depository institutions divided by total assets
Deposit ratio	BHC	Average deposits divided by average total assets
Cost-income ratio	BHC	Operating expenses divided by total income
Nonperforming loan ratio	BHC	Past due and nonaccrual loans divided by total loans
Real estate loan ratio	BHC	Loans secured by real estate divided by total loans
CPP recipient indicator	TR	Capital Purchase Program indicator variable takes one if the bank is a current recipient of CPP funds in a given quarter, and zero otherwise

Notes. This table reports variable names, sources, and definitions. The data sources are FED Chicago BHC database (BHC), Compustat from Standard & Poor's (COM), Credit Suisse Hedge Fund Index (CS), Thomson Reuters Datastream (DS), Center for Research in Security Prices (CRSP), U.S. Department of the Treasury (TR). The data set covers the time period from Q2 2003 to Q2 2015.

and balances due from depository institutions.[15] In addition, we use the banks' idiosyncratic stock price volatility as the market's view on the risk of listed BHCs and analyze the announcement effect of the rule on the idiosyncratic volatility.[16] There are 385 publicly traded banks in our data set and, thus, this sample size is smaller than the sample sizes in our other tests.

Explanatory Variables and Controls. First, to identify the periods before and after the passing of the Volcker Rule as part of the Dodd–Frank Act, *after DFA* is set to one for all quarters between the third quarter of 2010 (when the Dodd–Frank Act was passed) and the second quarter of 2015. The variable is set to zero

[15] Here we use *dividend ratio* = (*common stock dividends* + *preferred stock dividends*)/*total average assets*, *recapitalization ratio* = (*total capital*$_t$ − *total capital*$_{t-1}$)/*total average assets*, *liquid asset ratio* = *cash and balances due from depository institutions*/*total average assets*, *and total capital* = *common equity* + *preferred equity* + *retained earnings*. These variables are from FED Chicago and the Compustat database.

[16] The daily stock return of each listed bank and the daily market return (SP 500 index return) are from the Center for Research in Security Prices (CRSP). The daily risk-free rate used is the four-week T-bills rate published by the Federal Reserve Bank of St. Louis (https://research.stlouisfed.org/fred2/series/DTB4WK#, accessed December 11, 2015). We use the capital asset pricing model (CAPM) to acquire the idiosyncratic volatility of each stock price, and we use the GJR-GARCH model to address the autocorrelation of the stock price volatility (see, e.g., http://vlab.stern.nyu.edu/doc/3?topic=mdls, accessed December 12, 2015).

Table 2 Summary Statistics

Variable	Unit	Mean	(Std. dev.)	Min.	Max.	*N*
Dependent variables						
Trading asset ratio	Percent	0.27	(2.02)	0	42.97	44,357
z-score		5.41	(1.67)	0.1	16.97	104,756
Return on assets	Percentage	0.11	(0.58)	−37.45	96.86	118,053
Capital asset ratio	Percentage	10.15	(6.28)	−76.23	115.8	118,145
Asset return volatility, σ		0.11	(0.44)	0	69.92	177,489
Volatility of banking return, σ		0.16	(0.32)	0	24.55	81,531
Volatility of trading return, σ		1.87	(14.07)	0	288.9	8,158
Correlation of banking and trading returns, ρ		−0.21	(0.53)	−1	1	4,920
Dividends ratio	Percentage	0	(0)	0	0.01	13,330
Recapitalization ratio	Percentage	0	(0)	−0.02	0.02	13,881
Stock price volatility		0.03	(0.02)	0.01	0.82	13,075
Explanatory variables and controls						
After DFA	Dummy	0.48	(0.5)	0	1	215,463
Affect	Percent	0.19	(1.7)	0	42.94	81,560
Affect (*pre*-2007)	Percent	0.14	(1.32)	0	38.43	79,711
Affected BHC	Dummy	0.01	(0.11)	0	1	81,560
Total assets	USD mn	5,020	(68,699)	0	2,577,148	126,739
Leverage ratio	Percent	10.15	(6.28)	−76.23	115.8	118,145
Profitability	Percent	0.18	(0.75)	−87.56	93.43	118,048
Liquidity ratio	Percent	6.57	(6.72)	0.02	98.09	107,354
Deposit ratio	Percent	68.8	(10.03)	0	99.81	197,062
Cost-income ratio	Percent	54.52	(83.63)	−1,247.83	15,636.92	45,504
Nonperforming loan ratio	Percent	2.85	(3.55)	0	75.37	47,650
Real estate loan ratio	Percent	73.90	(16.52)	0	101.91	47,650
CPP recipient indicator	Dummy	0.02	(0.14)	0	1	215,463

Notes. This table reports variable names, units, means, standard deviations, minimum and maximum values, and the number of observations for the main variables of the data set. The data sources are FED Chicago BHC database (BHC), Credit Suisse Hedge Fund Index (CS), Thomson Reuters Datastream (DS), U.S. Department of the Treasury (TR). The data set covers the time period from Q3 2004 to Q2 2015.

for the 10 quarters preceding the treatment, i.e., from the third quarter of 2004 to the second quarter of 2009 (when the Obama Administration first announced major reform proposals for the financial sector). Second, to identify the *affect*, the affectedness by the Volcker Rule, we compute the average trading asset ratio of a bank holding company during the pre-DFA period.[17] Third, to conduct one of the robustness tests, we define *affect* (*pre*-2007) as the trading asset ratio computed over the 15-quarter period between the second quarter of 2003 and the fourth quarter of 2006. Fourth, we define a treatment indicator variable that enables us to use a classical difference-in-differences setup and a propensity score matching approach. The variable *affected BHC* identifies the treatment in terms of affectedness by the Volcker Rule, and is set to one if the average trading asset ratio during the pre-DFA period was equal to or larger than 3%, and zero otherwise. Admittedly, this cutoff is highly arbitrary. However, we have to decide on a cutoff when employing above methodologies and regard this one as reasonable. Nevertheless, we only use this as a robustness check and perform our main analyses based on the continuous variable that captures more of the variation in the degree of affectedness.

In addition to our main explanatory variables, we control for a range of additional covariates that might influence bank business models and risk and that vary over institutions and quarters (i.e., that are not captured by the BHC and time fixed effects in our model). Most of these are standard in the empirical banking literature. In detail, we use total assets as a proxy for bank size, capital ratio (equity capital to total assets), profitability (net income to total assets), liquidity ratio (cash and balances at other depository institutions to total assets), deposit ratio (deposits to total assets), cost-income ratio (operating expenses to total income), as well as nonperforming loan ratio (nonperforming loans to total loans) and real estate loan ratio (real estate loans to total loans) as proxies for portfolio quality (and potentially even for earnings smoothing) and for portfolio composition. All of these variables are computed from the BHC reporting data set. Furthermore, several recent analyses have shown that banks tend to increase risk when they receive bailout assistance from the government, for example, from the Capital Purchase Program (CPP)

[17] We refer to the pre-DFA period as 20 quarters previous to the discussion and introduction of the Volcker Rule. That is, the pre-DFA period is from Q3 2004 to Q2 2009.

as part of the Troubled Asset Relief Program (TARP) (Black and Hazelwood 2013, Duchin and Sosyura 2014). We follow these studies and add an indicator for the CPP status of a bank that is one if a bank is a current recipient of CPP funds in a given quarter, and zero otherwise. The data for this indicator were obtained from the U.S. Department of the Treasury CPP Transactions Report.[18]

3.2. Baseline Model and Identification

To test the effect of the Volcker Rule, we start from a simple regression framework that evaluates the changes of the trading asset ratio, overall bank risk in terms of *z-score* and its components, the volatility of trading book return, and banking and trading return correlation over time at the bank holding company level. Since such a simple setup is prone to endogeneity concerns (e.g., by reverse causation or omitted variables), to prove causality we employ an additional identification framework that relies on the differential affectedness of BHCs by the Volcker Rule. In doing so, we rely on the assumption that those BHCs that have traditionally had their business models geared toward activities now banned or limited by the Volcker Rule (i.e., institutions with large trading books) will be affected most and should hence show the strongest reactions. Thus, we construct a regression model containing interaction terms, whose baseline version is given by

$$\begin{aligned} Y_{i,t} = {} & \alpha + \beta_1 \times \mathit{After\ DFA}_t + \beta_2 \times \mathit{Affect}_i \\ & + \beta_3 \times (\mathit{After\ DFA}_t \times \mathit{Affect}_i) \\ & + \gamma_i + \delta_t + X_{i,t} + \varepsilon_{i,t}. \end{aligned} \tag{1}$$

With our data being available on a BHC-quarter level, i indicates a particular BHC and t indicates a quarter. As we test for the impact of the Volcker Rule on several dimensions of banks' business models, the dependent variable of the model ($Y_{i,t}$) is the *trading asset ratio*, different measures of bank risk (*z-score*, σ *banking returns*, σ *trading returns*, and *CAR*), or the correlation between banking and trading returns (ρ). The core explanatory variables are *after DFA*$_t$ and *Affect*$_i$ that captures the varying degree of exposure to activities limited or banned by the Volcker Rule. Bank holding company (γ_i) and time (δ_t) fixed effects are used to control for influences constant either over time (e.g., time-invariant BHC characteristics) or across BHCs (e.g., the state of the economy or the financial system in a specific quarter). The model is complemented by the set of control variables ($X_{i,t}$) to test for additional covariates that might vary over both time and bank and that might influence banks' business models. We test the model both including and excluding these control variables to test for potential endogeneity. We cluster the standard errors at the BHC level to account for possible autocorrelation (i.e., we allow the error terms to be correlated within each BHC).

If banks comply with the Volcker Rule, the regulators expect that the affected banks reduce their trading assets ratio and bank risk (see Hypotheses 1 and 2A). The banks can reduce their risk by decreasing the volatilities of banking book or trading book, or by decreasing the correlation between the banking book and trading book returns (the two last effects would reject Hypothesis 3). These imply that we should find a negative and significant coefficient β_3 of the interaction term in Equation (1) when testing these hypotheses.

4. Results and robustness

4.1. The "Accounting Story": Do Banks Comply With Volcker?

4.1.1. Hypothesis 1 Results. Our first hypothesis, Hypothesis 1, is that the affected banks started to reduce their trading asset ratios after the announcement of the Volcker Rule. If this happened, we would have a significant and negative coefficient of the interaction term in the regression model (1). However, before this interaction regression model, we first test a simple model that contains a time indicator and add our vector of control variables, with the results being reported in panel A (columns (1) and (2)) of Table 3. For this model, we only find a weakly significant result when controlling other effects, indicating that overall there is no strong shift toward lower trading asset ratios. However, most of the BHCs had low or zero trading asset ratios when the Volcker Rule was introduced. Therefore, it is most interesting to know whether those BHCs that were particularly affected, i.e., had high trading asset ratios before, reacted stronger to the introduction of the Volcker Rule. We test this by turning to the model including the interaction between the *affect* and *after DFA*, which is reported in column (3) in panel A, and complemented by BHC and quarter fixed effect in column (4) in panel A of Table 3. The level effects are not very surprising. First, we find that overall there might be a slight, although not significant, decrease in the trading asset ratio after the Volcker Rule is passed. Second, the *affect* enters the regression positively and highly significantly. This is also not surprising, as

[18] We also used additional control variables, such as the indicators of banks' political influence suggested by Ignatowski et al. (2015). All results are robust to the inclusion of these variables, but we decided to exclude them from the final models because they were either insignificant or vastly reduced the number of observations for which all data is available.

Table 3 Changes in the Trading Book—Initial Compliance with the Volcker Rule?

Panel A: Baseline tests

	(1)	(2)	(3)	(4)
Dependent variable:			*Trading asset ratio*	
After DFA	0.00052	−0.00121*	−0.00002	
	(0.0006)	(0.0007)	(0.0001)	
Affect			0.993***	
			(0.005)	
After DFA × *Affect*			−0.161***	−0.202***
			(0.061)	(0.047)
Controls	No	Yes	Yes	Yes
Fixed effects	No	No	No	Yes
Observations	44,357	41,342	40,026	40,026
R-squared	0.000	0.228	0.902	0.925

Panel B: Robustness tests

Robustnest test:	(1) Treatment dummy	(2) Propensity score matching	(3) Pre-2007 affectedness	(4) Excluding nontrading BHCs
Dependent variable:		*Trading asset ratio*		
After DFA × *Affected BHC*	−0.0234***	−0.0282***		
	(0.009)	(0.009)		
After DFA × *Affect* (*pre*-2007)			−0.203***	−0.210***
			(0.056)	(0.054)
Controls and fixed effects	Yes	Yes	Yes	Yes
Observations	40,026	1,389	38,783	4,411
R-squared	0.923	0.936	0.894	0.934

Notes. Panel A reports multivariate estimates of the enactment effect of the Volcker Rule (part of the Dodd–Frank Act) on bank holding companies' trading asset ratios. Panel B reports the robustness tests. *After DFA* is one for the quarters Q3 2010–Q2 2015 and zero for the quarters Q3 2004–Q2 2009. *Affect* is the average trading asset ratio during the pre-DFA period (Q3 2004–Q2 2009). *Affected BHC* takes a value of one if the average trading asset ratio during the pre-DFA period (Q3 2004–Q2 2009) was equal to or larger than 3%, and zero otherwise. *Affect* (*pre*-2007) is the average trading asset ratio in the 15 quarters prior to 2007 (Q2 2003–Q4 2006). Control variables comprise total assets, profitability, leverage ratio, liquidity ratio, deposit ratio, NPL ratio, RE loan ratio, cost-income ratio, and an indicator variable that takes the value of one if the bank was a recipient of the TARP CPP program in a respective quarter (and zero otherwise). Quarter and BHC fixed effects are included in the models as indicated. Standard errors are clustered at the BHC level and reported in parentheses.
***$p < 0.01$; *$p < 0.1$.

banks that had a relatively high trading asset ratio before the Volcker Rule tend to have a relatively high trading asset ratio thereafter.[19] What is most interesting, though, is the negative and significant coefficient on the interaction term. This indicates that, consistent with Hypothesis 1, those BHCs that are presumably most affected by the Volcker Rule experience the strongest reduction in their trading asset ratios. This effect holds even when controlling for other potential explanations and for fixed effects. Might there even be a nonlinear effect, i.e., more affected banks disproportionately reducing their trading asset ratios? We test for the nonlinearity of the effect by including a squared term of the *affect* indicator as well as an interaction between this squared term and the time indicator into our baseline model. The results are shown in Table D2 of Online Appendix D. While we find the above results for the level effects and the interaction generally confirmed, we do not find significant indicators for a nonlinear adjustment.

[19] Note that the level effects drop in our last specification when the fixed effects are included.

4.1.2. Various Robustness Tests. For robustness tests of the above results, we take the fixed effects model presented in column (4) and test it in varying specifications. The results of these robustness tests are reported in panel B of Table 3. In the first test, we define all BHCs with a trading asset ratio of 3% or larger during the pre-DFA period as our treatment (or affected) group in this difference-in-differences model. Unsurprisingly, the coefficient on the difference-in-differences term is again negative and significant. The regression model indicates that the affected BHCs' average trading ratio pre-DFA was 11% and that they reduced the trading asset ratios for 2.34% more than the BHCs in the control group after the announcement of the Volcker Rule. This reduction is relatively large and accounts

for more than 20% of the average trading ratio pre-DFA.

In the second test, we use the treatment dummy specification with the propensity score matching for the treatment group and the control group. The result is reported in column (2) of panel B in Table 3. We first compute a score for the propensity of a BHC to be in the treatment group (i.e., affected by the Volcker Rule) based on a simple logit regression on our vector of control variables. In a second step, we use a one-on-one nearest neighbor matching without replacement to match each affected BHC with a BHC that is not affected but has the closest propensity score. Finally, we run our model on the matched sample that should only contain banks that are very similar in their propensity to be affected, with half of them being affected and half of them not. Although this matching exercise strongly decreases our sample size, we find a coefficient of similar economic and statistical significance.

So far, we have defined the *affect*, the affectedness of a BHC by the Volcker Rule, by its average trading asset ratio during the pre-DFA period. This, however, might be argued to be endogenous, as banks might have already changed their business models during the financial crisis in anticipation of future regulation. To overcome this concern, we define an alternative affectedness indicator using the average trading asset ratio over the 15 quarters before 2007, i.e., before the financial crisis became imminent. We find remarkably consistent results using this pre-2007 ratio as an identifier, which are depicted in column (3) of panel B in Table 3. In addition, we test the robustness of our results when excluding all entities that have zero trading books. The results are displayed in column (4) of panel B in Table 3 and remain largely unchanged. Additional various robustness tests have been carried out,[20] and we report the placebo test in Online Appendix B. All these additional tests also indicate that our results are robust.

Taken together, these findings support Hypothesis 1 that the affected banks started to reduce their trading asset ratios after the announcement of the Volcker Rule. However, by limiting the risky activities, the intention of the Volcker Rule is to reduce the risk of those banks. Thus, we now have a closer look at the impact of the Volcker Rule on banks' risk taking.

4.2. The "Risk Story": What Is the Impact of the Volcker Rule on Banks' Risk Taking?

4.2.1. Hypotheses 2A and 2B Results. Turning to BHCs' risk, we use the *z-score* as a composite measure for an institution's distance to default. The results are reported in Table 4. First of all, it is interesting to note that the coefficient on the *after DFA* indicator is positive and significant for the regressions using the *z-score* as dependent variable (see columns (1)–(4) in Table 4). This indicates that, overall bank holding companies have reduced their risk of default significantly after the passage of the rule. This, however, is likely to be driven mainly by the financial crisis that coincides with the pre-DFA period, not just an effect of regulatory reforms. As we cannot infer much from this level effect, we are, however, interested in whether this effect is varying by the likely affectedness of a bank by the Volcker Rule. Turning to the coefficient on the interaction term in columns (3)–(5) in Table 4, we find the coefficient to be negative, but not significant. A negative sign indicates that the affected BHCs are closer to default after DFA. Therefore, we conduct additional one-sided tests for the null hypothesis of a positive coefficient on the interaction term, i.e., for Hypothesis 2A. We reject Hypothesis 2A based on p-values at or below 0.1. Hence, if anything, the effect on affected BHCs is smaller, i.e., they do not reduce their overall risk more strongly as compared to unaffected institutions. This means that we confirm Hypothesis 2B.

This is illustrated in Figure 3, where the *z-scores* of the 10 most affected banks, all the affected banks, and unaffected banks that have similar propensity to be affected as the affected banks are illustrated over time.[21] The figure indicates that after the introduction of the rule, the most affected banks became even riskier than the other banks.

4.2.2. Components of *z-score*. We continue to assess the components of the *z-score*: first, return on assets (RoA), then the capital asset ratio (CAR), and finally the standard deviation of the return on asset (σRoA). Panel A of Table 5 presents the results of ordinary least squares (OLS) regressions with and without quarter and BHC fixed effects for RoA, CAR, and σRoA. Panel B of Table 5 reports robustness tests for CAR and σRoA.

[20] We ran our analysis on subsamples (a) excluding all BHCs that have been affected by mergers, acquisitions, or divestitures; and (b) BHCs that have been affected by the Supervisory Capital Assessment Program of the Federal Reserve, as those factors could drive different bank behavior, providing for an alternative explanation. Further, since there is some persistency in the trading asset ratio, we also control the lagged one-quarter trading asset ratio. To control the changes in overall industry, we also run our regressions with the difference of quarterly bank level trading asset ratios and the corresponding average trading asset ratios over all the banks. All these additional robustness test results are very similar in direction and significance to the baseline results (for brevity, results are not reported).

[21] Figure C3 of Online Appendix C plots the average quarterly *z-score* of the banks in the top 10 group, treatment group, and control group with 95% confidence intervals.

Table 4 Changes in Overall Risk in Terms of *z-score*—Have Affected BHCs Become Safer?

	(1)	(2)	(3)	(4)	(5)
Dependent variable:			*z-score*		
After DFA	0.499***	0.445***	0.479***	0.385***	
	(0.021)	(0.061)	(0.032)	(0.063)	
Affect			−2.397**	1.209	
			(1.088)	(1.161)	
After DFA × *Affect*			−1.609	−1.541	−2.723
			(1.257)	(1.050)	(1.913)
Controls	No	Yes	No	Yes	Yes
Fixed effects	No	No	No	No	Yes
Observations	104,756	40,000	53,301	38,823	38,823
R-squared	0.022	0.039	0.022	0.035	0.631
p-value for H0: $\beta_3 > 0$			0.100	0.071	0.077

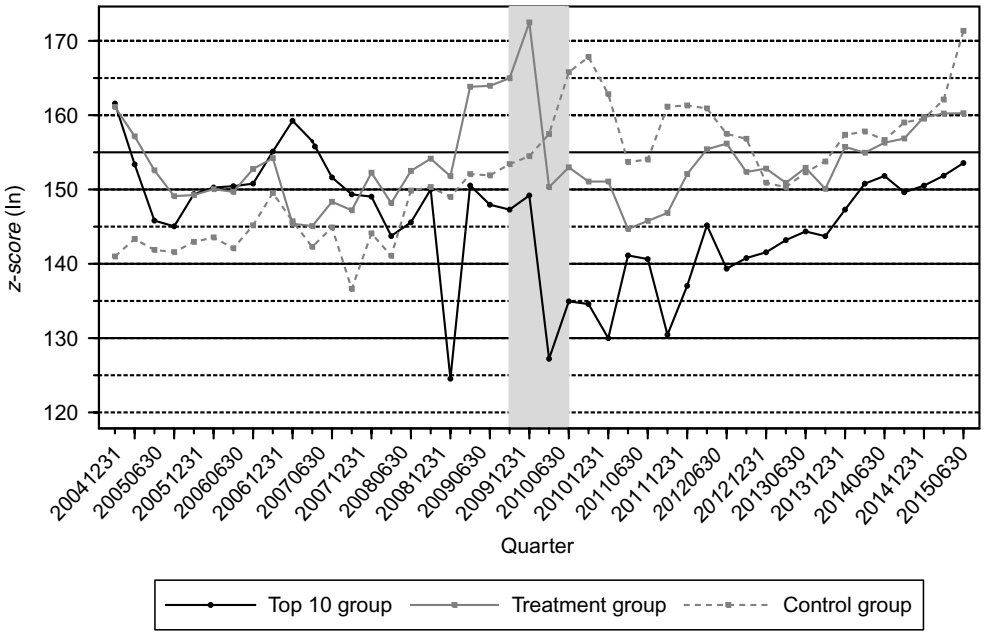
Notes. This table reports multivariate estimates of the enactment effect of the Volcker Rule (part of the Dodd–Frank Act) on bank holding companies' overall risk taking. *After DFA* is one for the quarters Q3 2010–Q2 2015 and zero for the quarters Q3 2004–Q2 2009. *Affect* is the average trading asset ratio during the pre-DFA period (Q3 2004–Q2 2009). Control variables comprise total assets, liquidity ratio, deposit ratio, NPL ratio, RE loan ratio, cost-income ratio, and an indicator variable that takes the value of one if the bank was a recipient of the TARP CPP program in a respective quarter (and zero otherwise). Quarter and BHC fixed effects are included in the models as indicated. Standard errors are clustered at the BHC level and reported in parentheses. In models (4) and (5), there are 2,458 banks in total, and 354 of them have nonzero trading asset ratios.

***$p < 0.01$; **$p < 0.05$.

First, overall the return on assets have decreased significantly after the rule. However, we do not find any pronounced effect on the BHCs that are particularly affected. If anything, the affected banks have increased their return on assets.

Second, we find a significant increase in *CAR* for the affected banks, though this is not robust. Thus, if anything, the affected banks have decreased their leverage. Related to the capital asset ratio, we next analyze if the dividend and recapitalization policies have changed after the introduction of the Volcker Rule. The results are in Tables D3 and D4 of Online Appendix D. We do not find significant changes in the dividend and recapitalization policies for the

Figure 3 *z-score* of Banks in Three Different Groups



Notes. This figure plots the average quarterly *z-score* in natural logarithm of the banks in the top 10 group, treatment group, and control group separately. The 10 BHCs with the highest average trading asset ratio during Q3 2004–Q2 2009 are in the top 10 group, and banks with an average trading asset ratio greater than 3% during the same period are in the treatment group. Banks with a nonzero average trading asset ratio but less than 3% and the closest propensity score with the banks in the treatment group are in the control group. The vertical gray area is the Volcker Rule's announcement period, 2009 Q3–2010 Q2.

Table 5 Components of *z-score*

Panel A: Baseline tests

	(1a)	(2a)	(1b)	(2b)	(1c)	(2c)
Dependent variable:	*RoA*		*CAR*		σ *RoA*	
After DFA	−0.122***		0.090***		−0.339***	
	(0.046)		(0.014)		(0.063)	
Affect	−2.221		−4.455***		−4.267**	
	(2.124)		(1.550)		(1.949)	
After DFA × *Affect*	0.892	0.518	3.286***	1.059**	4.057**	3.513*
	(1.965)	(1.368)	(1.248)	(0.040)	(1.782)	(2.044)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Fixed effects	No	Yes	No	Yes	No	Yes
Observations	23,771	23,771	39,794	39,794	39,067	39,067
R-squared	0.033	0.491	0.106	0.769	0.055	0.635
p-value for H0: $\beta_3 < 0$	0.325	0.353	0.004	0.008	0.011	0.043

Panel B: Robustness tests

	(1) Treatment dummy	(2) Propensity score matching	(3) Pre-2007 affectedness	(4) Excluding non-trading BHCs
Dependent variable:	*CAR*			
After DFA × *Affect*				
After DFA × *Affected BHC*	0.086	0.067		
	(0.068)	(0.081)		
After DFA × *Affect* (*pre*-2007)			1.396**	0.382
			(0.608)	(0.427)
Controls and fixed effects	Yes	Yes	Yes	Yes
Observations	39,794	1,383	38,555	4,406
R-squared	0.769	0.898	0.734	0.806
p-value for H0: $\beta_3 > 0$	0.103	0.204	0.011	0.185
Dependent variable:	σ *RoA*			
After DFA × *Affected BHC*	0.469**	0.601**		
	(0.227)	(0.292)		
After DFA × *Affect* (*pre*-2007)			3.787*	4.753**
			(2.226)	(2.397)
Controls and fixed effects	Yes	Yes	Yes	Yes
Observations	39,067	1,262	38,026	4,378
R-squared	0.635	0.615	0.635	0.596
p-value for H0: $\beta_3 < 0$	0.020	0.020	0.044	0.024

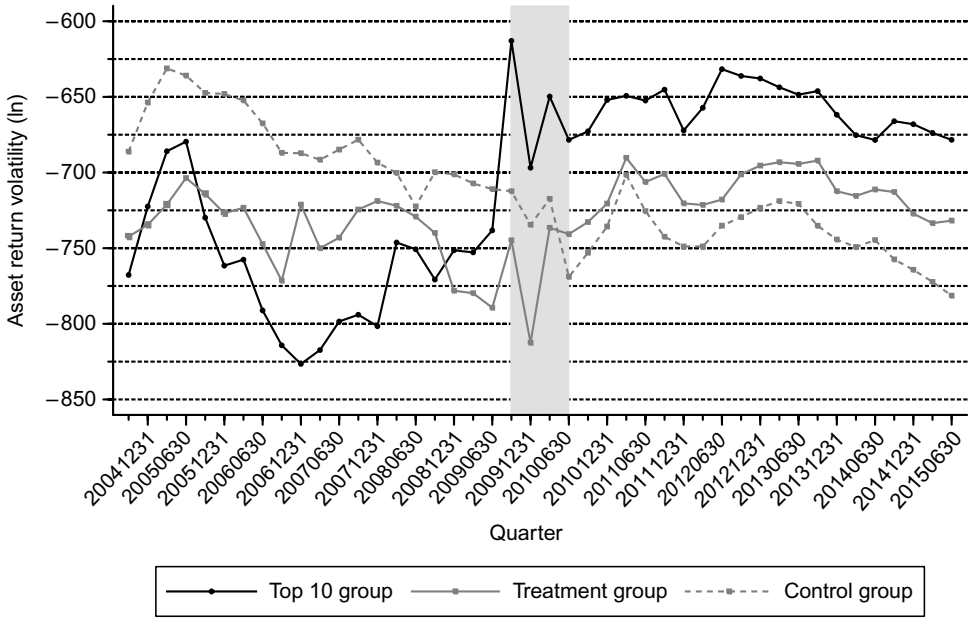
Notes. Panel A reports multivariate estimates of the enactment effect of the Volcker Rule (part of the Dodd–Frank Act) on bank holding companies' return on assets (*RoA*), capital asset ratio (*CAR*), and asset return volatility (σ *RoA*). Panel B reports the robustness tests for capital asset ratio (*CAR*) and asset return volatility (σ *RoA*). *After DFA* is one for the quarters Q3 2010–Q2 2015 and zero for the quarters Q3 2004–Q2 2009. *Affect* is the average trading asset ratio during the pre-DFA period (Q3 2004–Q2 2009). *Affected BHC* takes a value of one if the average trading asset ratio during the pre-DFA period (Q3 2004–Q2 2009) was equal to or larger than 3%, and zero otherwise. *Affect (pre-2007)* is the average trading asset ratio in the 15 quarters previous to 2007 (Q2 2003–Q4 2006). Control variables comprise total assets, profitability, leverage ratio, liquidity ratio, deposit ratio, NPL ratio, RE loan ratio, cost-income ratio, and an indicator variable that takes the value of one if the bank was a recipient of the TARP CPP program in a respective quarter (and zero otherwise). Quarter and BHC fixed effects are included in the models as indicated. Standard errors are clustered at the BHC level and reported in parentheses.

***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

affected banks after the passing of the Volcker Rule. When combining the recapitalization and dividends (i.e., recapitalization minus dividends), we only find a weak significance or insignificant negative effects. If anything, the negative signs indicate that the affected banks have collected less capital than they have paid dividends (for brevity, not reported).

Third, banks, on average, decreased the volatility of the asset return after the passage of the Volcker Rule, the coefficient on the time indicator is negative and significant in all the specifications. Turning to the coefficient on the interaction term (columns (1c) and (2c) of Table 5), however, reveals that the opposite is true for the affected BHCs. Thus, the

Figure 4 Asset Return Volatility of Banks in Three Different Groups



Notes. This figure plots the average quarterly asset return volatility in natural logarithm of the banks in the top 10 group, treatment group, and control group separately. The 10 BHCs with the highest average trading asset ratio during Q3 2004–Q2 2009 are in the top 10 group, and banks with average trading asset ratio greater than 3% during the same period are in the treatment group. Banks with nonzero average trading asset ratio but less than 3% and closest propensity score with the banks in treatment group are in the control group. The vertical gray area is the Volcker Rule's announcement period, 2009 Q3–2010 Q2.

affected banks increased the volatility significantly, with the interaction terms all being positive and significant.[22] This indicates that the affected banks' asset quality has fallen after the introduction of the rule. In addition, we perform the robustness test for σRoA in panel B of Table 5, using the alternative specifications used earlier. The coefficients on the interaction term are all positive and significant when using a treatment dummy and propensity score matching approach (columns (1) and (2)), pre-2007 affectedness definition, and further excluding nontrading BHCs (columns (3) and (4)). Overall, these robustness tests confirm our earlier results. Further, since there is some persistency in the asset return volatility (see Figure 4), we also control the lagged one-quarter asset return volatility in the regression models (1c) and (2c) in Table 5 and find that our results are still significant (for brevity, results are not reported). To control the changes in overall industry, we also run our regressions with quarterly bank level asset return volatility minus the corresponding average asset return volatility over all the banks, and the results of this robustness test remain significant and largely unchanged compared with our baseline results (for brevity, not reported).

Figure 4 illustrates the effect of the rule on the asset return volatility.[23] While there is an overall tendency to lower volatility after the enactment of the Dodd–Frank Act, there is a pronounced effect on the affected BHCs, as reported above. In particular, the difference between the most affected banks in the top 10 group banks and the unaffected banks has changed substantially after the Volcker Rule.

Our conclusion in this subsection is that the overall risk in terms of the *z-score* has not changed. However, when we look at the components of the *z-score*, we find that the affected banks have decreased their leverage (although this is not robust), at least partly by selling equity, and they have increased their asset return volatility.

4.3. The "Trading Story": Are Remaining Trading Activities Less Risky and Used for Hedging?

4.3.1. Channels of Increasing Asset Return Volatility. There are several potential reasons why the asset return volatility of the affected banks has risen. First, their banking book could have gotten riskier. Second, the risks in the banks' trading book could have increased. Third, if the trading book has been

[22] As studied, for example, in Ahmed et al. (1999), Beatty et al. (2002), and Beatty and Liao (2014), banks might smooth their earnings. If that was the case, then the changes in the volatility estimates would be smaller than the actual changes and this would decrease the significance of our results. Thus, if we were able to remove the smoothing then our results would be more significant.

[23] Figure C4 of Online Appendix C plots the average quarterly asset return volatility of the banks in the top 10 group, treatment group, and control group with 95% confidence intervals.

Table 6 Channels of Increasing Asset Return Volatility

Panel A: Baseline tests

	(1a)	(2a)	(1b)	(2b)	(1c)	(2c)
Dependent variable:	σ *banking returns*		σ *trading returns*		*correlation* ρ	
After DFA	0.183***		0.305*		−0.079**	
	(0.040)		(0.177)		(0.039)	
Affect	0.999		−13.524***		−3.123***	
	(1.082)		(2.890)		(0.429)	
After DFA × *Affect*	−1.431**	−1.524**	4.587*	1.427	1.292***	1.161***
	(0.726)	(0.685)	(2.576)	(1.007)	(0.372)	(0.377)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Fixed effects	No	Yes	No	Yes	No	Yes
Observations	39,257	39,257	5,739	5,739	4,415	4,415
R-squared	0.083	0.862	0.115	0.954	0.071	0.412
p-value for H0: $\beta_3 < 0$	0.024	0.013	0.038	0.078	0.000	0.001

Panel B: Robustness tests

	(1) Treatment dummy	(2) Propensity score matching	(3) Pre-2007 affectedness	(4) Excluding non-trading BHCs
Dependent variable:	σ *banking returns*			
After DFA × *Affected BHC*	−0.175**	0.050		
	(0.082)	(0.131)		
After DFA × *Affect* (*pre*-2007)			−1.847**	−1.415
			(0.772)	(0.933)
Controls and fixed effects	Yes	Yes	Yes	Yes
Observations	39,257	1,289	38,201	4,389
R-squared	0.862	0.855	0.864	0.758
p-value for H0: $\beta_3 > 0$	0.017	0.650	0.008	0.065
Dependent variable:	*Correlation of banking and trading returns* ρ			
After DFA × *Affected BHC*	0.099	0.158		
	(0.087)	(0.148)		
After DFA × *Affect* (*pre*-2007)			1.046***	1.070***
			(0.359)	(0.390)
Controls and fixed effects	Yes	Yes	Yes	Yes
Observations	4,415	1,298	4,167	3,076
R-squared	0.411	0.426	0.407	0.386
p-value for H0: $\beta_3 < 0$	0.128	0.143	0.002	0.003

Notes. Panel A reports multivariate estimates of the enactment effect of the Volcker Rule (part of the Dodd–Frank Act) on bank holding companies' banking return volatility, trading return volatility, and correlation of banking and trading returns. Panel B reports the robustness tests for banking return volatility and correlation of banking and trading returns. *After DFA* is one for the quarters Q3 2010–Q2 2015 and zero for the quarters Q3 2004–Q2 2009. *Affect* is the average trading asset ratio during the pre-DFA period (Q3 2004–Q2 2009). *Affected BHC* takes a value of one if the average trading asset ratio during the pre-DFA period (Q3 2004–Q2 2009) was equal to or larger than 3%, and zero otherwise. *Affect* (*pre*-2007) is the average trading asset ratio in the 15 quarters previous to 2007 (Q2 2003–Q4 2006). Control variables comprise total assets, profitability, leverage ratio, liquidity ratio, deposit ratio, NPL ratio, RE loan ratio, cost-income ratio, and an indicator variable that takes the value of one if the bank was a recipient of the TARP CPP program in a respective quarter (and zero otherwise). Quarter and BHC fixed effects are included in the models as indicated. Standard errors are clustered at the BHC level and reported in parentheses.
***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

used less in the hedging of the banking book, then the overall asset return volatility rises. The last two channels address Hypothesis 3. Panel A of Table 6 presents the results of OLS regressions with and without quarter and BHC fixed effects for σ *banking returns*, σ *trading returns*, and the correlation between banking and trading returns (ρ). Panel B of Table 6 reports robustness tests for σ *banking returns* and ρ. We analyze first the banking return volatility. When overall banks have increased the banking return volatility, the affected banks have decreased this volatility significantly (columns (1a) and (2a) in panel A of Table 6). This result is robust when we control the lagged one-quarter banking return volatility (for brevity, unreported), but it holds robustness in panel B of Table 6 only in specifications columns (1) and (3). On average,

the affected banks have not raised their banking book risk relative to the unaffected banks and, thus, the risk taking has not moved to the banking book. Further, this indicates that the increase in the affected banks' asset return volatility is due to a riskier trading book or a lower hedging of the banking book, suggesting Hypothesis 3 is at least partly true.

4.3.2. Hypothesis 3 Results. First, we focus on the volatility of trading returns.[24] Consistent with Hypothesis 3, we find significant effects in columns (1b) on the BHCs that are particularly affected, indicating that the affected banks have increased their trading book risk. Since there is some persistency in the trading return volatility, we add the lagged one-quarter trading return volatility to the control variables of the regression models (1b) and find that the interaction terms are still positive but lose their significance (for brevity, unreported). Further, the finding of column (1b) is neither significant in the fixed effects regression model in column (2b), nor robust in various specifications. However, the signs of the coefficients in all the four robustness tests remain positive indicating that, if anything, the affected banks have taken more risk in their trading book (for brevity, unreported).

Second, we analyze the hedging of the banking book returns. Note that the lack of trading risk reduction discussed above is not necessarily a signal for the ineffectiveness of the Volcker Rule. Rather, there might be trading activity that is wanted and hence permitted by way of exemptions. In fact, the Volcker Rule stipulates that trading accounts held for hedging purposes are permitted. In this spirit, banks could, for example, hedge banking cash flows using interest rate swaps and sovereign and index credit default swaps to manage part of the exposures in the banking book (see, e.g., Froot and Stein 1998, Froot et al. 1993). Alternatively, running a trading book could also be viewed as diversification among different businesses.[25] If affected banks were increasingly using their trading accounts for the hedging of banking business (or as effective diversification), we would expect the correlation between trading and banking returns to strongly decrease, or at least to be negative after the introduction of the Volcker Rule. The coefficient on the time indicator is indeed negative and significant in column (1c) of Table 6. However, consistent with Hypothesis 3, the coefficients on the interaction term are positive and significant in columns (1c) and (2c), indicating that, compared to their peers, the affected banks increased the return correlation. Further, we add the lagged one-quarter return correlation into the control variables to address the possible persistent issue, and find these results are still positive and significant (for brevity, unreported). The results still remain significant and almost the same as our baseline results when we control the changes in overall industry (for brevity, not reported). We interpret these findings as indication that the affected banks do not increasingly and disproportionately use their trading accounts for hedging purposes. Again, we robustness test these results in panel B of Table 6, using the alternative specifications that were employed earlier. Using the pre-2007 affectedness definition results in positive and significant coefficients on the interaction term (columns (3) and (4)), indicating less hedging for affected BHCs after the passing of the Volcker Rule. Turning to other specifications results in a positive, but not significant coefficient, as is shown in columns (1) and (2). Overall, these robustness tests partly confirm the direction of the effect.

Overall, the results in this subsection show that the affected banks have not decreased their trading risks, and they have not increased the hedging of their banking business after the introduction of the Volcker Rule. Actually, consistent with Hypothesis 3, we found some evidence for the opposite changes.

4.4. Market Volatility and Liquid Assets

Turning to the market's view, we test the stock price volatility of those listed BHCs as an alternative measure of bank risk. We cannot find significant effects in columns (1a) and (2a) of Table 7 when controlling other explanatory variables. We also test the liquidity ratio of BHCs and show the results in columns (1b) and (2b) of Table 7. Overall, banks have increased their liquidity ratio significantly, and the affected banks do not differ from the other banks after the passing of the Volcker Rule.

4.5. Repeal of the Glass–Steagall Act

In November 1999 the Gramm–Leach–Bliley Act (GLBA) repealed the Glass–Steagall Act of 1933 and the Bank Holding Company Act of 1956. Contrary to the Volcker Rule that introduced constraints on banks' nonbanking business, the GLBA allowed BHCs to engage in nonbanking business such as insurance and securities businesses. In this subsection we analyze whether the Volcker Rule and the GLBA have opposite effects on banks' risk taking.

Since the Glass–Steagall Act limited banks' own trading, the cross-sectional variation in the trading

[24] To understand the trading book better, we first analyzed its returns with respect to Fama and French (1993) factors. In this regression, only the market portfolio return is significant, indicating that the banks take equity market risk in the trading book (for brevity, not reported).

[25] See Subsection 2.2 for a discussion of potential diversification benefits in the literature. However, if diversification is the main motivation, it is not obvious that running a trading book adds any value, since investors could do the trading themselves or through active funds.

Table 7 Stock Price Volatility and Liquidity Ratio—Have Affected BHCs Become Safer?

	(1a)	(2a)	(1b)	(2b)
Dependent variable:	*Stock price volatility*		*Liquidity ratio*	
After DFA	−0.174***		0.560***	
	(0.018)		(0.025)	
Affect	2.024***		1.564	
	(0.652)		(1.009)	
After DFA × *Affect*	−0.671	−0.237	−0.580	−0.227
	(0.434)	(0.184)	(0.901)	(0.437)
Controls	Yes	Yes	Yes	Yes
Fixed effects	No	Yes	No	Yes
Observations	10,499	10,499	40,026	40,026
R-squared	0.279	0.741	0.252	0.696
p-value for H0: $\beta_3 > 0$	0.061	0.099	0.260	0.302

Notes. The table reports multivariate estimates of the enactment effect of the Volcker Rule (part of the Dodd–Frank Act) on bank holding companies' stock price volatility and liquidity ratio. *After DFA* is one for the quarters Q3 2010–Q2 2015 and zero for the quarters Q3 2004–Q2 2009. *Affect* is the average trading asset ratio in the 20 quarters previous to the discussion and introduction of the Volcker Rule (Q3 2004–Q2 2009). Control variables comprise total assets, leverage ratio, profitability, deposit ratio, NPL ratio, RE loan ratio, cost-income ratio, and an indicator variable that takes the value of one if the bank was a recipient of the TARP CPP program in a respective quarter (and zero otherwise). Quarter and BHC fixed effects are included in the models as indicated. Standard errors are clustered at the BHC level and reported in parentheses.

***$p < 0.01$.

Table 8 Changes in the Trading Asset Ratio and Banking Return Volatility After the GLBA

	(1a)	(2a)	(1b)	(2b)
Dependent variable:	*Trading asset ratio*		σ *banking returns*	
After GLBA × *Bank size*	0.001***		−0.037**	
	(0.000)		(0.016)	
After GLBA × *Section 20 BHC*		0.016***		−0.283***
		(0.005)		(0.090)
Controls	Yes	Yes	Yes	Yes
Fixed effects	Yes	Yes	Yes	Yes
Observations	48,091	53,909	34,147	39,338
R-squared	0.833	0.836	0.796	0.830

Notes. This table reports multivariate estimates of the enactment effect of the Gramm–Leach–Bliley Act (GLBA) on trading asset ratio and banking return volatility. *After GLBA* is one for the quarters Q1 2000–Q4 2005 and zero for the quarters Q1 1993–Q4 1998. In models (1a) and (1b), *bank size* is the average natural logarithm of total bank asset in the 24 quarters previous to the discussion and introduction of the Gramm–Leach–Bliley Act (Q1 1993–Q4 1998). In models (2a) and (2b), *Section 20 BHC* takes a value of one if the BHC has established Section 20 subsidiaries before 1999 Q1, and zero otherwise. Control variables comprise leverage ratio, profitability, deposit ratio, RE loan ratio, and cost-income ratio. Quarter and BHC fixed effects are included in all models. Standard errors are clustered at the BHC level and reported in parentheses.

***$p < 0.01$; **$p < 0.05$.

asset ratios during the Glass–Steagall Act is only one-third of that during the pre-Volcker period used earlier in this section and, therefore, the definition of affectedness used with the Volcker Rule cannot be used here. Instead, we follow Geyfman and Yeager (2009) and Cornett et al. (2002) and use bank size and Section 20 subsidiaries as the affectedness measures of the GLBA.[26] The time period for this analysis is 24 quarters before and after the discussion period of the GLBA, which is the longest period we can use in our data set, such that the pre- and postperiods are equally long. The discussion period is from the first quarter 1999 (the Financial Services Reform Bill was introduced in Congress) to the fourth quarter 1999 (President Clinton signed the bill into law). The treatment period indicator *After GLBA* is set to one for all the quarters from the first quarter 2000 to the fourth quarter 2005, and to zero from the first quarter 1993 to the fourth quarter 1998.

By using the affectedness measures described above, we find significant results with trading asset ratio and banking return volatility: the affected banks have increased their trading asset ratio and decreased their banking book risk after the passage of the GLBA. These results are in Table 8. Thus, trading increased after the repeal of the Glass–Steagall Act and the banking book risk decreased. The trading asset result is consistent with the Volcker Rule effect reported in Subsection 4.1. The banking book result indicates that the risks did not increase after the repeal of the Glass–Steagall Act; however, we do not find significant risk reduction in terms of *z-score* (for brevity, not reported). In this sense, also, this risk finding is consistent with our Volcker Rule results in Subsection 4.2, where we report that the affected banks do not reduce their overall risk relative to the unaffected banks. The further tested effects of the GLBA, such as trading volatility and banking and trading correlation, are not found to be significant (for brevity, not reported).

5. Conclusion

We analyze the Volcker Rule's announcement effects on U.S. bank holding companies. In doing so, we construct an identification framework that defines the affectedness of a BHC by the rule in terms of its pre-Volcker reliance on business that is limited or banned as the rule becomes effective. We find that those BHCs that are most affected reduce their trading books to a greater extent than less affected BHCs after the Volcker Rule was passed as part of the Dodd–Frank Act. However, we do not find corresponding significant

[26] Beginning in 1987, the Federal Reserve authorized bank holding companies to establish securities subsidiaries under Section 20 of the Glass–Steagall Act to engage in limited underwriting and dealing in bank-ineligible securities. The list of BHCs with Section 20 banking subsidiaries is given by Cornett et al. (2002) and Yeager et al. (2007). There are 49 banks with Section 20 banking subsidiaries before 1999 in our data sample.

effects on overall bank risk, indicating that the banks have not changed their risk targets.

Each bank optimizes its own risk level, and if its trading book is decreased by a regulation, then the target risk level can be reached by raising the asset return risk or by increasing the leverage. Our results indicate that the affected banks raised the riskiness of their asset returns, and on average, the risk taking has not moved to the banking book. We also find some evidence that the affected banks decreased their leverage, raised their trading risk, and decreased the hedging of their banking business.

To be fair, the Volcker Rule is not yet fully implemented with regard to its final regulatory rulebook, and will only start to be fully binding after 2016. Thus, affected BHCs' behaviors might yet again shift, and we might find different results when repeating this study after 2016. However, our results (together with several banks' self-declared compliance) identify serious risks in the Volcker Rule. Since banks' risk-taking incentives have not changed, the remaining assets in the trading books have been used less in the hedging of banking book returns. Thus, U.S. regulators might want to analyze further possible implementation risks to ensure increasing bank and thereby financial stability.

Our findings also have important implications for other regulators, for example, in the European Union, who are currently debating the introduction of similar separations between commercial banking and investment/trading business.

Supplemental Material

Supplemental material to this paper is available at https://doi.org/10.1287/mnsc.2016.2583.

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