THE IMPACT OF STRESS TESTING ON THE SYSTEMIC RISK OF BANK HOLDING COMPANIES

By

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ABSTRACT

THEODOROS KONSTANTOPOULOS. The Impact of Stress Testing on the Systemic Risk of Bank Holding Companies (Under the direction of DR. CRAIG DEPKEN)

The impact of the financial crisis of 2007-2008 to the global banking system raised concerns regarding the capital adequacy of banks. While the banks were already conducting internal stress tests before the financial crisis that was not enough to ensure their capital adequacy in the case of an extremely adverse economic scenario. In 2009, under the Obama administration, large Bank Holding Companies (BHCs) were required to conduct stress tests under the supervision of the Federal Reserve Board (FED). This paper evaluates the impact of stress testing on the systemic risk and marginal expected shortfall of Bank Holding Companies.

The objective of this study is to examine if the implementation of stress testing by the FED has affected the systemic risk of Bank Holding Companies. This study considers 55 US Bank Holding Companies with data from 2000 to 2018. The overall sample includes stress test BHCs as well as non-stress test BHCs. I use a variety of techniques including regression discontinuity with kernel triangular approach and OLS regression with fixed effects. The models contain bank-specific control variables including Log of Assets, Pre-Provision Net Revenue to Assets, Loan Loss Provision to Assets Real Estate Loans to Assets, Consumer Loans to Assets, Commercial Loans to Assets, Debt to Capital, Deposits to Assets, as well as capital requirements such as Tier 1 Capital Ratio.

The results suggest that after the regulation of the stress test, the systemic risk of the stress test BHCs is significantly higher than the non-stress test BHCs. However, the stress test BHCs decrease their systemic risk more than the non-stress BHCs. The Tier 1 capital ratio, which is a key ratio that determines whether the BHCs pass the stress test, is found to have a negative effect on systemic risk (SRISK). Furthermore, I show that BHCs see an increase in their systemic risk when they run stress testing for the first time. Finally, the stress test BHCs decrease their systemic risk the quarter before the stress test and increase it a quarter after.

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LIST OF ABBREVIATIONS

MES	Marginal Expected Shortfall
LRMES	Long Run Marginal Expected Shortfall
VAR	Value at Risk
ES	Expected Shortfall
SCAP	Supervisory Capital Assessment Program
CCaR	Comprehensive Capital Assessment Program
DFAST	Dodd Frank Act Stress Test
BHC	Bank Holding Company
FED	Board of Governors of the Federal Reserve System
LLP	Loan Loss Provisions
PPNR	Pre-Provision Net Revenues

CHAPTER 1: INTRODUCTION

No one can deny that banks are at the heart of the economic system. Millions of people start businesses, buy a new house or car, or pay college tuition through loans issued by banks. One of the most spoken phrases during the 2007-2009 financial crisis was *"too-big-to-fail"*. By saying "big" we do not necessarily mean big in size but interconnected to the economic system. That means that a collapse of a *"too-big-to-fail"* bank will trigger the collapse of the other banks within the economic system. For this reason, regulators will attempt to bail out the "*too-big-to-fail"* bank in order to secure the sustainability of the whole banking and economic system.

The domino effect from a collapse of one bank to the collapse of other banks is known as systemic risk. According to Cummins and Weiss (2014), systemic risk is the risk that an event will trigger a loss of economic value or confidence in a substantial segment of the financial system that is serious enough to have significant adverse effects on the real economy with a high probability.

The question becomes what is going to happen when more than one bank collapses at the same time? Will the regulators bail them out? The answer may be found if we recall the consequences of the bankruptcy of Lehman Brothers, which triggered a series of events that affected economies and caused the public to lose confidence in the banking sector. The collapse of Lehman Brothers was only one of several events that occurred during the crisis. These events shed light on the deficiencies of the financial and banking sector and showed the need for further regulation and control towards banks.

On February 25th, 2008 shortly after the financial crisis, the Federal Reserve (FED) announced the implementation of the Supervisory Capital Assessment Program (SCAP), known as stress testing, to assess the need for additional capital of large Bank Holding Companies (BHCs) under a baseline as well as adverse economic scenarios for a two-year horizon.

On April 24, 2009, the Federal Reserve released a paper describing the methodology of the stress test. Specifically, BHCs with more than $100 billion in assets are required to estimate their pre-provision net revenues[1] as well as their potential losses on loans, securities and trading positions over a two-year horizon based on two scenarios and starting their projections in the last financial quarter of 2008.

The FED, in order to have a better idea of the BHCs' capital structure and decide if they will require additional capital emphasized two ratios, the Tier 1 Capital ratio and the Tier 1 Common Equity Ratio. The minimum buffers were 6% for the Tier 1 Capital Ratio and 4% for the Tier 1 Common Equity ratio at the end of the two year horizon. The capital requirements were in line with the proposed capital requirements suggested by Basel III.

Therefore, the BHCs are required to carry additional capital if their ratios, based on macroeconomic scenarios, are below the threshold. The projected results were announced to the public on May 7th, stating that 10 out of the 19 BHCs were required to raise an aggregate capital totaling $74.6 billion, while the remaining 9 had enough capital to cover unexpected losses in adverse economic scenarios. Whether the supervision of BHCs and imposition of additional capital requirements eliminated systemic risk as intended is a controversial issue.

This study analyzes the impact of stress testing on the systemic risk of Bank Holding Companies. The research questions are as follows:

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[1] (net interest income + noninterest income – noninterest expense)/total assets

1. *Did the implementation of stress testing decrease the systemic risk of stress test BHCs?*
2. *Do the stress test banks have higher systemic risk after the stress test period compared to non-stress BHCs?*
3. *How does the stress testing affect the systemic risk of new stress test BHCs?*
4. *Is there any significant change in the systemic risk of stress test BHCs around stress test quarters?*
5. *Do the imposed capital requirements have an impact on the systemic risk?*

This paper consists of seven parts. In the first part, I explain my motivation of studying this topic. In the second part I discuss previous literature related to stress test and systemic risk. In the third part, I analyze the fundamentals of systemic risk. In the fourth part, I perform an extensive analysis regarding the stress test, the capital requirements and the revised regulations imposed by the FED. In the fifth part, I analyze my methodology and data. In the sixth part, I present my results, while in the seventh part I explain my conclusions.

There are two important factors that motivated me to conduct my master thesis in systemic risk and stress testing. First off, Charlotte, NC is one of the biggest banking centers in the USA, with several banks' headquarters located in the greater area. During my first semester as a student at UNC Charlotte, I had the pleasure to discuss with industry experts and Professors specializing in stress testing. One of the most frequently asked questions during my conversations with them was whether the regulations in the banking industry have actually had a positive effect on banks as well as society. More specifically, one of the questions raised was if the stress test has actually decreased the systemic risk of Bank Holding Companies. This question is based on Goldstein and Sapras's (2013) hypothesis that when the stress tests become routine, the systemic risk might increase due to increased homogeneity across the risk models of banks and the standardized risk methodologies. My conclusions and results will contribute not only in the banking and academic society but also in regulation. The results will for supervisors because they will be able to find out if the regulation of higher capital requirements and stress tests decrease or increase homogeneity across the risk models of BHCs and have a positive impact on the banks' ability to survive against a financial crisis.

CHAPTER 2: PREVIOUS LITERATURE

After the regulation of stress testing many researchers have examined behaviors of stress test and non-stress test banks. While there are not many published papers examining the impact of stress tests on systemic risk, there is an adequate number of working papers analyzing the impact of stress testing on the financial elements of BHCs.

Cornett, Minnick, Schorno and Tehranian (2017) analyze the impact of stress testing on financial ratios and dividends. By using regression discontinuity and a difference-in-difference approach, they find that stress test banks have, on average, higher capital ratios including Tier 1 Capital Ratio (tier 1 capital/risk-weighted assets), Tier 1 Leverage Ratio (tier 1 capital/total assets for leverage purposes), and Risk Based Ratio (total risk-based capital/risk-weighted assets) than non-stress test banks, while they have on average lower pre-provision net revenues per assets and loan losses provisions to assets. In addition, they test for changes in capital ratios around the stress test and find that in the quarter preceding the conduction of stress test, stress test banks have lower Tier 1 capital ratio and Tier 1 Leverage ratio compared to non-stress test banks while they report higher capital ratios a quarter after the stress test.

Acharya, Berger, and Roman (2018), examine the behavior of stress test and non-stress test banks on loan spreads by using difference-in-difference approach. They find that stress tested banks reduce the supply of credit, particularly to relatively risky borrowers.

Bostandzic and Weiß (2014) use data from 1991 to 2011 to study whether US banks are more systematically important and higher contributors to the global systemic risk than European banks. They find that US banks have higher systemic risk than European banks, the non-interest income is a key variable that causes the increase in the systemic risk, while the loans to assets contribute to the decrease. A striking feature of their paper is that capital requirements have a limiting effect on banks' global systemic risk after the financial crisis. The same authors published a revised version of their paper in 2018 using data from 1999 to 2014 and they find no significant impact of loan loss provisions, loans, deposits, and non-interest income on the systemic risk (SRISK), while they find no significant evidence of assets and leverage on Marginal Expected Shortfall (MES). Their concluding remarks contradict the findings of their first paper since they find that European banks contribute significantly higher to the global systemic risk.

My work is closely related that of Huang (2018), in which he examines the impact of the Dodd-Frank Act on systemic risk of banks. His methodology includes a difference-in-difference approach and synthetic control approach between US banks (treatment group) and European banks (control group). He argues that there is no evidence that the implementation of the Dodd-Frank Act has decreased the systemic risk of US banks. By including the lagged dependent variable as the explanatory variable, he finds that the decrease in systemic risk is mainly due to endogenous risk persistence. The other key explanatory variables included in his model are exogenous macroeconomic variables such as inflation, economic growth and interest rates. In contrast to his study, I focus on US banks and test for specific changes over the years and stress test quarters. Furthermore, my analysis focuses on changes around the Comprehensive Capital Analysis and Review and not on the Dodd-Frank Act. Furthermore, I extend his research by using regression discontinuity. I also follow a different approach in the variable selection, since I focus on bank specific variables to test for an impact of capital requirements on the systemic risk.

Furthermore, while his analysis focuses on the marginal expected shortfall and conditional value at risk (CoVar), I extend my research to see whether there is any impact on SRISK.

Weiß, Bostandzic, and Neumann (2013) examine the factors that cause domestic as well as the global systemic risk. They find no empirical evidence that bank specific characteristics such as bank size, leverage or non-interest income are determinants of systemic risk across financial crises. The most striking finding of their research is that one of the key determinants of systemic risk are regulatory regimes. They also analyze the systemic risk effects of bank mergers. By using marginal expected shortfall (MES) as the dependent variable, they find a significant increase in the systemic risk of the acquirers, targets and their competitors following the mergers.

Banerjee and Mio (2018) examine whether there is a causal effect of liquidity regulation on balance sheets in the United Kingdom. They also use a difference-in-difference approach. One of the key variables included in the model was the Tier 1 Capital Ratio. They find that banks subject to liquidity regulation change both their assets and liabilities structure.

Laeven, Ratnovski, Tong (2014) examine the relation of bank characteristics to the SRISK. They find a negative relationship between capital and systemic risk as well as between deposits and systemic risk for large banks, while a positive impact between markets based activities and systemic risk.

Goldstein and Sapra (2014) raise concerns regarding the benefits of stress testing. They claim that as the banks run stress tests implemented by the FED, they stop developing their own internal models and tend to mimic the supervisory models. This routine and lack of internal risk management models might increase the systemic risk.

CHAPTER 3: FUNDAMENTALS OF SYSTEMIC RISK

As mentioned, the dependent variables are SRISK and marginal expected shortfall (MES) based on the Standard & Poor's 500 (S&P 500). In this chapter, I will explain the components of each dependent variable. All the dependent variables are retrieved from the V-Lab of Stern Business School of New York University. Before I analyze the systemic risk by V-Lab, I will first describe risk measures that are used by the financial institutions as well as theoretical approaches of systemic risk that exist in literature.

3.1 Value at Risk

One of the most common measures of risk used by banks is Value-at-Risk (VaR). Even though it became widely used in 1990's, it was first implemented by several firms in 1922 (Holton, 2002). The VaR simply measures the maximum loss of an investment given a significance level a. Artzner (1998) defines the VaR as:

$$VaR_a(X) = -\inf\{x|\mathbb{P}[X \leq x \cdot r] > a\}, \quad (1)$$

where a ∈ [0, 1] is a confidence level, r is a reference instrument, P is the distribution, X is the final net worth.

3.2 Expected Shortfall

According to Benoit, Colletaz, Hurlin, and Pérignon (2014) expected shortfall (ES) is defined as the expected return of the market or system given its *x%* worst days or if the drop of the market exceeds a given threshold. Lehar (2005) defines the ES as the amount of debt that cannot be covered by the assets in case of default. Acharya, et al (2009) specify the *x%* days as the Value-at-Risk of the market. According to Yamai and Yoshiba (2002) the expected shortfall is optimized compared to VaR:

$$ES_{mt} = E_{t-1}(r_{mt}\,|r_{mt} < C) = \sum_{I=1}^{N} w_{it}\, E_{t-1}(r_{it}\,|r_{mt} < C), \quad (2)$$

where w_{it} the weight of all the institutions within the system, r_{mt} the aggregate return of the market, and r_{it} the return of the institution's equity.

3.3 Marginal Expected Shortfall

The MES is an extension of the Expected Shortfall. MES is simply the expected return of an equity given the worst *x%* days of the market. Put differently, it can be defined as the expected equity loss when the market falls by more than a specific threshold or when the market is in its left tail[2]. The MES is linked with the ES. The higher the MES of a firm the higher the contribution to the risk in the financial system. The equation that expresses the MES is the following:

$$MES_a(a) = \beta_{it} \; ES_{mt}(a)\,, \; (3)$$

while the β_{it} is estimated based on the following formula:

$$\beta_{it} = \frac{cov(r_{it}, r_{mt})}{var(r_{mt})} = \frac{\rho_{it} \;\; \sigma_{it}}{\sigma_{mt}}\,, \; (4)$$

As can be observed from equation (3), the first step for the MES calculation is the estimation of the conditional beta with respect to the market. Equation (4) shows the conditional beta of an equity with respect to the market. Acharya, Engle, and Richardson (2012) suggest that the threshold of C or VaR is -2%. Therefore, the MES estimates the equity of an institution when the market drops more than 2%. While the MES estimates the daily loss of equity, the LRMES estimates the equity loss in a 6-month horizon under the extreme scenario that the market falls by 40%. One way to estimate the LRMES is the following formula (Acharya, Pedersen, Philippon, and Richardson, 2010):

$$LRMES = 1 - \exp(-18 \cdot MES), \; (5)$$

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[2] Left tail can be defined as the observations that belong in the lowest 1%, 5% or 10% of a given distribution.

where MES considers a -2% drop in the market as we mentioned above, the LRMES is calculated quite differently. Another way to express the formula (5) is the following:

$$LRMES = 1 - \exp(\log(1 - d) \cdot beta, \ (6)$$

where d is the 40% drop of the market (Global or S&P 500) and beta is the beta of the equity return with respect to the market index. Engle (2016) extensively analyzes the process of the dynamic beta estimation. The method he used is based on the Glosten, Jagannathan, and Runkle Generalized Autoregressive Conditional Heteroscedastic (GJR-GARCH), which is a model that estimates asymmetry volatility (or conditional variance). That means that the GJR-GARCH allows the consideration of a leverage effect[3]and the Generalized Autoregressive Conditional Heteroscedastic Dynamic Conditional Correlation (GARCH-DCC) which calculates the time varying correlation between the market index and the stock return. Engle and Ruan, (2018) consider a drop of the global index MSCI ACWI ETF. Since the time of closing price is different among the countries due to the different time zones, they express the relation of the return to the market return and its lag:

$$r_t{}^f = \beta_t{}^f R_t{}^M + \gamma_t{}^f R_{t-1}{}^M + \varepsilon_t{}^f. \ (7)$$

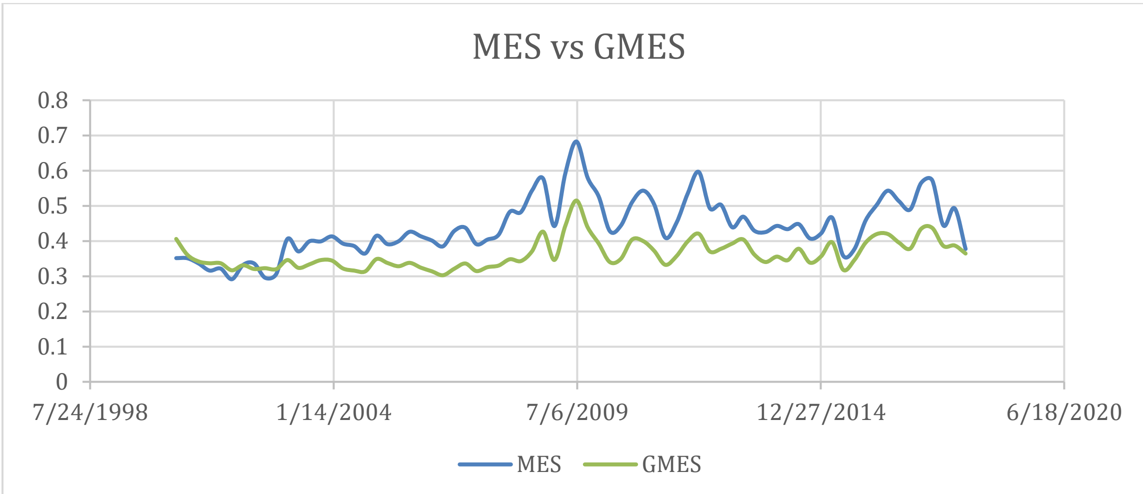
In order to be allowed for both time varying and constant beta, Eagle (2016) proposes the following model:

$$r_t{}^f = (\phi_1 + \phi_2 \hat{\beta}_t{}^f) R_t{}^M + (\phi_3 + \phi_4 \hat{\gamma}_t{}^f) R_{t-1}{}^M + \varepsilon_t{}^f. \ (8)$$

[3] Leverage effect refers to the situation when the correlation between an asset return and its volatility is negative

After running the regression and obtaining the coefficients, can estimate the total beta which consists of the coefficients of the market's return and its lag:

$$\tilde{\beta} = (\widehat{\phi_1} + \widehat{\phi_2}\,\hat{\beta}_t{}^{f}) + (\widehat{\phi_3} + \widehat{\phi_4}\,\hat{\gamma}_t{}^{f}). \quad (9)$$



Source: V-Lab, Stern Business School of the New York University

Figure 3.3.1: Average of MES and GMES of the total sample from 2000-2018.

Figure 3.3.1 illustrates the average Marginal Expected Shortfall (MES), which is calculated based on the S&P 500 index, and Global Marginal expected shortfall (GMES), which is estimated based on the global MSCI global index. It is obvious that the pattern of both series is quite similar, which probably means they are highly correlated. In addition, the significance increases of both series in 2007-2009 during the financial crisis can be seen.

3.4 SRISK

One of the most common measures of systemic risk is the SRISK. That is, the capital that a bank would need to raise in order to pay its debt during a financial crisis in order to continue to stay solvent. The estimation and definition of SRISK is explained by Engle and Ruan (2010). They define SRISK as the median capital shortfall conditional on a financial crisis. The steps that they emphasize for the calculation of the SRISK are as follows:

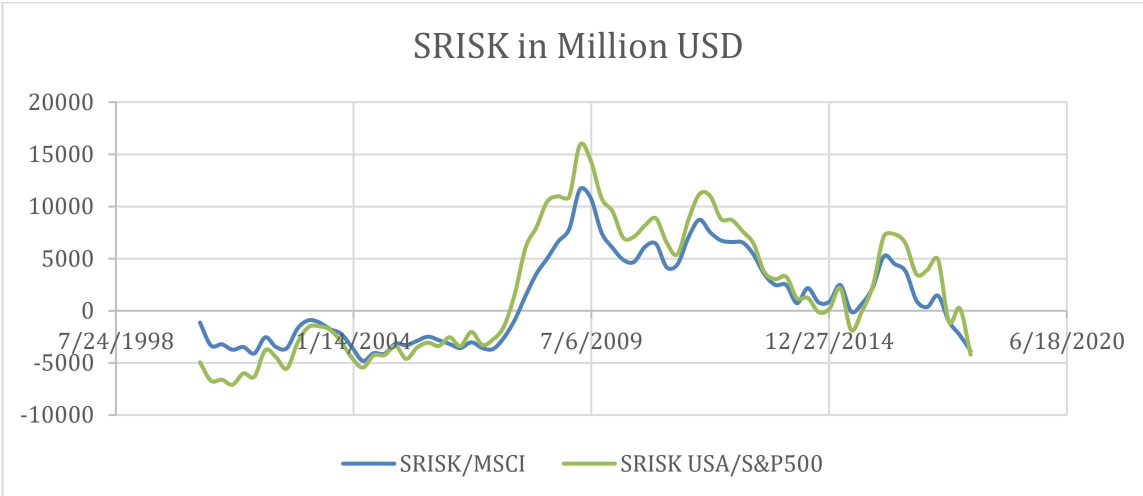
1) Estimation of the MES;
2) Estimation of the LRMES;
3) Estimation of Leverage Ratio;
4) Prudential Capital Ratio;

The estimation of MES is the most important step. If we are able to estimate the MES we can then estimate the other systemic risk measures. The leverage ratio can be easily retrieved from publicly announced data of the financial institutions. The calculation of SRISK is therefore:

$$SRISK = k \cdot Debt - (1-k) \cdot Equity \cdot (1 - LRMES), \quad (10)$$

where k, is a prudential capital ratio imposed by the regulator. The Volatility Laboratory (V-Lab)[4] considers an 8% prudential ratio. Debt is the debt of the firms and it is calculated as the difference between the assets and equity. Therefore, the debt is treated as the liabilities of the institution. Equity is the equity of the institution and LRMES is the Long Marginal Expected Shortfall that was discussed in section 3.3. If we need to estimate the systemic risk contribution for each institution then we simply add the SRISK of all the institutions and then divide the SRISK of the institution by the aggregate SRISK of the industry.

[4] The Volatility Laboratory was created at New York University and provides real time measurement, modeling and forecasting of financial volatility, correlation and systemic risk analysis



Source: V-Lab, Stern Business School of the New York University

Figure 3.4.1: Comparison of the SRISK Measures of the total sample from 2000-2018.

Similar to Figure 3.3.1, Figure 3.4.1 shows the average SRISK based on the global index and S&P 500. The graph indicates a perfect correlation between the two systemic risk measures. It can also be observed the increase in the SRISK during the crisis.

3.4.1 Differences between MES and SRISK

According to Colletaz, Hurlin, and Pérignon (2014) the MES is highly linked with the beta of the institution with respect to the market, while the SRISK is highly linked to the liabilities of the institution. Therefore, the higher the leverage of an institution the higher the SRISK. Similarly, the higher the beta of an institution with respect to the market index, the higher the MES. Different systemic risk measures are expected to give different results. As an example, Table 3.4.1.1 shows the different rankings of the systemic BHCs based on the MES and SRISK.

Table 3.4.1.1: Ranking of Systemic Risk Measures. This table presents the ranking of the Banks based on the MES and SRISK in 2017.

BHC	SRISK/S&P 500	BHC	MES
1. Citigroup	41.68	1. SVB Financial Group	0.663
2. Goldman Sachs	28.03	2. Texas Capital Bancshares Inc	0.643
3. Bank of America	27.07	3. Wintrust Financial Corp	0.601
4. Morgan Stanley	24.42	4. United Bankshares, Inc.	0.573
5. JPMorgan Chase	9.029	5. Morgan Stanley	0.572
6. Capital One	7.095	6. Umpqua Holdings Corp	0.572
7. State Street Corp	1.158	7. Capital One	0.568
8. SunTrust Banks	0.844	8. Western Alliance Bancorporation	0.563
9. Texas Capital Bancshares Inc	0.362	9. Goldman Sachs	0.556
10. Wintrust Financial Corp	0.288	10. Charles Schwab Corporation	0.553
11. SVB Financial Group	0.193	11. E*TRADE Financial Corp	0.548
12. Associated Banc Corp	0.19	12. IBERIABANK Corp	0.543
13. TCF Financial Corporation	0.166	13. F.N.B. Corp	0.5419

Source: V-Lab, Stern Business School of the New York University

From Table 3.4.1.1, each BHC has different ranking of systemic risk in 2017. Citigroup, for example, has higher SRISK among its peers but when looking at the MES Citigroup is not even included in the list above. Similarly, SVB Financial Group had higher MES in 2017 among its peers but only the eleventh highest SRISK.

3.5 Indicator-Based Measurement Approach

In 2011, the Basel Committee on Banking Supervision established a methodology for identifying highly systemically banks, commonly known as globally systemically important banks (G-SIBs). The G-SIBs that will be identified will be required to surcharge additional capital in order to avoid a possible bailout during a financial crisis.

The methodology was named as indicator-based measurement approach and the selected indicators included variables that mirror the size, cross-jurisdictional activity, interconnectedness, substitutability, institution infrastructure, and complexity. Each of these categories takes into account several other indicators. Each category contributes 20% to the final systemic risk score, while each subcategory contributes an equal weight to the total category. The score of each category is calculated by dividing the individual amount of the indicator by the aggregate amount of the banks in the sample. The final score is multiplied by 10,000:

$$\text{Indicator Score (bps)} = \frac{Bank\ Indicator(Euros)}{Sample\ Total\ (Euros)} \cdot 10{,}000. \quad (11)$$

The average score of the five indicators is the final score. Table 3.5.1 shows the methodology in detail.

Table 3.5.1: Indicator Based Measurement Approach

The table shows the categories that are studied for identifying highly systemically risky banks by the Basel Committee of Banking supervision.

Category	Individual indicator	Indicator weighting
Cross-jurisdictional activity (20%)	Cross-jurisdictional claims	10%
	Cross-jurisdictional liabilities	10%
Size (20%)	Total exposures as defined for use in the Basel III leverage ratio	20%
Interconnectedness (20%)	Intra-financial system assets	6.67%
	Intra-financial system liabilities	6.67%
	Securities outstanding	6.67%
Substitutability Institution infrastructure (20%)	Assets under custody	6.67%
	Payments activity	6.67%
	Underwritten transactions in debt and equity markets	6.67%
Complexity (20%)	Notional amount of over-the-counter (OTC) derivative	6.67%
	Level 3 assets	6.67%
	Trading and available-for-sale securities	6.67%

Source: Basel Committee on Banking Supervision

Banks that have a score higher than a cutoff point are considered as G-SIBs. The scores are divided into buckets from A to E. A-B is considered a low bucket while D-E a high bucket. If the final score of a bank is assigned to the highest bucket then the bank is required to issue additional capital. The additional capital can be estimated by the expected impact approach. The methodology of the expected impact approach for capital surcharge is better explained by the FED. The methodology takes into account three indicators: i) the estimation of probability of default F (·); ii) social losses (the scores) given the probability of default H (·); iii) a choice of a reference bank. The reference bank is described as a bank with no less than a 7% risk based capital ratio. The goal of this approach is to make the expected impact of a systemically important bank equal to the expected impact of a non-systemically important bank by reducing the probability of default of the systemically important bank.

$$\frac{F(f-k_r-k_{GSIB})}{F(f-k_r)} = \frac{H(r)}{H(GSIB)} \leq 1, \quad (12)$$

where k_r is the capital held by the reference bank, k_{GSIB} is the capital surcharge, and f is a proxy for the failure point at which a bank can no longer be solvent. Therefore, solving for k_{GSIB}, we can estimate the additional capital surcharge.

Table 3.5.2: G-SIBs by the Financial Stability Board (Body of the Bank of International Settlements).This table shows the banks that are considered as global systemically banks by the Financial Stability Board which is part of the Bank of International settlements. First column shows the additional capital that the banks must raise.

Bucket	2014	2015	2016	2017
2.5%	JP Morgan Chase	JP Morgan Chase	Citigroup	JP Morgan Chase
			JP Morgan Chase	
2%	Citigroup	Citigroup	Bank of America	Bank of America
				Citigroup
1.5%	Bank of America	Bank of America	Goldman Sachs	Goldman Sachs
	Goldman Sachs	Goldman Sachs	Wells Fargo	Wells Fargo
	Morgan Stanley	Morgan Stanley		
1%	Bank of New York	Bank of New York	Bank of New York	Bank of New York
	Mellon	Mellon	Mellon	Mellon
	State Street	State Street	Morgan Stanley	Morgan Stanley
	Wells Fargo	Wells Fargo	State Street	State Street

Source: Basel Committee on Banking Supervision

The table above shows the Global Systemically Important Banks, as they are considered by the Basel. We can observe that for every year the sample of the banks that are considered as global systemically has not changed. In general, the approach used by the Basel Committee is not used by the literature. The methodology is used only to estimate the additional capital that need to be raised.

CHAPTER 4: REGULATIONS AND CAPITAL REQUIREMENTS

4.1 The Supervisory Capital Assessment Program

The Supervisory Capital Assessment Program (SCAP) was one response to the financial crisis in 2007-2009. The purpose of the SCAP was to ensure that the banks had enough capital to address their lending activities under adverse macroeconomic scenarios. US Bank Holding Companies with more than $100 billion in assets in the 4th quarter of 2008 were required to participate in the program and project loan losses, including sub-loan categories for a 2-year horizon. Banks exceeding $100 billion in trading assets were required to estimate trading losses. Except for the losses and revenues, the banks were required to estimate the available resources for covering the projected losses, such as the pre-provision net revenues, which is the net interest income plus non-interest income minus net interest expense.

The main macroeconomic indicators that were used for the projections were the real GDP, unemployment rate and house prices. However, the FED could decide the need of additional capital not only based on quantitative analysis but also on qualitative analysis. That means that the BHCs had also to take decisions regarding the projection process, risk management measures, corporate governance and adjustment to policies. For example, in the Comprehensive Capital Assessment Review (CCaR) in 2014, the FED objected to the capital plans of Citigroup Inc., HSBC North America Holdings Inc., RBS Citizens Financial Group, Inc., and Santander Holdings USA, Inc. based on qualitative criteria, while Zions Bancorporation's capital plan was objected to based on quantitative criteria.

4.2 Comprehensive Capital Assessment Program

In November 2011, the FED revised the capital assessment and renamed it to Comprehensive Capital Assessment Review (CCaR). The main difference from SCAP was that the BHCs with more than $50 billion in assets were required to conduct stress tests. However, the sample of banks did not change until 2013 when more BHCs were added to the stress test group. Over the years, the CCaR has been revised. The CCaR 2012 also took into account three macroeconomic scenarios instead of two; a severely adverse, an adverse, and a baseline. Another notable difference in CCaR 2014 was that BHCs with more than $250 billion were subject to the liquidity coverage ratio (LCR). This proposal aimed to create a liquidity requirement and BHCs were required to hold high quality liquid assets easily convertible to cash.

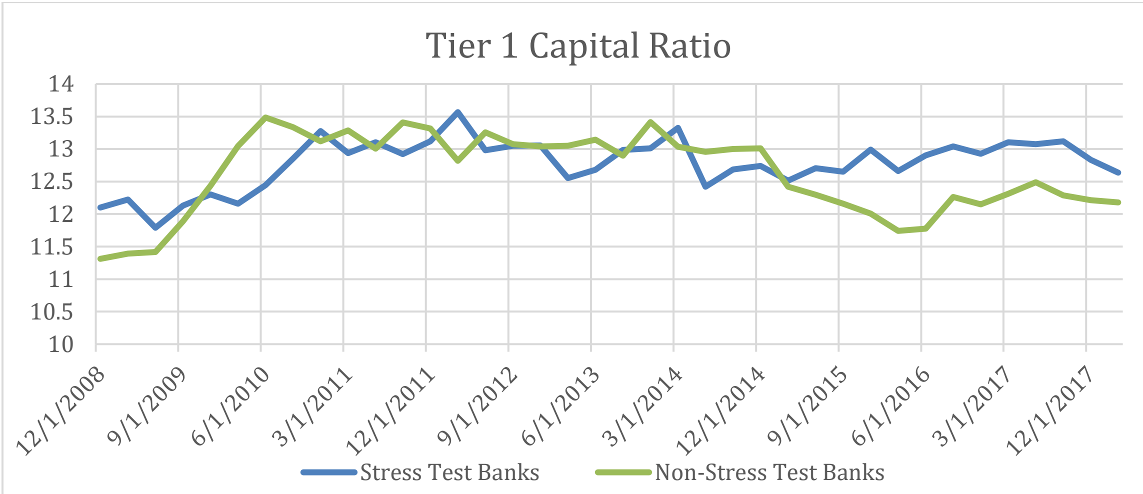
Except for the CCaR, the Federal Reserve Bank introduced the Dodd-Frank Act Stress Test (DFAST) in 2013. The process of the Dodd Frank Act is quite similar to the CCaR except for some important differences. The main difference between the Dodd-Frank Act supervisory stress tests and the CCaR is that the BHCs in CCaR can create their own assumptions regarding the capital raised in the post stress scenarios. For example, common stock dividend payments are assumed to be the same as the year before, repurchases of common stock are assumed to be zero, issuance of new common stock and preferred stock (except for issuance of common stock related to employee compensation) is not assumed. In contrast, the BHCs can develop their own strategies to raise capital in the post stress period and FED can decide if the actions meet expectations. Therefore, a BHC might have different capital ratios in the DFAST and CCaR and the public and market participants can have a better idea after reading both reports. The dates when these tests were conducted are similar. The following table shows the dates and the projected horizon of the stress tests.

Table 4.2.1: Starting Point of Projections and Projected Horizon in Stress Test.
The table shows the starting point of the projections for the stress test. The first column shows the name of the assessment program that year, the second column shows the starting point of the projections and the third column the projected horizon.

Assessment Program	Starting Point of Projections	Projected Horizon
SCAP	Q4 2008	2-years
CCaR 2012	Q3 2011	9-quarters
DFAST/CCaR 2013	Q3 2012	9-quarters
DFAST/CCaR 2014	Q3 2013	9-quarters
DFAST/CCaR 2015	Q3 2014	9-quarters
DFAST/CCaR 2016	Q1 2015	9-quarters
DFAST/CCaR 2017	Q1 2016	9-quarters
DFAST/CCaR 2018	Q1 2017	9-quarters

Source: Federal Reserve Bank

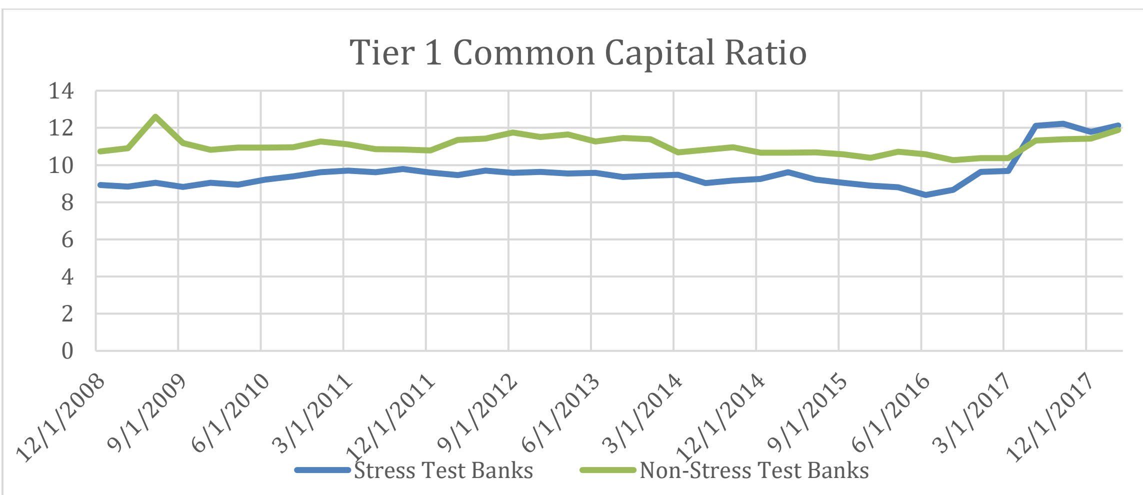
The following figures illustrate the capital and profitability ratios for stress test and non-stress banks from 2000 to 2018.



Source: Bloomberg Terminal

Figure 4.2.1: Tier 1 Capital Ratio of Stress Test and Non-Stress BHCs from 2008 to 2018.

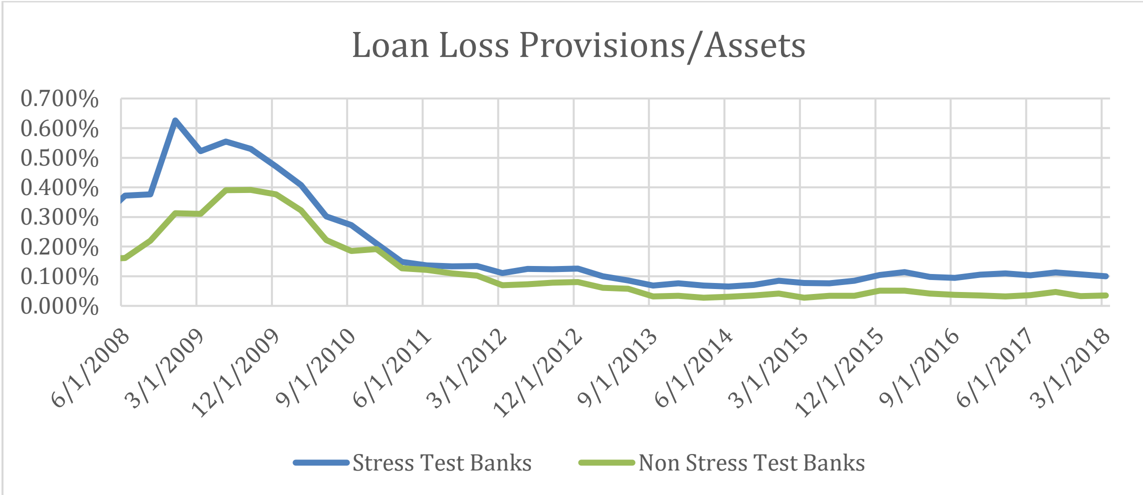
As can be easily observed in Figure 4.2.1, the Tier 1 Capital ratio of stress test banks significantly increased after 2018 and remained in high levels since then.



Source: Bloomberg Terminal

Figure 4.2.2: CET1 Ratio of Stress and Non-Stress BHCs from 2008 to 2018.

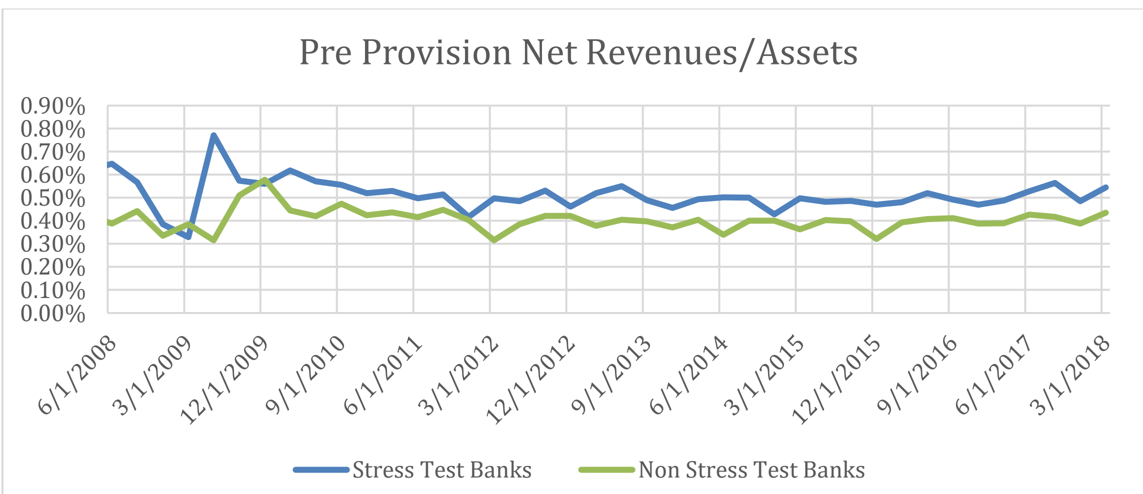
The Figure above shows the Tier 1 common Capital Ratio (CET1). Non-stress test banks hold more CET1 capital compared to stress test except for the last 1 year.



Source: Bloomberg Terminal

Figure 4.2.3: LLP/Assets of Stress Test and Non-Stress BHCs from 2000 to 2018.

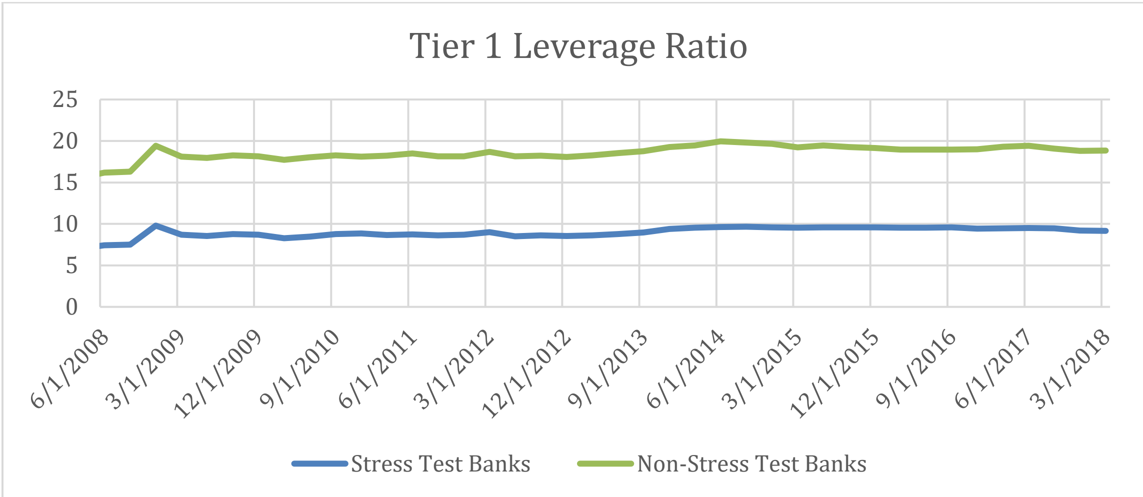
Even though the LLP to assets is higher on average for the stress test BHCs than the LLP to assets of the non-stress test, the changes of the LLP to assets are decreasing over the years more than the ratio of the non-stress test BHCs. (see Table 6.3.2, page 40)



Source: Bloomberg Terminal

Figure 4.2.4: PPNR/Assets of Stress Test and Non-Stress BHCs from 2008 to 2018.

As can be seen in Figure 4.2.4 the stress test BHCs have higher PPNR to assets compared to the non-stress test BHCs.



Source: Bloomberg Terminal

Figure 4.2.5: Tier 1 Leverage Ratio of Stress Test and Non-Stress BHCs from 2008 to 2018.

Stress test BHCs have lower Tier1 leverage ratio that the non-stress test BHCs. From the graph, we see that the leverage ratio ranges from 7 to 10%. In contrast, the Tier 1 Leverage ratio ranges between 15 and 20 % for the non-stress test BHCs.

CHAPTER 5: DATA AND METHODOLOGY

5.1 Data

The dependent variables, which are the SRISK and Marginal Expected Shortfall based on S&P 500, were provided by the V-Lab of the New York University. The data of the independent variables was retrieved from Bloomberg Terminal database and the regression models were run using STATA and SAS.

The SRISK and MES show different results. As I previously mentioned, the SRISK shows the expected shortfall of an institution as a function of its debt or liabilities, market capitalization and, MES. Whereas, MES shows only the loss of equity given a crisis. Since they are both different systemic risk measures and give different rankings, I will include both measures in my models. The data of systemic risk measures consisted of the SRISK and MES based on the MSCI world index, and the SRISK and MES based on the S&P 500 Index. After the correlation analysis, I decided to use only the SRISK and MES based on the S&P500. The SRISK (MES) based on the S&P 500 had a very high correlation with the SRISK (GMES) based on MSCI world index. The systemic risk measures were provided on a daily basis. Data were transformed to quarterly and yearly by taking the average over each time period. The SRISK is measured in billion dollars, while the MES is measured as expected return (%).

Independent variables consist of bank specific variables, mainly focused on the size, funding structure, banking activities and capital. Therefore, most variables are illustrated as function of the assets. The variables were downloaded by Bloomberg Professional. In order to see whether systemic risk decreases or increases over time and control for endogeneity, I transformed the dependent variables into changes (either yearly or quarterly changes). In order to control for bank and time specific characteristics that could affect my results, I have included time and bank fixed effects. In order to ensure that the fixed effects method is optimal, Hausman test is employed. In addition, in order to avoid heteroscedasticity across the banks I have included bank clustered errors. Finally, in order to avoid multi-collinearity, I implement Variance Inflation Factor (VIF). If the value of a VIF exceeds 10, then it is an indication of multi-collinearity (Hair, et al. 2014).

5.2 Explanatory Variables

This section discusses the predictor variables and the reasons for choosing them. Consistent with previous literature, I use bank characteristics found to affect the systemic risk including size, capitalization, and bank funding. In addition, the variables are related to the primary components of systemic risk: size and debt.

Ln (Assets)

Assets is used to proxy the size of Bank Holding Companies. Previous literature suggests that size does not necessarily impact systemic risk. Brunnermeier, Dong, and Paliab (2012) suggest that when assets are large they contribute more to systemic risk; while Weiß, Bostandzic, and Neumann (2014) suggest that the size of banks has either none or a negative impact on systemic risk during a financial crisis. The transformation of my variables to changes will be a good way to mitigate the size problem. Thus, I will not only focus on the impact of size on systemic risk but also the impact of the changes in size of the assets on systemic risk.

Tier 1 Capital Ratio

The Tier 1 Capital Ratio or Tier 1 risk-based Capital Ratio is an ideal proxy of capital requirements. Including the Tier 1 Capital ratio helps to determine if the imposition of the capital requirements has an impact on systemic risk. A positive association between the Tier 1 Capital Ratio and the systemic risk means that higher capital increases systemic risk. BHC's performance on the stress test is dependent on the Tier 1 Capital Ratio as discussed above. Even though the FED includes Tier 1 common ratio, Tier 1 Leverage Ratio, and Total Risk Based Ratio, I will only report the Tier 1 Capital Ratio since the capital ratios are highly correlated with each other (see Appendix 1). Moreover, the Tier 1 Capital Ratio is a more reliable representation of a bank's financial health. Tier 1 Capital includes the core equity component plus disclosed reserves, preferred shares, and non-controlling interests.

Pre-Provision Net Revenues to Assets (PPNR)

Pre-provision net revenues is a profitability indicator that affects a bank's capital. It is one of the most important indicators on which BHCs focus in the stress test process. The PPNR is calculated as net interest income plus noninterest income minus noninterest expense. I expect a negative association between the PPNR/Assets and systemic risk.

Loan Loss Provisions to Assets

Similar to PPNR, Loan Loss Provisions (LLP) is a financial ratio that affects the capital. The LLP is a measure of the "bad loans" issued by a BHC, and therefore, I expect a positive impact on systemic risk

Deposits to Assets

Deposits to assets are included because they are a significant share of a BHCs liabilities and I test whether the deposits have an impact on systemic risk. Higher deposits mean higher interest expense which is a component of the pre-provision net revenues. Also, higher deposits means more money for banks to invest.

Loans to Assets

Consumer Loans/Assets, Real Estate Loans/Assets, and Commercial Loans capture any effects of loan specific characteristics on systemic risk. I am interested in seeing if the different type of loans will have different impact on systemic risk.

Debt to Capital

Finally, in order to control for the capital structure of a BHC, I have included Debt/Total Capital as an explanatory variable. Even though the debt is not part of assets I include it in my models because debt is part of SRISK. The expectation is that an increase in the debt to capital ratio will increase systemic risk and, more specifically, SRISK.

5.3 Fixed Effects vs Random Effects

In many cases, in panel data models there are unobserved explanatory variables that are constant over time and affects the dependent variable. That unobserved factor can either be an individual (bank) specific characteristic or time. Even though my unbalanced data includes several BHCs over the years, there might be a factor that is constant by bank or constant by year and affect my dependent variable. In order to address this issue, I use a fixed effect a model. I illustrate the model with the time invariant variable as follows:

$$SRISK_{b,t} \text{ or } MES_{b,t} = \beta_0 + \beta_1 * Bank\ Characteristics_{b,t} + a_b + u_{bt}$$

where a_b captures unobserved time invariant factors that affect the dependent variable. This time-invariant variable is also known as unobserved heterogeneity and bank dummies can control for this. To eliminate the unobserved fixed factor we differentiate our data over time and eliminate the unobserved effect, as below:

$$\Delta SRISK_{b,t} \text{ or } \Delta MES_{b,t} = \beta_1 * \Delta Bank\ Characteristics_{b,t} + \Delta u_{bt}$$

In this case, I have not included bank specific fixed effects when I measure my variables as changes. Similarly, we can construct a model by including dummies by time and catch any unobserved factor that affects the dependent variable over time.

$$\Delta SRISK_{b,t} \text{ or } \Delta MES_{b,t} = \beta_0 + \beta_1 * Bank\ Characteristics_{b,t} + a_b + c_t + u_{bt}$$

where c_t is an unobserved factor that is time specific. The goal of fixed effects, or first differencing, is to eliminate the unobserved factor that is assumed to be correlated with one or more of the explanatory variables. If the unobserved factor is assumed to be uncorrelated with the explanatory variable then a random effects model is preferable. One way to choose between fixed effects and random effect is to conduct the Hausman test. The null hypothesis of the Hausman test is that both methods can be used, while the alternative method is that the fixed effects method is ideal. My models include fixed effects method, either time or bank or both.

5.4 Heteroscedasticity and Autocorrelation

According to Stock and Watson (2012), the main assumptions of a fixed effect regression include:

1) The error term u_{bt} has a conditional mean of zero
2) The variables are independent across entities
3) Large outliers are unlikely

4) There is no perfect multicollinearity

Assumption 2, implies that the variables are independent across entities but not within entities. That means that the fixed effect assumption allows for autocorrelation of the time series within the entities. In order to deal with the correlation within entities, I use clustered standard errors. This approach considers each entity (BHC) as a cluster, allows correlation and heteroscedasticity within entities yet treats the error term of the clusters as uncorrelated across entities[5] (Stock and Watson, 2012).

5.5 Explanation of Methods Used

5.5.1 Regression Discontinuity Approach

The regression discontinuity (RD) was first introduced in the literature in 1960 by Thisthlewaite and Cook. Since then the regression discontinuity design has been used in a growing number of papers. The regression discontinuity design consists of two groups, the treatment group and the control group. A treatment group is a group that receives a treatment during an experiment while the control does not. In my research, the treatment group is considered the stress test banks, because by regulation, BHCs with more than 50 billion have to conduct stress test. In other words, what differentiates the treatment and the control group is asset size, 50 billion USD. The latter is considered the cutoff. The RD design simply compares two outcome variables, the outcome from the treatment that is above the cutoff and the outcome from the control group that is below the cutoff. The RD design estimates the casual impact of the treatment group by estimating the difference between the two outcomes. The goal is to study whether the treatment group has a different

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[5] In STATA, I address this issue by including the function cluster (entity), where entity is an identification of the Bank Holding Companies.

outcome from the control. One way to achieve that is to run a regression that estimates the effect of the independent variables on the dependent variable (assets) above the cutoff and one regression that estimates the effect of the independent variables on the dependent variable (assets) below the cutoff. The next step is to estimate the difference between the dependent values of the two regressions that are related to their intercepts.

5.5.1.1 Parametric

For example, assuming that the dependent variable is systemic risk, regression 1 shows the outcome if the assets are above the cutoff.

If $Assets \geq 50\ billion\ USD,$ then regression 1:

$$Systemic\ risk = a_1 + f_1(Assets - 50) + u$$

If $Assets < 50\ billion\ USD,$ then regression 2:

$$Systemic\ risk = a_2 + f_2(Assets - 50) + u,$$

where $f(Assets - 50)$, is a functional form. More generally, if we assume that the regression model is linear, then we can create the following formula:

$$Systemic\ risk = a + \tau T_i + \ f(X) + u,$$

where

$a =$ The average value of outcome of the treatment group

T_i = a dummy variable that equals 1 if the bank belongs to the treatment group

X= Assets-50

τ = The marginal impact of the regulation on the systemic risk for the treatment group. Combining these two equations we can create the following formula (Thisthlewaite and Cook, 1960):

$$Systemic\ risk = a_1 + \tau T_i + f_1(Assets_i - 50) + T_i[f_2(Assets_i - 50) - f_1(Assets - 50)] + u_i,$$

where T_i is a dummy variable that equals 1 if the bank belongs to the treatment group and τ equals $a_2 - a_1$. If τ is positive and significant it means that the treatment group has positive association with the systemic risk.

We can simply observe that if

$T = 0$ then

$$Systemic\ risk = a_1 + f_1(Assets_i - 50) + u_i,$$

And if $T = 1$ then

$$Systemic\ risk = a_2 + f_2(Assets_i - 50) + u_i$$

we can estimate the differences of the intercepts.

5.5.1.2 Non-Parametric-Kernel Approach

If we consider all the observations above and below the cutoff then the regression that is used is parametric. When we are concerned with measuring the impact of the treatment group near to the cutoff then the best approach would be non-parametric. In the non-parametric approach a local polynomial method is applied. I use non-parametric, local polynomial approach because I want to explore the effect of the treatment and control group around the cutoff. The local polynomial approach consists of the following factors according to Matias, Cattaneo, Idrobo, and Titiunik (2018):

a) A polynomial order p and a kernel function $K(\cdot)$;

b) Selection of the optimal bandwidth h;

c) For observations above the cutoff $Assets \geq 50\ billion\ USD$, a weighted least square regression is implemented, such as $Systemic\ risk = a_a + f_{a1}(X) + f_{a2}(X^2) + \cdots + f_{ap}(X^P) + u$, with weight $K(\frac{Assets_i - 50}{h})$ for each observation.

d) For observations below the cutoff: $Systemic\ risk = a_b + f_{b1}(X) + f_{b2}(X^2) + \cdots + f_{bp}(X^P) + u$, with weight $K(\frac{Assets_i - 50}{h})$ for each observation.

Therefore, the RD point estimate is similar to the earlier approach, the difference between the two intercepts. The triangular kernel approach simply assigns zero weight to the observations outside of the optimal bandwidth $[50 - h, 50 + h]$ while it assigns maximum weights to observations at the cutoff $[50 = h]$.

The optimal bandwidth h can be determined in STATA by using the "rdrobust" function. The "rdrobust" function allows me to include additional variables in the model for better estimation, as well as optimal selection of bandwidth. Consistent with the previous literature of bank behavior regarding the stress test, Schorno et al. (2018), I implement a non-parametric triangular kernel approach.

5.6 Models

First, I illustrate the number of Bank Holding Companies included in my sample over the years. The total sample consists of 55 Bank Holding Companies with assets of more than $10 billion. Then I present the mean, median and correlations of the SRISK and MES measures as well as the control variables. The rest of my research is divided into the following 9 parts.

1. Impact of Capital requirements on the Systemic Risk.
2. Differences in the systemic risk measures between stress test and non-stress test banks. After the stress test period (2008-2018).
3. Differences in the systemic risk measures for the stress test banks before and after the initial stress test. (2000-2018).

4. Differences in the changes of the systemic risk measures between stress test and non-stress test banks after the stress test period (2008-2018).
5. Differences in the changes for systemic risk measures for the stress test banks before and after the stress test period. (2000-2018).
6. The impact of stress test on newly joined BHCs.
7. Changes in the systemic risk around the stress test quarters.
8. The impact on the systemic risk between banks around the cut off imposed by FED ($50 billion in assets)
9. Specific changes of the systemic risk from a stress test quarter to the next.

5.7 Robustness

Several robustness checks have been used in the literature. Banerjeea and Mio (2017) study the impact of liquidity regulations on banks and limit their data by excluding US banks. Huang (2018) excludes large banks, defined by size, to test if results regarding the systemic risk contribution are dominated by larger banks. Acharya, Berger and Roman (2017) use median regression to mitigate the effect of outliers. Similar to previous literature, I limit the effect of extreme values that might affect my results. I modify the observations that are in the lowest or highest 1% in each tail to adjust my model for outliers. The results are consistent with my initial models and my conclusions are the same. To further check robustness I exclude systemically important BHCs. Following the previous findings, the results and conclusions remain unchanged for most cases. The tables of the latter approach are reported in the Appendix.

CHAPTER 6: RESULTS

6.1 Sample-Stress Test/Non-Stress Test

Table 6.1.1: Total BHCs used in the data

Year	Stress test BHCs (Assets>$50B)	Stress Test BHCs used	Non-Stress test BHCs	Total BHCs used in the sample (Assets > $10B)
2009	19	17	38	55
2010	0	0	55	55
2011	19	17	38	55
2012	19	17	38	55
2013	18	17	38	55
2014	30	23	32	55
2015	31	23	32	55
2016	33	23	32	55
2017	33	23	32	55

Source: S&P Global Market Intelligence

Table 6.1.1 illustrates the total sample of the Bank Holding Companies included in my research. In 2010, none of the BHCs conducted stress tests; therefore, none of the BHCs will be considered as stress test BHCs if they are not specified otherwise. The overall sample consists of 55 BHCs. Of the 19 stress test banks from 2009 to 2012, 17 BHCs are used because of limited data. The rest of the sample consists of BHCs with more than $10 billion in assets. In 2014, 12 BHCs joined the stress test group. However, only 6 have been included in my sample, due to limited data.

6.2 Correlations

Table 6.2.1: Correlations between Systemic Risk Measures

	SRISK/MSCI	SRISK/S&P 500	GMES	MES
SRISK/MSCI	1.0000			
SRISK/ S&P500	0.9841	1.0000		
GMES	0.3606	0.3569	1.0000	
MES	0.3195	0.3353	0.8078	1.0000

Table 6.2.1 shows the correlations of the systemic risk measures. As can be observed, the SRISK/MSCI and the SRISK/S&P500 are highly correlated. Therefore, my research will focus on SRISK based on the S&P 500. The GMES and MES are also highly correlated and MES is preferred over the GMES for the same reason as the SRISK/S&P 500. The correlation between SRISK and MES ranges from 31.95% to 36%. We know from the previous literature that the MES and SRISK show different results.

6.3 Summary Statistics

Table 6.3.1: Mean differences – Variables in Level Form

This table reports whether there is a significant difference between the stress test, non-stress test banks and new stress test BHCs.

Level	Stress Test Banks	Non-Stress Test Banks	Significance	New Stress Test Banks	Significance	Significance
	(1)	(2)	(1)-(2)	(3)	(3)-(1)	(3)-(2)
SRISK-MSCI (bn.)	10.75826	.5950768	***	-2.311677	***	
SRISK-S&P 500(bn.)	14.94273	1.184298	***	-1.772035	***	*
GMES%	.4152683	.3693318	***	.3674158	**	
MES%	.4981571	.4736221		.4145105		***
Assets (mil.)	610230.9	55938.6	***	80983.25	***	
PPNR/Assets%	.0049334	.0042508		.0052485	**	
LLP/Assets%	.0016288	.0013246	***	.0008566	***	
Tier 1 Capital Ratio%	12.76009	12.56374	*	12.6858		
Ln(Assets)	12.65319	10.04214	***	11.27504	***	***
Deposits/Assets%	62.6697	74.23341	***	76.35779		***
Commercial Loans/Assets%	.2788196	.4247628	***	.4348479		***
Consumer Loans/Assets%	.2347683	.1989278	***	.2875606	***	*

Real Estate Loans/Assets%	.2037035	.3737059	***	.2816617	**	***
Debt/Capital%	58.78257	46.06332	***	41.84786		***
Debt/Equity	201.6456	108.9839	***	88.0518		***
Tier 1 Leverage Ratio%	9.205181	9.681501	***	10.51708		***
CET1%	10.80243	11.82083	***	11.36792		
Risk Based Capital Ratio%	15.22425	14.56515	***	14.6125		

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

Table 6.3.1 displays the mean and significance of the mean differences in the level form between the variables for the period 2008-2018. The averages of the SRISK/MSCI and the SRISK/S&P500 for the stress test BHCs are significantly higher than the SRISK measures of the non-stress test BHCs. Specifically, the SRISK/MSCI is approximately $10.75 billion for the stress test banks while the SRISK/MSCI for non-stress test banks is $0.59 billion on average. Similarly, the SRISK/S&P 500 is approximately $15 billion while it is only $1.18 billion for the non-stress test BHCs. The average of the new stress test banks is the average of the variables of the BHCs that joined the stress test group in 2014. The average of the SRISK for the new stress test BHCs is significantly lower compared to the non-stress test and existing stress test BHCs. I also observe that the stress test BHCs have higher GMES and MES on average than the non-stress test BHCs and new-stress test BHCs. In all cases, the means of the variables of interest are significantly different from each other.

Table 6.3.2: Mean Differences-Variables in Yearly Changes

This table reports whether there are significant differences between the stress test, non-stress test and new stress test BHCs when the variables are measured as yearly changes.

	Stress Test BHCs	Non-Stress Test BHCs	Significance	New Stress Test BHCs	Significance	Significance
	(1)	(2)	(1)-(2)	(3)	(3)-(1)	(3)-(2)
ΔSRISK/ MSCI (bn.)	-4.534106	-.1863188	***	.9787311		***
ΔSRISK/S&P 500(bn.)	-4.698174	-.1871768	***	.8353124		***
ΔGMES%	-.0035256	.0026972		.0271241		
ΔAssets (mil)	11886.39	1796.724	***	4230.304		
ΔMES%	-.0171398	-.0056558		.0072959		
ΔPPNR/Assets%	.0003598	.000261		.000146		
ΔLLP/Assets%	-.000181	-4.35e-06		.0001809		
ΔTier 1 Capital Ratio%	.0417683	-.1334909		-.4266667		
ΔLog(Assets) (mil.)	.031403	.0936588	***	.0520725		
ΔDeposits/Assets%	.8760707	.0874754		-.6906667		
ΔCommercial Loans/Assets%	.0013646	.0061729		-.0006435		
ΔConsumer Loans/Assets%	-.0029677	-.0032524		-.0052832		
ΔReal Estate Loans/Assets%	-.0033068	-.0003216		.0015732		
ΔDebt/Capital%	-.8768774	-1.979936		1.816383		
ΔDebt/Equity%	-10.64845	-8.918946		9.134067		
ΔTier 1 Leverage Ratio%	-.0445963	-.0250958		-.4483333		
ΔCET1%	.3014024	.167782		-.42		
ΔRisk Based Capital Ratio%	.0269512	-.1478467		-.3466667		

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

Table 6.3.2 shows the average changes a year before and a year after the stress test for the variables of interest. The changes for the stress-test banks are on average considerably less than the average of the non-stress test banks while the differences of the means are significantly different from zero. When using yearly changes, we see that none of the variables, except for Ln (Assets), are significantly different from each other; while the variables of interest, such as SRISK, are significantly different not only between the stress test and non-stress banks but also between new stress test and non-stress test banks.

The average Ln (Assets) change of the non-stress test banks is approximately 0.9 billion dollars while the average change for stress test banks is around 0.3 billion dollars.

Table 6.3.3: Mean and Median of the Systemic Risk Measures in 2007

2007	Mean		Median	
	Stress Test Banks	Non-Stress Banks	Stress Test Banks	Non-Stress Test
SRISK/MSCI	-5.89749	-2.60000***	-0.88080***	-0.59769***
SRISK/S&P 500	2.48221***	-3.07509***	-0.64385***	-0.39257***
GMES	0.363030***	0.338120***	0.314471***	0.304951***
MES	0.449498***	0.444261***	0.412194***	0.415133***

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

The table above shows the mean and median of systemic risk measures and the difference from zero one year before the initial stress test in 2007. As illustrated, the average SRISK is negative for the stress test and non-stress test banks. The SRISK-S&P 500 for stress test BHCs is $2.4 billion and the GMES and MES of both stress test and non-stress test are quite similar to each other.

Table 6.3.4: Mean and Median of the Systemic Risk Measures in 2009

2009	Mean		Median	
	Stress Test	Non-Stress Test	Stress Test	Non-Stress Test
SRISK/MSCI	28.23137	0.380235***	7.78588***	0.201606***
SRISK/S&P 500	32.92181***	0.598146***	9.44428***	0.350138***
GMES	0.512616***	0.416870***	0.512616***	0.408034***
MES	0.655912***	0.566409***	0.629684***	0.570381***

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

Table 6.3.4 shows the means of systemic measures a year after the first stress test. The difference between the systemic risk measures are extremely high. Even though the mean of SRISK/MSCI is not significantly different from zero at 10% level it increased by 579% from -5.89 billion to 28.23 billion, while the SRISK S&P 500 increased by 1226% from 2.48 to 33 billion. The dramatic increase in SRISK is possibly due to the financial crisis.

Table 6.3.5: Mean and Median of the Systemic Risk Measures of New Stress Test BHCs

New Stress Test Banks	Before Stress Test (2011)		After Stress Test (2014)	
	Mean	Median	Mean	Median
SRISK/MSCI	-0.04981	0.17813***	-2.311677***	-0.74789**
SRISK/S&P 500	0.593057*	0.862408**	-1.772035**	-0.47209
GMES	0.366009***	0.370638***	.3674158***	0.364983***
MES	0.462464***	0.566409***	.4145105***	0.419085***

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

Table 6.3.5 shows the difference between the mean and medians of new stress test banks three years before the stress test and one year after. I chose to test three years before the BHCs already knowing that they will join the stress test group, as discussed earlier. The average of the SRISK/S&P 500 was 0.59 billion in 2011 while in 2014 it considerably decreased to -1.77 billion. Except for the SRISK/SP500, all the systemic risk decreased except for the GMES which slightly increased by 0.384%.

6.4 Capital Requirements

Table 6.4.1: The Impact of Capital Requirements on Systemic Risk. This table provides the impact of the capital requirement Tier 1 capital ratio on Systemic Risk measures. The Tier 1 capital ratio is one of the key ratios that shows whether the BHCs pass the stress test. The goal of the BHCs is to achieve a Tier 1 Capital ratio higher than the minimum buffer. All the models are adjusted for outliers at 1% level.

	Stress Test BHCs 2009-2018		Non-Stress Test BHCs 2009-2018	
	(1)	(2)	(3)	(4)
VARIABLES	SRISK/S&P 500	MES	SRISK/S&P 500	MES
Ln(Assets)	27.17***	0.0423	0.0201	0.0369**
	(9.306)	(0.0265)	(0.131)	(0.0175)
PPNR/Assets	-0.332	-0.00505	-0.652***	-0.0385***
	(4.362)	(0.0107)	(0.165)	(0.0128)
LLP/Assets	1.958	0.0901**	1.055***	0.0821***
	(7.157)	(0.0347)	(0.231)	(0.0181)
Tier 1 Capital Ratio	-2.500**	-0.000995	-0.0107	-0.000230
	(1.126)	(0.00357)	(0.0116)	(0.00157)
Debt/Capital	-0.130	-0.000439	0.0125*	0.000493
	(0.120)	(0.000515)	(0.00712)	(0.000358)
Real Estate Loans/Assets	-39.41	0.0420	-0.0922	-0.0599
	(31.93)	(0.0726)	(0.596)	(0.0618)
Consumer Loans/Assets	92.46	-0.0660	-0.595	0.0175
	(68.43)	(0.158)	(0.591)	(0.0786)

Commercial Loans/Assets	-76.98	-0.236	-1.086*	-0.0503
	(47.36)	(0.160)	(0.617)	(0.0711)
Constant	-265.0**	0.0589	-0.0644	0.0495
	(105.4)	(0.376)	(1.356)	(0.180)
Observations	684	684	1,212	1,212
R-squared	0.449	0.817	0.490	0.727
Number of id	18	18	35	35
Bank Controls	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

The table above is based on the following regression:

$SRISK_{b,t}$ *or* $MES_{b,t} = \beta_0+\beta_{1*}$*Bank Characteristics*$_{b,t}+\beta_{2*}$*Bank Fixed Effects*$_b+\beta_{3*}$*Time Fixed Effects*$_t+\varepsilon_{b,t}$

Table 6.4.1 shows the determinants of the systemic risk for stress test as well for non-stress test BHCs. Assets are a key determinant of the stress test BHCs which are also large in size. An increase in assets by 100%, will increase the SRISK of stress test BHCs by 26.19 billion USD. In contrast, assets have no statistically significant impact on SRISK for the non-stress test BHCs. In addition, the Tier1 capital ratio has a negative impact on systemic risk for stress test BHCs, while having no impact on non-stress test BHCs. Therefore, the increase in the capital requirement is effective for the stress test BHCs.

6.5 Impact on the Systemic Risk Measures-Variables in Level Form

Table 6.5.1: Impact of the Stress Test on Systemic Risk. This table shows the differences in systemic risk measures between stress test and non-stress test banks from 2008 to 2018. The data is measured as quarterly observations in the level form. The stress test indicator is a binary variable that equals 1 if the bank is a stress test bank and 0 otherwise. All the OLS regression models are adjusted for outliers at 1% level.

	Total Sample Included 2008-2018 *(Outliers Adjusted)*	
	(1)	(2)
VARIABLES	SRISK/S&P 500	MES
Stress Test	5.377**	0.00267
	(2.523)	(0.0115)
LN(Assets)	8.998**	0.0690***
	(3.526)	(0.0198)
PPNR/Assets	-1.664	-0.0227**
	(2.391)	(0.00982)
LLP/Assets	1.549	0.0927***

	(2.247)	(0.0201)
Tier 1 Capital Ratio	-0.601	-0.000207
	(0.415)	(0.00171)
Debt/Total Capital	-0.0406	0.000757
	(0.0781)	(0.000457)
Real Estate Loans/Assets	-0.125	-0.0294
	(6.078)	(0.0504)
Consumer Loans/Assets	20.20	0.0245
	(15.70)	(0.0812)
Commercial Loans/Assets	7.746	0.00440
	(13.00)	(0.0769)
Deposits/Assets	-0.248	0.00207*
	(0.258)	(0.00112)
Constant	-70.62*	-0.501
	(39.34)	(0.299)
Observations	1,783	1,783
R-squared	0.219	0.727
Number of id	47	47
Bank Controls	YES	YES
Year Fixed Effects	Yes	Yes

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 6.5.1 considers the following estimated regression:

$SRISK_{b,t}$ *or* $MES_{b,t} = \beta_0+\beta_1 * Stress\ Test_b+\beta_2 * Bank\ Characteristics+\beta_3 * Bank\ Fixed\ Effects_b+\beta_4 * Time\ Fixed\ Effects_t+\varepsilon_{b,t}$.

The results are in Table 6.5.1. Column 1 suggests that the coefficient of the stress test dummy is positive and significant at 5% level. That means that the stress test BHCs have on average, higher systemic risk than the non-stress test BHCs. More specifically, the stress test BHCs have $5.377 billion higher SRISK than the non-stress test BHCs.

The results also suggest that the Ln (Assets) have an impact on SRISK as well as on MES. In addition, LLP is also a key indicator during the stress test process with a positive impact on MES. During the stress test process, the goal of the stress test BHCs is to decrease this indicator; additionally, the positive association with the MES shows how important it is for BHCs to keep the LLP as low as possible. In order to validate my results, I also perform regression discontinuity.

Table 6.5.2: Impact on the Systemic Risk of Stress Test BHCs after the Stress Test Period. This table shows the difference in the systemic risk measures before and after the stress test period for the stress test BHCs. The indicator of stress test is equal to 0 from 2000 to 2008, while it equals 1 after the fourth quarter of 2008 for the majority of the BHCs because in 2014 six more BHCs were added in the sample. Columns 3, 4, 7 and 8 include a dummy for the 2010 period, in which no stress test is conducted. Columns 5-8 show the robustness check of the results by excluding the systemically important BHCs. All the OLS regression models are adjusted for outliers at 1% level.

	Stress Test Banks 2000-2018				Stress Test Banks 2000-2018 (Systemically Important BHCs are excluded)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	SRISK/S&P 500	MES	SRISK/S&P 500	MES	SRISK USA	MES	SRISK/S&P 500	MES
Post Stress	13.75**	0.00510	13.32**	0.00308	5.623*	-0.00125	5.315*	-0.00412
	(5.921)	(0.0183)	(5.815)	(0.0176)	(2.774)	(0.0192)	(2.591)	(0.0182)
Stress2010			5.397**	0.0252*			4.149*	0.0385***
			(2.065)	(0.0125)			(2.329)	(0.0125)
LN(Assets)	7.445**	0.0438*	7.639**	0.0447*	4.728	0.0520**	4.905	0.0537**
	(3.423)	(0.0216)	(3.442)	(0.0212)	(3.168)	(0.0232)	(3.268)	(0.0225)
PPNR/Asset	-2.743	-0.0540*	-2.969	-0.0551**	-0.0921	-0.0406	-0.499	-0.0443
	(7.915)	(0.0257)	(7.652)	(0.0256)	(4.709)	(0.0284)	(4.477)	(0.0285)
LLP/Assets	22.24***	0.293***	21.79***	0.290***	14.39***	0.275***	14.09***	0.272***
	(7.248)	(0.0363)	(7.082)	(0.0362)	(4.527)	(0.0392)	(4.345)	(0.0388)
Tier 1	0.763	0.00389	0.641	0.00332	0.0259	0.00335	-0.0919	0.00226
	(0.911)	(0.00332)	(0.920)	(0.00336)	(0.426)	(0.00380)	(0.473)	(0.00369)
Debt/Total Capital	0.429*	-0.00107**	0.412*	-0.00115**	0.111*	-0.00133***	0.0996	-0.00144***
	(0.220)	(0.000482)	(0.217)	(0.000485)	(0.0612)	(0.000436)	(0.0590)	(0.000427)
Real Estate Loans/Asset	7.679	0.0741	6.974	0.0708	6.461	0.0837	5.680	0.0765
	(10.19)	(0.130)	(10.23)	(0.128)	(7.244)	(0.142)	(6.720)	(0.139)
Consumer Loans/Asset	-4.300	-0.122	-3.967	-0.121	5.657	-0.0757	6.202	-0.0707
	(24.59)	(0.167)	(24.77)	(0.166)	(11.06)	(0.175)	(10.91)	(0.172)
Commercial Loans/Asset	-16.21	0.0910	-15.09	0.0962	1.303	0.123	1.759	0.127
	(22.25)	(0.111)	(22.30)	(0.109)	(9.209)	(0.116)	(9.147)	(0.113)
Constant	-121.4**	-0.0847	-121.5**	-0.0855	-71.48	-0.185	-71.50	-0.185
	(55.00)	(0.282)	(54.96)	(0.279)	(45.06)	(0.276)	(45.24)	(0.274)
Observations	1,234	1,234	1,234	1,234	1,052	1,052	1,052	1,052
R-squared	0.268	0.394	0.272	0.396	0.260	0.402	0.268	0.407
Number of id	18	18	18	18	15	15	15	15
Bank Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	No	No	No	No	No	No	No	No

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

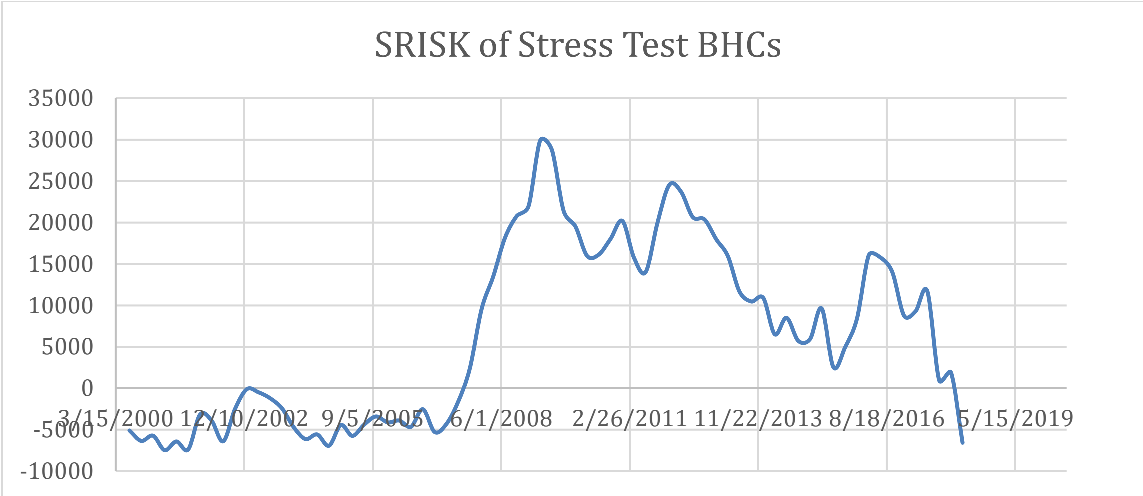
Table 6.5.2 considers the following estimated regressions:

$SRISK_{b,t}$ or $MES_{b,t} = \beta_0+\beta_1 * Stress\ Test_i+\beta_2 * Bank\ Characteristics_{b,t}+\beta_3 * Bank\ Fixed\ Effects_b+\varepsilon_{b,t}$ (Columns 1,2,5 and 6)

$SRISK_{b,t}$ or $MES_{b,t} = \beta_0 + \beta_1 * Stress\ Test_i + Stress2010_i+\beta_2 * Bank\ Characteristics_{b,t}+\beta_3 * Bank\ Fixed\ Effects_b + \varepsilon_{b,t}$ (Columns 3,4,7, and 8)

Table 6.5.2 compares the SRISK and MES in the pre-stress and post-stress test period only for the stress test BHCs. The SRISK is higher over the post stress period by $13.75 billion compared to the pre-stress test period. In addition, The PPNR to assets has a negative impact on MES. This is consistent with my expectation in chapter 5. As long as the PPNR increases, the capital increases as well. Similar to Table 6.2.1, the LLP to assets has a positive impact on MES. In columns 3 and 4, in which the 2010 dummy has been included, its coefficient is significant but lower than the stress test period. Columns 5 to 8 illustrate OLS regression results with systemically important banks excluded. The stress test indicator suggests that SRISK increased over the stress test period, while SRISK for the year 2010 has a positive impact on SRISK and MES. A possible explanation is that after the dramatic increase of SRISK during the crisis, the BHCs didnot reduce their SRISK to pre-crisis levels. This not a surprise since the same had happened with the credit risk spreads. During the crisis, the credit risk spreads rose, and the spreads remained higher than the pre-crisis period (Baker and Cumming, 2017).

In addition, LLP has a positive impact on SRISK as well as MES. A unit increase of LLP is associated with a 22.24 billion increase in SRISK and 0.293 percentage points in MES. Finally, a unit increase of debt increases the SRISK by 0.49 billion USD. Consistent with the formula of SRISK, as the debt increases, while the capital remains constant, the SRISK increases as well.



Source: V-Lab, New York University

Figure 6.5.1: SRISK for Stress Test BHCs from 2008 to 2018.

SRISK before the stress period is very low and in some cases below zero. During the crisis, SRISK dramatically increased but in the post crisis period (stress test period) SRISK has continuously decreased except for 2015-2016 in which SRISK dramatically increased. A possible explanation for the spike could be the financial crisis in China, when some of the largest BHCs had credit exposure according to the US-China Economic and Security Review Commission.

6.6 Impact on Yearly Changes-First Yearly Difference

Table 6.6.1: Impact of the Stress Test on yearly changes of the Systemic Risk. This table illustrates the impact of the stress test on the changes of SRISK and MES between the stress test and non-stress test BHCs. The variables are measured as yearly changes. The stress test variable, is a dummy indicator that equals 1 if the BHC runs stress test that year, 0 otherwise. All the OLS regression models are adjusted for outliers at 1% level.

	All Banks 2008-2018	
	(1)	(2)
VARIABLES	ΔSRISK/S&P 500	ΔMES
Stress Test	-5.198**	-0.0294***
	(2.050)	(0.00911)
ΔLN(Assets)	4.949*	0.0190
	(2.738)	(0.0169)
ΔPPNR/Assets	0.960	0.000906
	(0.729)	(0.00432)
ΔLLP/Assets	1.225**	0.0359***
	(0.543)	(0.00657)
ΔTier 1 Capital Ratio	-0.0803	0.00397*
	(0.164)	(0.00231)
ΔDebt/Total Capital	-0.00609	-0.000115
	(0.0283)	(0.000446)
ΔReal Estate Loans/Assets	11.47*	0.0285
	(5.933)	(0.110)
ΔCommercial Loans/Assets	-11.21	0.0192
	(7.543)	(0.0748)
ΔConsumer Loans/Assets	-13.33*	0.137*
	(7.225)	(0.0714)
ΔDeposits/Assets	-11.47	-0.0655
	(12.37)	(0.121)
Constant	3.545***	0.0565***
	(1.173)	(0.00942)
Observations	500	500
R-squared	0.208	0.724
Number of id	53	53
Bank Controls	Yes	Yes
Year Fixed Effects	Yes	Yes

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 6.6.1 considers the following estimated regression:

$$\Delta SRISK_{b,t} \text{ or } \Delta MES_{b,t} = \beta_{1*} Stress\ Test_b + \beta_{2*} \Delta Bank\ Characteristics_{b,t} + \beta_{3*} Fixed\ Effects_t + \varepsilon_{b,}$$

Table 6.6.1 shows the differences of the changes of SRISK and MES between the stress test and non-stress test BHCs. The variables are measured as average yearly changes (first difference). Since the stress test is conducted every year the variables can be considered as changes from the stress test year to the next. Stress test BHCs report lower SRISK and MES than the non-stress test BHCs. The SRISK is -5.198 billion USD lower for stress test BHCs than non-stress test BHCs. While the SRISK of the stress test BHCs in the level form is higher than the SRISK of the non-stress BHCs, the changes of systemic risk measures of the stress test BHCs are negatively higher than the non-stress test BHCs.

After controlling for bank specific characteristics, and time fixed effects, the stress test BHCs decrease their SRISK and MES compared to non-stress BHCs. A possible explanation is that the regulation of the stress test and the increase in capital requirements are effective for the stress test BHCs and key factors in mitigating the systemic risk compared to non-stress test BHCs. Similar to Table 6.5.1, I also conduct a regression discontinuity in order to see whether the BHCs above the cutoff decrease their systemic risk.

Table 6.6.2: Impact on yearly changes of the systemic risk for stress test BHCs after the stress test period. This table shows the differences of the yearly changes of the systemic risk between the pre-stress test period and the post stress test period. Post stress is a dummy variable that equals 1 when the BHCs started conducting stress test. Columns 3, 4, 6 and 7 include a dummy that equals 1 for the year 2010, in which the FED did not require stress test. The columns 5-8 show the robustness check of the results by excluding the systemically important BHCs. All the OLS regression models have been adjusted for outliers at 1% level.

	Stress Test BHCs 2000-2018				Stress Test BHCs 2000-2018 (Systemically Important BHCs are excluded)			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	ΔSRISK/ S&P 500	ΔMES	ΔSRISK/S &P 500	ΔMES	ΔSRISK/S &P 500	ΔMES	ΔSRISK/S &P 500	ΔMES
Post Stress	-1.185*	-0.00935*	-1.608**	-0.0111**	-0.656**	-0.0110**	-0.806***	-0.0124**
	(0.673)	(0.00475)	(0.771)	(0.00480)	(0.300)	(0.00480)	(0.278)	(0.00491)
Stress2010			6.500**	0.0271*			2.306*	0.0212
			(2.883)	(0.0133)			(1.233)	(0.0155)
ΔLN(Assets)	8.711	0.0471	8.683	0.0470	5.567	0.0468	5.505	0.0463
	(6.426)	(0.0355)	(6.826)	(0.0374)	(6.770)	(0.0385)	(6.896)	(0.0401)
ΔPPNR/Asset	1.557	0.00380	2.119	0.00614	1.740	0.00367	1.917	0.00530
	(1.728)	(0.00857)	(1.863)	(0.00903)	(1.901)	(0.0105)	(1.981)	(0.0109)
ΔLLP/Assets	4.284**	0.0684***	4.941**	0.0711***	2.825**	0.0652***	3.040**	0.0672***
	(1.549)	(0.00873)	(1.862)	(0.00958)	(1.037)	(0.00866)	(1.156)	(0.00934)
ΔTier 1 Capital Ratio	0.878*	0.00690*	0.904*	0.00700**	0.224	0.00552	0.238	0.00565
	(0.471)	(0.00339)	(0.478)	(0.00337)	(0.176)	(0.00346)	(0.178)	(0.00345)
ΔDebt/Total Capital	0.0558	-0.000320	0.0498	-0.000345	0.0397	-0.000475	0.0367	-0.000502
	(0.0513)	(0.000619)	(0.0488)	(0.000601)	(0.0455)	(0.000705)	(0.0449)	(0.000688)
ΔReal Estate Loans/Assets	10.49	0.108	11.52	0.112	12.89	0.0995	13.28	0.103
	(10.46)	(0.127)	(11.27)	(0.132)	(11.03)	(0.129)	(11.38)	(0.134)
ΔCommercial Loans/Assets	-16.73	0.0661	-17.29	0.0638	-1.133	0.0863	-1.287	0.0848
	(11.51)	(0.112)	(12.05)	(0.114)	(5.885)	(0.113)	(6.237)	(0.115)
ΔConsumer Loans/Assets	-17.08	-0.159	-14.21	-0.147	-4.476	-0.107	-3.641	-0.0996
	(11.08)	(0.198)	(10.91)	(0.199)	(8.462)	(0.210)	(8.395)	(0.210)
ΔDeposits/Assets	11.79	0.0577	2.858	0.0204	17.46	0.0454	14.35	0.0167
	(12.11)	(0.145)	(13.91)	(0.148)	(12.28)	(0.182)	(11.98)	(0.183)
Constant	-0.0958	0.00607	-0.0909	0.00609	0.116	0.00788*	0.124	0.00796*
	(0.551)	(0.00394)	(0.596)	(0.00412)	(0.475)	(0.00400)	(0.487)	(0.00413)
Observations	323	323	323	323	280	280	280	280
R-squared	0.091	0.325	0.105	0.330	0.092	0.321	0.096	0.324
Number of id	23	23	23	23	20	20	20	20
Bank Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	No	No	No	No	No	No	No	No

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 6.6.2 considers the following estimated regressions:

$\Delta SRISK_{b,t}$ or $\Delta MES_{b,t} = \beta_1 * Post\ Test_i + \beta_2 * \Delta Bank\ Characteristics_{b,t} + \beta_3 * Fixed\ Effects_b + \varepsilon_{b,t}$

$\Delta SRISK_{b,t}$ or $\Delta MES_{b,t} = \beta_1 * PostTest_t + Stress2010_i + \beta_2 * \Delta Bank\ Characteristics_{b,t} + \beta_3 * Fixed\ Effects_b + \varepsilon_{b,t}$

Table 6.6.2 shows the first difference of yearly observations. The purpose of this model is to show whether there is a decrease or increase over the years in the systemic risk between the pre-stress test period and the post-stress period. My findings in Table 6.6.2 suggest that the stress test BHCs decrease their systemic risk after the stress test period compared to the period prior. Similarly, the yearly change of the MES is negative at -0.01 points every year. The models in Columns 3 and 4 include a dummy for the non-stress test year in 2010. The BHCs that did not conduct a stress test in that year reported a significant increase in their SRISK but no significant impact on MES. This can mean that the stress test regulation has a negative impact on systemic risk, but when the stress test is not conducted then the systemic risk increases. Columns 5, 6, 7, and 8 illustrate the OLS regression models by excluding systemically important BHCs.

The yearly changes are lower for the stress test BHCs, not only compared to non-stress test banks but also compared to the years before the stress test period. Therefore, even though the systemic risk is higher compared to the pre-stress period, the systemic risk decreases. The results are consistent when I exclude highly systemically BHCs from my sample.

6.7 Impact on New Stress Test BHCs

Table 6.7.1: Impact of Stress Test of the Systemic Risk on New Stress Test Banks. This table shows the impact of stress test testing on the new stress test BHCs. The variables are measured as changes from 2007 to 2009 and from 2013 to 2015. New stress equals 1 if the BHCs conducts stress test that year. Columns 3 and 4 exclude the systemically important BHCs. All the OLS regression models have been adjusted for outliers at 1% level.

	All Banks 2007-2009, 2012-2015		All Banks 2007-2009, 2012-2015 (Systemically Important are Excluded)	
	(1)	(2)	(3)	(4)
VARIABLES	ΔSRISK/S&P 500	ΔMES	ΔSRISK/S&P 500	ΔMES
New Stress Test	8.036**	0.00581	3.236*	0.000492
	(3.905)	(0.0281)	(1.738)	(0.0292)
ΔLN(Assets)	22.62*	0.0774*	18.68	0.0777
	(11.98)	(0.0458)	(12.70)	(0.0463)
ΔPPNR/Assets	-9.033	-0.0305	-6.913*	-0.0340
	(6.156)	(0.0497)	(3.975)	(0.0500)
ΔLLP/Assets	4.128	0.169**	0.380	0.164**
	(5.534)	(0.0738)	(3.620)	(0.0766)
ΔTier 1 Capital Ratio	-0.189	-0.000502	0.470	0.000129
	(0.775)	(0.00712)	(0.511)	(0.00746)
ΔDebt/Total Capital	0.0933	-0.000487	0.0519	-0.000430
	(0.149)	(0.00132)	(0.0750)	(0.00136)
ΔReal Estate Loans/Assets	15.60	-0.0662	15.02	-0.0735
	(20.07)	(0.236)	(13.20)	(0.234)
ΔConsumer Loans/Assets	-29.07	-0.236	-8.197	-0.227
	(25.30)	(0.235)	(7.845)	(0.238)
ΔCommercial Loans/Assets	8.063	-0.107	8.634	-0.102
	(24.60)	(0.332)	(12.49)	(0.333)
ΔDeposits/Assets	0.0198	0.00184	0.318	0.00233
	(0.384)	(0.00329)	(0.221)	(0.00340)
Constant	0.0960	-0.0225	-2.288	-0.0261
	(3.781)	(0.0216)	(3.187)	(0.0227)
Observations	94	94	89	89
R-squared	0.440	0.574	0.431	0.560
Number of id	48	48	45	45
Bank Controls	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

The model in columns 1-4:
$\Delta SRISK_{b,t}$ *or* $\Delta MES_{b,t} = \beta_1 * New\ Stress\ Test_b + \beta_2 * \Delta Bank\ Characteristics_{b,t} + \beta_3 * Time\ Fixed\ Effects_b + \varepsilon_{b,t}$

The variable of interest is *New Stress Test*. I find that new stress test banks considerably increased their SRISK by 8.036 billion USD on average, compared to non-stress BHCs as well as existing stress test BHCs. The coefficient is statistically significant at 5% level. In columns 3 and 4 the results suggest that new stress test BHCs increased their SRISK by 3.236 billion USD compared to the existing and non-stress test BHCs. The variable of interest is significant at 5% level and it is quite close with the coefficient in Column 1. The high increase in systemic risk for the stress test BHCs can mean that the BHCs are not fully adjusted to the new requirements the first time, while the BHCs have a high exposure to debt due to the financial crisis the years prior. As mentioned in Chapter 3, during the first stress test, only 9 out of the 19 BHCs passed the test. The failure of the majority of the banks to pass the stress test may be related to the high increase in SRISK. In addition, one BHC failed to pass the stress test the first time in 2014. Therefore, the *New Stress Test* indicator might be significant because the failed BHCs drive the results. Finally, there is no impact on MES among the new stress test BHCs.

6.8 Around the Stress Test Quarters

Table 6.8.1: Impact of Stress Test on the Systemic Risk around the Stress Test Quarters. This table shows the changes of SRISK and MES around the stress test quarters compared to non-stress test BHCs. The variables have been transformed as quarterly changes. The StressQ is a dummy that isolates changes of the SRISK and MES in the stress test quarter. StressQ1 isolates changes a quarter after the stress test, while the StressQ-1isolates changes a quarter before the stress test. Columns 3 and 4 exclude the systemically important BHCs. All the OLS models have been adjusted for outliers at 1% level.

	All Banks 2000-2018		All Banks 2000-2018 (Systemically Important BHCs are excluded)	
	(1)	(2)	(3)	(4)
VARIABLES	ΔSRISK/S&P 500	ΔMES	ΔSRISK/S&P 500	ΔMES
StressQ	0.111	0.0236***	-0.421	0.0206***
	(0.520)	(0.00563)	(0.252)	(0.00545)
StressQ1	3.619**	0.00528	2.801*	0.00315
	(1.377)	(0.00501)	(1.602)	(0.00547)
StressQ-1	-1.665***	0.00350	-1.035***	0.00295
	(0.551)	(0.00325)	(0.333)	(0.00333)
ΔLN(Assets)	-1.738	-0.000944	-0.603	-0.00204
	(1.074)	(0.0257)	(0.532)	(0.0266)
ΔPPNR/Assets	1.314*	0.00667	0.980	0.00119
	(0.680)	(0.00834)	(0.724)	(0.00759)
ΔDebt/Total Capital	0.0278	0.000766**	0.0177	0.000804**
	(0.0175)	(0.000342)	(0.0141)	(0.000350)
ΔReal Estate Loans/Assets	0.878	0.00602	-0.165	0.00574
	(1.470)	(0.0415)	(1.005)	(0.0412)
ΔDeposits/Assets	0.0621	0.00112	0.0333	0.00137
	(0.0403)	(0.000810)	(0.0275)	(0.000844)
ΔCommercial Loans/Assets	-3.839	-0.0376	-1.064	-0.0409
	(2.793)	(0.0660)	(1.448)	(0.0650)
ΔConsumer Loans/Assets	-3.022	0.0894*	-0.469	0.0783
	(3.312)	(0.0488)	(1.985)	(0.0502)
ΔTier 1 Capital Ratio	0.158**	0.000222	0.0729*	0.000488
	(0.0747)	(0.00185)	(0.0377)	(0.00188)
ΔLLP/Assets	-13.75	-0.465	-41.85	-0.513
	(61.11)	(0.753)	(56.48)	(0.762)
Constant	-0.481	-0.0215**	-0.976*	-0.0218*
	(0.599)	(0.0105)	(0.493)	(0.0111)
Observations	3,033	3,033	2,856	2,856
R-squared	0.148	0.598	0.149	0.600
Number of id	47	47	44	44
Bank Controls	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Model in columns 1-6:
$\Delta SRISK_{b,t}$ *or* $\Delta MES_{b,t} = \beta_0 + \beta_1 * Stress\ Test * Q_b + \beta_2 * Stress\ Test * Q{+}1_b + \beta_3 * Stress\ Test * Q{-}1_b + \beta_4 * \Delta Bank\ Characteristics_{b,t} + \beta_5 * Time\ Fixed\ Effects_b + \varepsilon_{b,t},$

The purpose of Table 6.8.1 is to show the impact of stress test around stress test quarters. Column 1 of Table 6.8.1 shows no impact of the stress test on the SRISK during the stress test quarter when the stress test BHCs are compared to the non-stress BHCs, while a quarter after the stress test is positive and statistically significant at the 5% level. More specifically, the change of the SRISK increases by $3.619 billion a quarter after the stress test, while it decreases by $1.665 billion a quarter before the stress test. We can conclude that the stress test has an impact a quarter after and a quarter before the stress test, while there is no immediate effect in the stress test quarter. Similarly, Columns 3 and 4 show the changes of the SRISK and MES of stress test BHCs excluding the non-stress banks. The indicators in this case suggest that the BHCs increase their SRISK during the stress test quarter as well as the quarter after the stress test, while the SRISK decreases a quarter prior. One possible explanation is that the BHCs, in order to pass the stress test, adjust their capital and risky assets a quarter before the stress test, and then after passing the test, they return back to normality. Previous studies e.g., (Schorno, et al., 2017) suggest that stress test BHCs decrease their capital after the stress test quarter and increase it during the stress test quarter. The decrease of capital a quarter after the stress test might explain the increase in SRISK. Surprisingly, the MES increases during the stress test quarter. More specifically, stress test BHCs increase their MES by 0.0236 points (0.0206, when systemically important BHCs are excluded). First, MES is based on the volatility and beta with the market. Second, previous studies e.g., (Schorno, et al. 2017) suggest that stress test BHCs decrease their dividends during the stress test quarter. The negative correlation between the dividend and volatility (Cambell and Hentschel, 1992) of a stock return can have an impact on MES. Since the dividends paid decreases, the volatility of stock returns increases, resulting in MES increase.

6.9 Regression Discontinuity

Table 6.9.1: Regression Discontinuity from 2009 to 2018.This table presents the results of the regression discontinuity (RD) estimates of treatment effects that estimate the change in the SRISK and MES as well as the average SRISK and MES (level form) given that the BHC is part of the stress test group. The regression discontinuity includes triangular kernel weights. That means that the estimate of the regression discontinuity provides estimates close to the cutoff which in this case is 50 billion USD. The RD estimator is the difference in the dependent variable between the stress test and non-stress BHCs. The columns from 1 to 4 show the RD estimates of the changes and columns from 5 to 8 the RD estimates of the level form. The columns 1, 2, 5 and 6 show the RD estimates including covariates and columns 4, 5, 7 and 8 show the RD estimates without covariates.

	Yearly Changes 2009-2018 (with covariates)		Yearly Changes 2009-2018 (without covariates)		Level Form 2009-2018 (with covariates)		Level Form 2009-2018 (without covariates)	
Variables	(1) ΔSRISK/S &P 500	(2) ΔMES	(3) ΔSRISK/S &P 500	(4) ΔMES	(5) SRISK/S& P 500	(6) MES	(7) SRISK/S& P 500	(8) MES
RD	-0.552** (0.255)	-0.00598 (0.0196)	-0.767*** (0.256)	-0.0316 (0.0200)	0.745** (0.370)	0.0697*** (0.0246)	1.974*** (0.562)	0.112 (0.0695)
Observations	454	454	468	468	1,783	1,783	1,973	1,973
Covariates	Yes	Yes	No	No	Yes	Yes	No	No
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

The regression discontinuity is applicable in this study. The stress test requirement applied to BHCs with more than $100 billion in 2008, while the FED revised the regulation in 2011 requiring BHCs with more than $50 billion USD to participate in the stress test. Therefore, the stress test regulation by the FED is considered exogenous. I implement regression discontinuity to examine how the regulation by the FED affects the treatment group above the cut off, which, in this case, is $50 billion USD. Even though the cutoff point was $100 billion in assets, none of the non-stress test BHCs had more than $50 billion in assets from 2009 to 2011. Therefore, it would not make sense to use the $100 billion USD threshold.

Table 6.9.1 illustrates the RD estimator of the regression discontinuity. In Table 6.6.1, I show the differences of systemic risk measures when systemically important BHCs are excluded In the RD case, I specifically test whether there is an impact around the cutoff point of $50 billion USD. BHCs, which are relatively above the cutoff, have a negative change over the years and have higher systemic risk measures when the variables are measured in the level form than non-stress BHCs. The treatment group above the cutoff decrease their SRISK by 0.552 more than the non-stress BHCs. The RD estimates for MES show no significant difference between the stress and non-stress test BHCs. Consistent with Table 6.5.1, the stress test BHCs have $0.745 billion USD higher than the non-stress test BHCs. In addition, stress test BHCs report 0.0697 points higher than the non-stress test BHCs.

The significance of the RD estimator implies that the regulation actually has an impact on systemic risk. On one hand, systemic risk is higher for the stress test BHCs. This supports the FED's focus on BHCs with more than $50 billion in assets. On the other hand, the regulation is effective in decreasing systemic risk over the years for the stress test BHCs.

The regression discontinuity is done in STATA by using triangular kernel approach. The rdrobust in STATA allows the use of the triangular kernel approach by selecting optimal bandwidth. This is the optimal number of observations that are above and below the cutoff point. The table shows the difference of dependent variables by using the changes as well as the level form of the variables. As a robustness test, Columns 3, 4, 6 and 7 exclude the covariates from the models.

6.10 Years of Stress Testing

Table 6.10.1: Impact on the Systemic Risk as time passes. This table shows the evolution of the impact of stress on the systemic risk from the first stress test year of stress test to the recent year. The variables are measured as changes from one year before the stress test to a year after. The *Time of Stress Test* variable takes a value from 1 to 8 for the stress test BHCs, 4 to 8 for the new stress test and 0 for the non-stress test BHCs. The variable is controlled in STATA by using the "i." function.

	All BHCs		Excluding Systemically Important BHCs	
VARIABLES	(1) ΔSRISK/ S&P 500	(2) ΔMES	(4) ΔSRISK/S&P 500	(5) ΔMES
1.Time of Stress Test	4.125	0.0192	4.663	0.0215
	(2.856)	(0.0209)	(2.793)	(0.0223)
2.Time of Stress Test	3.467	0.0276	-0.393	0.0164
	(2.403)	(0.0190)	(1.307)	(0.0198)
3.Time of Stress Test	-7.501***	-0.0612***	-3.726***	-0.0529**
	(2.368)	(0.0204)	(1.278)	(0.0229)
4.Time of Stress Test	-1.842*	-0.0654***	-2.324**	-0.0676**
	(0.963)	(0.0226)	(1.054)	(0.0252)
5.Time of Stress Test	3.322**	-0.0103	2.808**	-0.0205
	(1.343)	(0.0181)	(1.356)	(0.0193)
6.Time of Stress Test	12.19***	0.0387*	8.258**	0.0256
	(4.188)	(0.0211)	(3.730)	(0.0210)
7.Time of Stress Test	-4.355	0.0202	-0.845	0.0312
	(2.665)	(0.0197)	(1.754)	(0.0210)
8.Time of Stress Test	-18.27***	-0.156***	-9.675***	-0.165***
	(6.017)	(0.0203)	(2.770)	(0.0222)
Constant	-1.515***	-0.00386	-0.675**	-0.00277
	(0.449)	(0.00815)	(0.279)	(0.00833)
Observations	374	374	350	350
R-squared	0.360	0.198	0.326	0.176
Number of id	47	47	44	44
Bank Controls	No	No	No	No
Year Fixed Effects	No	No	No	No

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Model in Columns 1-4:

$\Delta SRISK_{b,t}$ *or* $\Delta MES_{b,t} = \beta_0 + \beta_1 * Bank\ Characteristics_{b,t} + \beta_3 * Bank\ Fixed\ Effects_b + \beta_4 * Time\ of\ the\ Stress\ Test_t + \varepsilon_{b,t}$

The *Time of Stress Test* variable takes the value of 1 if the stress test bank runs stress test for first time; and 2, if the BHC runs for second time and so on. For non-stress test BHCs the value of *Time of Stress Test* is zero. For example dummy equal to 1 if that year is the first time of stress test for the stress tested BHCs, 2 if it is the second time of stress test, and so on. The idea of implementing this method is to examine specific changes of systemic risk over the years. More specifically, *1.Time of Stress Test* is the change from Q4 2008 to Q4 2009. Q4 was the starting point of the first stress test and Q4 2009 is the year after the first stress test, *2.Time of Stress Test* is the change from Q3 2011 to Q4 2012, since in the third quarter of 2011 the stress test was conducted for second time. Simply, *3.Time of Stress Test* is the change from Q3 2012 to Q3 2013, *4.Time of Stress Test* is the change from Q3 2013 to Q3 2014, *5.Time of Stress Test* is the change from Q3 2014 to Q4 2015, *6.Time of Stress Test* is the change from Q1 2015 to Q1 2016, *7.Time of Stress Test* is the change from Q1 2016 to Q1 2017 and *8.Time of Stress Test* is the change from Q1 2017 to Q1 2018.

Column 1 shows the result for SRISK. As mentioned before, the first time of the stress test is not effective for stress test BHCs since most of them failed to pass. The second time of the stress test is conducted in 2011, after 3 years of the initial stress test.

The first years show no significant impact on SRISK. The third time, the SRISK, which is associated with the change from Q3 2013 to Q3 2012, significantly decreased. The coefficient is -7.501 and it is statically significant at 1% level. While from Q3 2014 to Q3 2013, the SRISK decreased by -1.842. Even though the decrease from 2013 to 2014 is smaller than the decrease from 2012 to 2013, the change is still negative and I conclude that the stress test took some time to be effective.

The SRISK from the fourth time of the stress test to the fifth time and from the fifth to the sixth time rose by $3.222 and $12.19 billion USD respectively. The rise of the SRISK from 2014 to 2015 is explained by the increase of SRISK of the new stress test BHCs that joined in 2014. Therefore, my result in Table 6.10.1 match with my result in Table 6.7.1.

The significant change of the SRISK from 2015 to 2016 is probably explained by the financial crisis in China in 2015-2016. Some of the largest US BHCs have some exposure to the Chinese economy and therefore they probably incurred credit losses.

Finally, the decrease of SRISK from the sixth to the seventh time was not statistically significant, while from the seventh to the eighth time decreased by $18.27 billion USD for the stress test BHCs, suggesting that the stress test was effective. The declines and increases of the SRISK over the years might have happened because of other factors that this paper cannot explain, therefore further research is needed.

CHAPTER 7: CONCLUDING REMARKS

This analysis tested the impact of the stress test on the systemic risk of BHCs. My interest is to see the impact of the stress test on the systemic risk after the regulation of the stress test (post-stress test period), the impact on the systemic risk around the stress test quarters, the impact on the new stress test BHCs, the impact on BHCs that are close to the cutoff of $50 billion USD in assets, the impact a year before and a year after the stress test; and finally, whether the capital requirements decrease systemic risk.

I find that even though SRISK and MES of the stress test BHCs are higher than SRISK and MES of the non-stress BHCs, the systemic risk measurements are decreasing more for the stress test BHCs than the non-stress test BHCs over the years. In order to confirm these results, I conducted a regression discontinuity approach and I found that BHCs with assets relatively above the cutoff have higher SRISK and decrease their SRISK more compared to the BHCs with assets below the cutoff.

In addition, the systemic risk measurements are higher over the post stress test period mainly because of the dramatic increase after the financial crisis; however, they are decreasing with higher velocity than the systemic risk measurements over the pre-stress period for the stress test BHCs. This could indicate that, although stress test banks have higher absolute levels of systemic risk measures, the stress tests have done a reasonable job of lowering the increase in systemic risk measures.

Furthermore, the new stress test BHCs significantly increased their SRISK a year after their first year of stress tests. A possible explanation is the late adjustment to the requirements since the first time in 2008, more than the half BHCs failed to pass the stress test.

Moreover, specific changes happen around the stress test where the SRISK and MES increase a quarter after the stress test, but decrease a quarter prior. There is no significant impact during the stress test quarter for SRISK, instead, the MES of the stress test BHCs increases more than the MES of the non-stress test BHCs. That may be explained by the fact that the BHCs prepare for adjustments a quarter before the stress test in order to pass the test and a quarter after stress testing they return to normality.

The Tier 1 Capital Ratio is associated with a decrease in SRISK from 2008 to 2018 for the stress test BHCs, suggesting that the capital buffer helps the BHCs decrease their systemic risk. The LLP and the PPNR which are both important profitability ratios that are taken into account over the stress test process are found to have a positive and negative impact, respectively. Finally, when I tested for the impact of the stress test over time, I found that the stress test was not effective most of the time and therefore and stress test banks do not decrease their systemic risk consistently over time.

In conclusion, some of the results might have happened for reasons that cannot be explained by my analysis and given the fact that the regulations are revised over time more research is needed.

REFERENCES

Acharya, V.V., Berger, A.N. and Roman, R.A., 2018. Lending implications of US bank stress tests: Costs or benefits? *Journal of Financial Intermediation,* 34, pp. 58-90.

Acharya, V., Engle, R. and Richardson, M., 2012. Capital shortfall: A new approach to ranking and regulating systemic risks. *American Economic Review*, *102*(3), pp.59-64.

Acharya, V.V., Pedersen, L.H., Philippon, T. and Matthew, R., 2010. Measuring systemic risk. Working paper, New York University Stern School of Business. Available at: people.stern.nyu.edu/lpederse/papers/MeasuringSystemicRisk.pdf

Artzner, P., Delbaen, F., Eber, J.M. and Heath, D., 1999. Coherent measures of risk. *Mathematical Finance*, 9(3), pp.203-228.

Baker, C., Cummings, C. and Jagtiani, J., 2017. The impacts of financial regulations: solvency and liquidity in the post-crisis period. *Journal of Financial Regulation and Compliance*, 25(3), pp.253-270.

Benoit, S., Colletaz, G., Hurlin, C., Perignon, C., 2014. A Theoretical and Empirical Comparison of Systemic Risk Measures. Working paper, SSRN. Available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1973950

Board, F.S., 2013. 2013 update of group of global systemically important banks (G-SIBs). *FSB*. Available at: http://www.fsb.org/2013/11/r_131111/

Board, F.S., 2014. 2014 list of global systemically important banks (G-SIBs). *FSB*. Available at: http://www.fsb.org/wp-content/uploads/r_141106b.pdf

Board, F.S., 2015. 2015 list of global systemically important banks (G-SIBs). *FSB.* Available at: http://www.fsb.org/wp-content/uploads/2015-update-of-list-of-global-systemically-important-banks-G-SIBs.pdf

Board, F.S., 2016. 2016 list of global systemically important banks (G-SIBs). *FSB*. Available at: http://www. fsb. org/wp-content/uploads/P211117-1.pdf.

Board, F.S., 2017. 2017 list of global systemically important banks (G-SIBs). *FSB*. Available at: http://www.fsb.org/wp-content/uploads/P211117-1.pdf

Brunnermeier, M.K., Dong, G., Palia, D., 2011. Banks' Non-interest Income and Systemic Risk. Working Paper, Princeton University and Rutgers University. Available at:https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1786738

Banerjee, R.N. and Mio, H., 2018. The impact of liquidity regulation on banks. *Journal of Financial Intermediation*, 35, pp.30-44.

Bostandzic, D. and Weiß, G.N., 2018. Why do some banks contribute more to global systemic risk?. *Journal of Financial Intermediation* 35, July 2018, pp 17-40.

Cattaneo, M.D., Idrobo, N. and Titiunik, R., 2018. A Practical Introduction to Regression Discontinuity Designs: Volume II. Available at: http://www personal.umich.edu/~cattaneo/books/Cattaneo-Idrobo-Titiunik_2018_CUP-Vol2.pdf

Calonico, S., Cattaneo, M.D., Farrell, M.H. and Titiunik, R., 2017. rdrobust: Software for Regression Discontinuity Designs. *Stata Journal*, 17(2), pp.372-404.

Campbell, J.Y. and Hentschel, L., 1992. No news is good news: An asymmetric model of changing volatility in stock returns. *Journal of financial Economics*, 31(3), pp.281-318.

Cummins, J.D. and Weiss, M.A., 2014. Systemic risk and the US insurance sector. *Journal of Risk and Insurance*, 81(3), pp.489-528.

Cornett, M.M., Minnick, K., Schorno, P.J. and Tehranian, H., 2018. An Examination of Bank Behavior around Federal Reserve Stress Tests. *Journal of Financial Intermediation*. Available at: https://doi.org/10.1016/j.jfi.2018.05.001

Engle, R.F., 2016. Dynamic Conditional beta. *Journal of Financial Econometrics*, 14(4), pp.643-667.

Engle, R.F. and Ruan, T., 2018. How Much SRISK is Too Much? Working paper, SSRN. Available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3108269

Goldstein, I. and Sapra, H., 2014. Should Banks' Stress Test Results be Disclosed? An Analysis of the Costs and Benefits. *Foundations and Trends in Finance*, 8(1), pp.1-54.

J.F. Hair Jr., W.C. Black, B.J.Babin, R.E. Anderson (2014). Multivariate data analysis. Essex, UK: Pearson Education Limited.

Huang, Q., 2018. Impact of the Dodd-Frank Act on Systemic Risk: A Counterfactual Analysis. Working paper, SSRN. Available at: http://dx.doi.org/10.2139/ssrn.3019977

Holton, G.A., 2002. History of Value-at-Risk. Working Paper, Wharton Statistics Department. Available at: http://stat.wharton.upenn.edu/~steele/Courses/434/434Context/RiskManagement/VaRHistlory.pdf

Huang, H.C., Su, Y.C. and Tsui, J.T., 2015. Asymmetric GARCH Value-at-Risk over MSCI in Financial Crisis. *International Journal of Economics and Financial Issues*, 5(2), pp.390-398.

Idier, J., Lamé, G. and Mésonnier, J.S., 2014. How Useful Is The Marginal Expected Shortfall For The Measurement of Systemic Exposure? A practical assessment. *Journal of Banking & Finance*, 47, pp.134-146.

Laeven, M.L., Ratnovski, L. and Tong, H., 2014. Bank Size and Systemic Risk. International Monetary Fund. Available at: https://www.imf.org/external/pubs/ft/sdn/2014/sdn1404.pdf

Lee, D.S. and Lemieux, T., 2010. Regression Discontinuity Designs In Economics. *Journal of Economic Literature*, 48(2), pp.281-355.

Passmore and Hafften (2017), Are Basel's Capital Surcharges for Global Systemically Important Banks Too Small? *Finance and Economics Discussion Series Divisions of Research & Statistics and Monetary Affairs Federal Reserve Board, Washington, D.C.*
Available at: https://www.federalreserve.gov/econresdata/feds/2017/files/2017021pap.pdf

Reserve, F., 2009. The Supervisory Capital Assessment Program: Overview of results. *Federal Reserve*. Available at: https://www.federalreserve.gov/newsevents/files/bcreg20090507a1.pdf

Reserve, F., 2015. Comprehensive Capital Analysis And Review 2015: Assessment framework and results. *US Federal Reserve.* Available at:
https://www.federalreserve.gov/newsevents/pressreleases/files/bcreg20150311a1.pdf

Reserve, F (2013), Federal Reserve Board Proposes Rule To Strengthen Liquidity Positions Of Large Financial Institutions. Available at:
https://www.federalreserve.gov/newsevents/pressreleases/bcreg20131024a.htm

Reserve, F., 2013. Comprehensive Capital Analysis and Review 2013. *Federal Reserve*. Available at: https://www.federalreserve.gov/bankinforeg/CCaR-2013-results-20130314.pdf

Stock, J.H. and Watson, M.W., 2012. *Introduction to Econometrics*: Global Edition. US: Pearson Education.

Thistlethwaite, D.L. and Campbell, D.T., 1960. Regression-Discontinuity Analysis: An Alternative to the Ex Post Facto Experiment. *Journal of Educational psychology*, 51(6), p.309.

Weiß, G.N., Bostandzic, D. and Neumann, S., 2014. What Factors Drive Systemic Risk During International Financial Crises? *Journal of Banking & Finance*, 41, pp.78-96.

Weiß, G.N., Neumann, S. And Bostandzic, D., 2014. Systemic Risk and Bank Consolidation: International Evidence. *Journal of Banking & Finance*, 40, pp.165-181.

Yamai, Y. and Yoshiba, T., 2002. Comparative Analyses of Expected Shortfall and Value-At-Risk: Their Estimation Error, Decomposition, and Optimization. *Monetary And Economic studies*, 20(1), pp.87-121.

M. Ker, 2017, U.S. Financial Exposure to China. *U.S-China Economic and Security Review Commission.* Available at:
https://www.uscc.gov/sites/default/files/Research/U.S.%20Financial%20Exposure%20to%20China.pdf

APPENDIX 1: Total Sample of BHCs

Stress Test BHCs	Non-Stress Test BHCs
JPMorgan Chase & Co.	SVB Financial Group
Bank of America Corp.	New York Community Bancorp, Inc.
Wells Fargo & Company	People's United Financial, Inc.
Citigroup Inc.	Popular, Inc.
Goldman Sachs Group, Inc.	First Horizon National Corporation
Morgan Stanley	East West Bancorp, Inc.
U.S. Bancorp	Raymond James Financial, Inc.
PNC Financial Services Group, Inc.	First Citizens BancShares, Inc.
Bank of New York Mellon Corporation	BOK Financial Corporation
Capital One Financial Corporation	Cullen/Frost Bankers, Inc.
State Street Corporation	F.N.B. Corporation
BB&T Corporation	Synovus Financial Corp.
SunTrust Banks, Inc.	Associated Banc-Corp
American Express Company	Sterling Bancorp
Fifth Third Bancorp	Wintrust Financial Corporation
Northern Trust Corporation	IBERIABANK Corporation
KeyCorp	Hancock Whitney Corporation
Regions Financial Corporation	Webster Financial Corporation
M&T Bank Corporation	Umpqua Holdings Corporation
Huntington Bancshares	Investors Bancorp, Inc.
Discover Financial Services	Texas Capital Bancshares, Inc.
Comerica Incorporated	PacWest Bancorp
Zions Bancorporation	Commerce Bancshares, Inc.
	Valley National Bancorp
	TCF Financial Corporation
	Prosperity Bancshares, Inc.
	Pinnacle Financial Partners, Inc.
	UMB Financial Corporation
	Western Alliance Bancorporation
	Fulton Financial Corporation
	United Bankshares, Inc.
	Washington Federal, Inc.

Source: SNL Market Intelligence

APPENDIX 2: Correlations of all the Variables (2008-2018)

	SRISK USA	MES	PPNR/Asset	LLP/Assets	Tier 1	CET1	TIER1 LV	RBC
SRISK USA	1	0.3209	-0.1611	0.1264	0.1188	-0.0034	-0.1121	0.0944
MES		1	-0.1617	0.3502	0.1265	-0.0551	0.1449	0.1254
PPNR/Assets			1	0.0618	0.1186	-0.0931	-0.0341	-0.0945
LLP/Assets				1	-0.0334	-0.1574	0.0786	0.0655
Tier 1					1	0.7474	0.5537	0.8138
CET1						1	0.4795	0.6633
TIER1 LVR							1	0.5662
RBC								1
Debt/Capital								
Real Estate Loans/Assets								
Consumer Loans/Assets								
Commercial Loans/Assets								
Deposits/Asset								
Ln(Assets)								

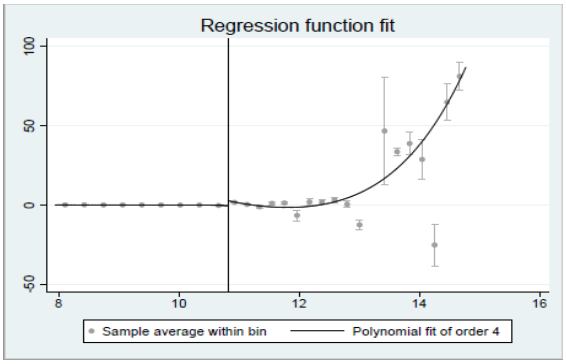
Ln(Assets)	Deposits/Assets	Commercial Loans/Assets	Consumer Loans/Assets	Real Estate/Loans	Debt/Capital
0.4206	-0.4109	-0.2646	-0.0192	-0.2082	0.2009
0.2100	-0.0164	0.0230	-0.0788	-0.0906	-0.1398
0.0299	-0.0882	-0.0483	0.1179	-0.0551	0.0531
0.1230	-0.1342	0.0151	0.1700	0.0504	0.1099
-0.1534	0.2496	-0.1519	-0.1810	-0.1080	-0.4598
-0.2078	0.1770	-0.1176	-0.1320	-0.0529	-0.3188
-0.2268	0.2912	0.3188	-0.0472	0.1426	-0.4661
0.0199	0.0800	-0.2237	-0.0545	-0.1421	-0.3135
0.3690	-0.7846	-0.3215	0.3583	-0.0166	1
-0.3904	0.1171	0.4052	0.2791	1	
0.1188	-0.2380	-0.4651	1		
-0.3926	0.3841	1			
-0.5930	1				
1					

APPENDIX 3: Summary Statistics

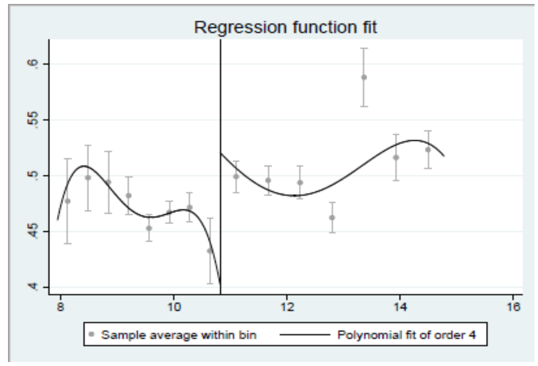
Variable	Obs	Mean	Standard Deviation	Min	Max
SRISK/S&P500	3,606	2.670521	17.78192	-34.1165	99.27338
MES	3,606	0.444927	0.112375	0.143696	0.728284
LN(Assets)	3,890	10.54508	1.743802	2.98138	14.77478
PPNR/Assets	3,891	0.005049	0.002865	-0.00064	0.018661
LLP/Assets	3,710	0.001206	0.001841	-0.00036	0.010365
Tier 1	3,785	11.52943	2.689153	6.95	21.2
CET 1	3,678	56.49161	18.7147	10.3815	93.1223
Tier 1 LV	3,565	0.336417	0.168047	0.001847	0.745453
Risk Based Ratio	3,776	0.226823	0.128304	0.003925	0.60385
Debt/Capital	3,894	0.368468	0.160363	0.034984	0.737699
Real Estate Loans/Assets	3,536	67.84632	14.8551	14.9369	87.3013
Consumer loans/Assets	3,533	2.670521	17.78192	-34.1165	99.27338
Commercial Loans/Assets	3,576	0.444927	0.112375	0.143696	0.728284
Deposits/Assets	3,894	10.54508	1.743802	2.98138	14.77478

APPENDIX 4: Graphs in Regression Discontinuity

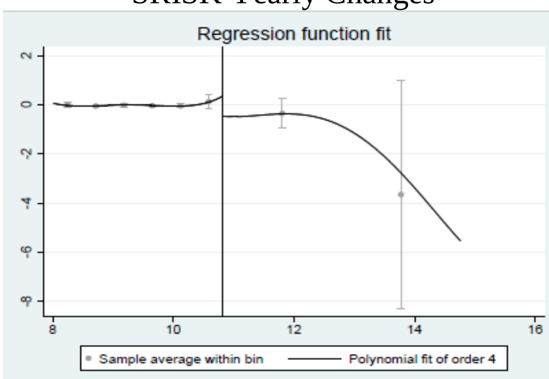
SRISK



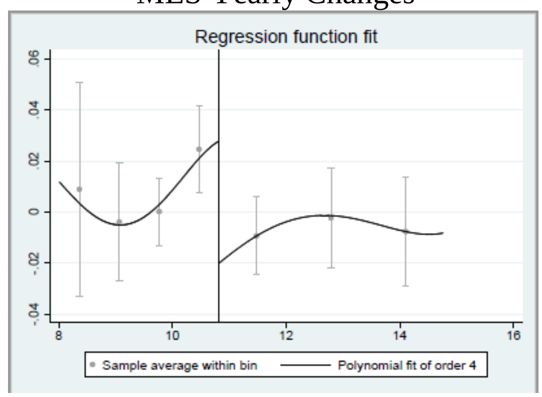
MES



SRISK Yearly Changes



MES Yearly Changes



APPENDIX 5: Hausman Test

(a) Variables	(b) Fixed	(B) Random	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
Ln(Assets)	0.749443	2.44763	-1.69819	0.473715
PPNR/Assets	-0.82768	-1.53757	0.709889	.
LLP/Assets	6.580346	6.927209	-0.34686	0.153671
Tier 1 Capital Ratio	-0.63184	-0.66659	0.034755	.
Debt/Capital	-0.10339	-0.10697	0.003576	0.00295
Real Estate Loans/Assets	0.323678	-0.4726	0.796282	1.004315
Consumer Loans/Assets	10.4348	7.133703	3.301098	1.883248
Commercial Loans/Assets	-10.1405	-17.5924	7.451901	1.91187
Deposits/Assets	-0.56762	-0.63721	0.069589	0.01264

b = consistent under Ho and Ha; obtained from xtreg
B = inconsistent under Ha, efficient under Ho; obtained from xtreg
Test: Ho: difference in coefficients not systematic
chi2(9) = (b-B)'[(V_b-V_B)^(-1)](b-B) = 41.71
Prob>chi2 = 0.0000
(V_b-V_B is not positive definite)

APPENDIX 6: Collinearity Diagnostics

Variable	VIF	SQRT-VIF	Tolerance	R-Squared
Ln(Assets)	2.3	1.52	0.4355	0.5645
PPNR/Assets	1.13	1.06	0.8872	0.1128
LLP/Assets	1.16	1.08	0.8599	0.1401
Tier 1 Capital Ratio	1.34	1.16	0.7463	0.2537
Debt/Capital	3.18	1.78	0.314	0.686
Real Estate Loans/Assets	2.44	1.56	0.4095	0.5905
Consumer Loans/Assets	2.18	1.48	0.4593	0.5407
Commercial Loans/Assets	2.7	1.64	0.3702	0.6298
Deposits/Assets	3.62	1.9	0.2764	0.7236
Mean VIF	2.23			