HOW DO FEDERAL RESERVE'S STRESS TESTS CHANGE BANKS' DEBT TAKING BEHAVIOR?

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ABSTRACT

The 2008 financial crisis revealed the harm that "too big to fail" banks could do to the global economy. As a result, policy makers adopted stress testing as an official check on big banks' behavior. This paper examines the effect of stress testing – including taking stress tests as well as having the targeted asset range of the stress test but not taking the test due to compliance reasons – on big banks' financial stability, specifically their short-term and long-term debt to asset ratios. My findings suggest that large banks that are subject to (or within the target asset range to take) both the Fed's supervisory stress tests and company-run stress tests are more responsive in terms of their short-term and long-term debt to asset ratios than medium-sized banks that are only subject to (or within the target asset range to take) company-run stress tests. My policy recommendations are that regulators should weigh the costs and benefits of certain regulations since that the closely supervised regulations tends to be more effective and that regulators should also take banks' moral hazard problems into consideration when making decisions.

The research and writing of this thesis is dedicated to everyone who helped along the way. I want to express my special gratitude to Dr. Andrew Wise, for his guidance, patience and encouragement. I also want to thank Dr. Jeffrey Mayer for his help, and Lipei Tao for always inspring and supporting me. Finally, I want to thank my parents for their unconditional love and support.

Many thanks,
Yichen Gong

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I. Introduction

This paper examines the effects of stress testing on financial stability; specifically, whether stress testing improves the resilience of banks and encourages less frequencies of risk-taking behaviors. The 2008 global recession warned the whole world about the potential harm that "too big to fail" banks could do to the global economy. Policy makers regretted not having monitored those institutions under stricter regulations and individuals in the general public were angry about the money they paid to bail the banks out. The whole world was alerted of the importance of regulation, and the precautions to take against the potential failure of the world's largest banks identified as systemically important financial institutions (SIFI).

The main reason for the 2008 financial crash was the big banks' lack of capital, high leverage ratios, and risky investments. In order to address this issue, the Federal Reserve (Fed) came up with exercises that were aimed at preventing these banks from making the same mistake, while also convincing the general public that the financial system was well monitored.

The Federal Reserve's exercises, the Comprehensive Capital Analysis and Review (CCAR) and the Dodd-Frank Act stress testing (DFAST), are both conducted on an annual basis and apply to banks that have assets of $10 billion or more. DFAST mainly consists of two kinds of stress tests – the company-run stress tests, and the Fed's supervisory stress tests. Banks with total consolidated asset of $10 billion or more are subject to annual company-run stress test, while banks with total consolidated asset of

$50 billion or more are subject to the additional Fed's annual supervisory stress tests. The Fed conducts the CCAR and reviews the largest bank holding companies operating in the United States to see whether they have sufficient capital to operate under financial stress and macro-economic instability. Reviewed banks are also required to have valid and practical capital-planning processes to account for their unique risks. For other smaller banks with assets below $10 billion, the stress testing is not mandatory.

This paper assesses the effect of stress testing on debt to asset ratios of large bank holding companies including SIFI banks. My hypothesis is that banks undergoing a supervisory stress test will decrease their short-term debt to asset ratios, since they might want to avoid the same liquidity problems they faced in the 2008 crisis, and might increase their long-term debt to asset ratio to account for the leverage they need for operation and growth, while banks that only undergo a company-run stress test may not see a robust change in their debt to asset ratios since they are usually less concerned about, and more in the need of, growth. To test my hypothesis, I build two sets of models – one set for testing the DFAST effect on banks with asset levels between $10 billion and $50 billion; the second set for testing the DFAST effect on banks with assets of $50 billion and above. For each set of models, there are three dependent variables – total debt to asset ratio, short-term debt to asset ratio, and long-term debt to asset ratio – with independent variables covering fundamental information on the banks as well as treatment dummy variables. The main source of data is the Wharton Research Data Services, where data are requested from the Capital IQ program. I also use SEC bank filings (Form 10-Q) for double-checking some data.

The paper proceeds as follows. Section II provides background and reviews related literature. Section III describes the underlying theoretical framework I propose to examine the relationships between the leverage status of the banks and their stress testing status. Section IV provides data and descriptive statistics. Section V presents the empirical models I use to test my hypothesis. Section VI presents my results and findings. Section VII presents the conclusion and policy implications of my study. I also point out limitations of the study and propose future directions for related research.

II. Background and Literature Review

Background

Micro-Prudential Stress Tests Before the 2008 Crisis

Greenlaw (2012) points out that there are two types of stress tests: micro-prudential stress tests and macro-prudential stress tests. He notes that, prompted by the U.S. savings and loan crisis in the early 1980s, with a goal to resolve insolvent banks and protect taxpayers, micro-prudential stress tests emphasize the "traditional role of bank capital as a buffer against loss, shielding the deposit insurance agency" (p.1). In contrast, macro-prudential stress tests focus on "whether the banking system as a whole has the balance sheet capacity to support the economy" (p.1). According to Greenlaw, macro-prudential tests' main aims are: (i) "averting runs on systemic banks by wholesale creditors that lead to a contraction of credit and damage to the broader economy" (p.1); and (ii) avoiding "aggregate deleveraging in periods of distress" (p.1). Macro-prudential remedies focus on raising new capital measured in total dollars, rather than on merely satisfying capital ratios. However, in this paper, I mainly address micro-prudential stress tests.

Micro-prudential stress tests date to the 1990s. In 1996, an amendment to the Basel Capital Accord required banks and investment firms to conduct stress tests as part of their internal assessments. The tests allowed the banks to self-assess their abilities to function under unpredictable negative market events. However, starting in 2007, regulatory institutions began to take stress tests more seriously and to routinely conduct tests on financial institutions to monitor their general behavior. Finally, in October 2012, the Fed made it mandatory for big banks to take stress tests every year and reveal the outcomes to

the public (Quagliariello, 2009). The trigger for this move was the 2008 global financial crisis.

The 2008 Financial Crisis

The 2008 financial crisis is considered by many to be the worst financial crisis since the Great Depression of the 1930s. Before the market panic, because mortgage backed securities (MBS) seemed solid and soaring, nobody would have thought of questioning the biggest banks on Wall Street about their solvency and resilience nor would they have thought that the economy could collapse one day. However, the naïve beliefs that mortgage backed securities were reliable and that the U.S. housing market was not overvalued led to tragedy. The bursting of the housing bubble caused millions of people to lose their jobs and houses, and led to large losses in the stock market, which eventually led to a global financial crisis.

As the main carriers of MBSs and their derivatives, big banks were deeply affected by the 2008 financial earthquake and many of them were on the verge of collapsing. Their overvaluation of subprime mortgages, imprudent trading strategies, prioritization of short-term benefits, and high leverage ratios with inadequate capital holdings left not only themselves, but also global markets in peril (Simkovic, 2009). Moreover, while ordinary people were losing their jobs and homes, some of the biggest banks that were "too big to fail" were bailed out by the U.S. government, using the taxpayers' money. As a result, people lost confidence in the stock markets and the U.S. financial system, and

they were furious about the bailout. Many people also blamed the regulators' inadequacy and their failure to regulate and supervise the banks.

In order to placate the general public and to monitor the risks posed by big banks, the U.S. government and regulatory agencies adopted stricter financial regulations on all institutions, especially the ones perceived as "too big to fail".

SIFI banks and the Dodd-Frank Act

In an effort to strengthen the financial system, the Basel III Accord was negotiated and the Dodd-Frank Act was enacted. Basel III, developed by the Basel Committee on Banking Supervision, and adopted by the Federal Reserve Board of Governors in December 2011, was aimed at strengthening bank capital requirements by increasing bank liquidity and decreasing bank leverage (Basel Committee, 2010). It specifically introduced the concept of the Systematically Important Financial Institution (SIFI) — a bank, insurance company, or other financial institution whose failure might trigger a financial crisis. In addition, in 2010, to prevent a crisis like the 2008 crisis from happening again, Congress enacted and President Obama signed the *Dodd-Frank Wall Street Reform and Consumer Protection Act*. The Dodd-Frank Act aims at preventing banks from taking excessive risk and strives to ensure a more stable economy (White House website). It also requires large bank holding companies with assets over $10 billion, including the SIFI banks, to conduct the Dodd-Frank Act Stress Testing (DFAST).

The Fed's Stress Tests

To assess whether SIFI banks and other banks that are "too big to fail" have enough capital to function well, even during economic downturns, the Federal Reserve conducts an annual exercise called the Comprehensive Capital Analysis and Review (CCAR). In addition, as a complementary exercise to CCAR, the Fed also conducts Dodd-Frank Act Stress Testing on large bank holding companies. The annual Fed's supervisory stress tests and company-run stress tests are mandatory for the bank holding companies with more than $50 billion in assets. Banks with assets between $10 billion to $50 billion will only have to conduct company-run stress tests each year (McGrane, 2012). The tests are usually computer-generated simulation models that test hypothetical scenarios with given unemployment rates, GDP, oil prices, and other factors that simulate the worsening of an economic recession.

To date, the Fed has conducted four annual supervisory Dodd-Frank stress tests. Last year's (2016) tests cleared 31 out of 33 bank holding companies, with only Santander and Deutsche Bank failing. One important thing to note is that the rules for the Fed's stress tests have been evolving through the years. Some banks within the qualifying asset range did not participate in the DFAST due to compliance and other reasons. Despite this, in this paper, I still use the asset level of banks to determine their category for stress testing. The reason is my belief that banks of the same size (asset level) are perceived to be similar by outside investors and should therefore have same influence over the financial market and similar attitudes towards regulation.

Positive Effects

According to Fed Governor Daniel K. Tarullo, who is the chair of the Federal Financial & Institution Examination Council, the six-year CCAR and stress tests have successfully pushed the biggest banks to strengthen their capital positions and risk management capacities. Tarullo also states that the process will enhance the resiliency of the banks, and that the banks are now more cautious than they were six years ago (Fed, 2016).

In addition, by helping monitor and supervise the big banks, the stress tests also have a positive effect on the general public (Borak and Tracy, 2016). Since the stress tests themselves were created as part of the restoration of the credibility of the U.S. financial regulation system, they may also have helped to restore the general public's confidence in the financial markets and the stock market, as well as public confidence in financial regulations. This is crucial both for the credibility of the government and the stability of the financial system, since public panic can lead to chaotic and uncontrollable outcomes.

Also, the stress tests may have helped to create a large number of jobs here in the U.S. In addition to the team that the Fed set up to conduct stress tests on the banks every year, the regulatory compliance and the benchmarking of the banks' internal policy drove the banks to hire professionals to help them with the stress tests along with other regulatory compliance issues (Borak and Tracy, 2016). Some of the big banks set up their own quantitative analysis divisions for conducting internal stress tests, while others relied on outside consultants. Since no banks wanted to be shamed by the public revelation of

failing the test, their perceived values for passing the tests have been high, and this has generated considerable profits and job opportunities.

Negative Effects

Despite their merits, however, stress tests also have a negative side and some people have even begun to question their credibility and validity. For example, since the Fed's stress tests limit banks' investments and capital ratios, and are crucial in determining the banks' capital-returns to their investors, some bankers have complained that the tests have been "overly opaque and stringent" and the high capital requirements have "choked lending and harmed the economy" (Borak and Tracy, 2016). People have also questioned the consistency in the stringency of the tests. Some say that as the years have passed, tests have become much less stringent, and are signaling the wrong information to the public just to calm them down. In contrast, others believe that the difficulty of the tests has increased over the years. Moody's Analytics Chief Economist Mark Zandi has said that this year's exams were "arguably the most stressful stress tests yet" (Borak and Tracy, 2016).

Since regulations sometimes can be broad and stringent, big banks have to make considerable efforts to comply with them. They need to spend time and money in hiring the right people, building the perfect team to run daily operations and risk management, and seek outside expertise or consultancy from time to time. According to Standard & Poor, due to the Dodd-Frank Act compliance, big banks' annual pre-tax earnings will

drop by $22 billion to $34 billion (Chaudhuri, 2014), and if costs keep going up, they hinder the growth of the banks and threaten the health of the entire U.S. financial system.

Patrick McHenry's Fin-Tech Bills

Financial Technology (Fin-Tech) has become an increasingly hot topic. It is an industry that introduces innovations and technology into the finance industry. It mainly applied to banking operations, but now has increased its application to personal and commercial finance. Examples of Fin-Tech are mobile banking, digital wallets (Applepay, Venmo), and Uber's payment systems, which people use almost every day. Countries like China, and the U.K. have embraced the technology and have implemented corresponding regulations. The U.S. has also begun to move toward regulating in this direction, perhaps spurring financial innovations.

On July 11, 2016, Chief Deputy Whip Patrick McHenry (R, NC-10), the Vice Chairman of the House Financial Services Committee, introduced two bills: H.R. 5724, the *Protecting Consumers' Access to Credit Act of 2016* and H.R. 5725, the *IRS Data Verification Modernization Act of 2016*. McHenry's bills are friendly to Fin-Tech and aim to incorporate new financial innovations and make online lending part of the lending system, thus making the system more accessible to the general public. The congressman agrees that, "Innovation in financial services has created more convenient and secure ways to meet the demands of American consumers," and for these efforts to succeed, "Washington must rethink its own laws and regulations to keep up with the growth and creativity in the private sector" (Butler, 2016).

McHenry's bills also signal to the public that the era of the Fin-Tech and financial innovation is coming, that they need to embrace it, and that related laws and regulations might need to be adjusted. In particular, the stress tests may need to incorporate more technology to keep pace with the trend.

In fact, technology companies have already taken actions to incorporate regulation with technologies. On September 29, 2016, International Business Machines (IBM) announced its acquisition of Promontory Financial Group, a risk management and regulatory compliance consulting firm. IBM intends to use Promontory's regulatory expertise to teach Watson, IBM's artificial-intelligence computer system, about new regulatory requirements. The goal is that Watson will quickly absorb the expertise and help banks meet regulatory requirements related to Anti-Money Laundering, the Fed's Stress Tests, and other laws and regulations (Burne and Tracy, 2016).

This may present opportunities for stress testing in that it may help to develop more sophisticated tests and thus contribute to a more stable financial system. However, it may also be the case that, when faced with vague and conflicting regulatory compliance requirements, the technology will not be as flexible as human beings

Trump's Agenda for the Dodd Frank Act

For the Democratic Party, which typically favors more financial regulation, and the Republican Party, which traditionally favors deregulation and free markets, the outcome

of the 2016 Presidential Election may have important implications for the financial regulation agenda.

Hillary Clinton supported reform of the Federal Reserve and advocated for greater oversight of the financial industry. She also supported the Dodd-Frank Act and advocated to strengthen the law, giving less protection to the big banks and allowing them to fail.

But in the 2016 election, Clinton lost and Trump won, and Trump advocates for deregulation and wants to reduce the power of the Federal Reserve. He even calls for repeal of the Dodd-Frank Act, and claims that regulations have imposed unnecessary costs and are hindering the growth of the U.S. economy.

As a result, big banks will possibly have more freedom and even the chance to get rid of the Fed's mandatory stress tests if the Republicans manages to repeal the Dodd-Frank Act. So far, however, there have been no major changes to the Fed's stress test, and banks still have to comply with 2017 DFAST.

Literature Review

Since the 2008 financial crisis, an increasing number of studies have focused on stress tests' methodology, effectiveness and consequences. For example, Greenlaw, Kashyap, Schoenholtz and Shin (2012) studied the framework for evaluating stress tests. They started by introducing the concepts of macro-prudential stress tests and micro-prudential stress tests, then identified the differences in rationale between the two in terms of their

purpose, scope, liability considerations, asset considerations, and outputs. Their main conclusion, deducted from the study of stress tests conducted at different points in the past 15 years in Europe, Japan, and the United States, is that existing stress test results can contribute to financial stability through the identification of crucial elements in the results.

Ong and Pazarbasioglu (2014) studied the credibility of crisis stress tests, a type of macro-prudential stress test that focuses on crisis management. They proposed guidelines for constructing an effective crisis stress test and argued that previous stress test records and experiences should be taken into consideration. They also claimed that country authorities must be fully committed to testing, have a clear objective, take appropriate action and set the transparency bar based on the crisis level and timelines.

There are also studies of the Federal Reserve Board's stress tests. Glasserman and Tangirala (2015) studied the effectiveness of the Fed's stress tests and argued that the outcomes of stress tests have become more predictable as they have evolved and, therefore, they are less informative than they once were. Guerrieri and Welch (2012), on the other hand, studied the predictions of stress test for banks' performance, and found that including macro variables used in stress tests in models is sometimes helpful in forecasting the behavior of the banks, but that this is not always the case.

As for the consequences of the regulatory stress testing, Gallardo, Schuermann and Duane (2015) observed three major trends in the U.S. regulatory stress testing:

1. There is increasingly aggressive capital management especially in investment banks, universals, and custodians, who appear to be managing their capital more and more tightly, while regionals and card companies are choosing to manage capital less conservatively.
2. The tests are drivers of enhanced financial resource management. First, stress tests results become more stabilized and sometimes converge. Second, even though the Fed discourages or rejects aggressive capital management, the market seems to reward it.
3. The stress tests have unintended consequences. The Fed's stress testing models have become an increasingly important driver of the financial system. A highly conservative model may harm the efficiency of the financial system, while a model that is vulnerable to a specific source of risk may leave the financial system heavily undercapitalized at a time of stress.

In addition, several papers have examined the effect of banking supervision and regulation on banks' risk taking behavior. These papers have concluded, first, that banks respond to increases in regulatory capital requirements by reducing credit supply in the short run (Gropp et al., 2016; Mésonnier and Monks, 2015). Second, there is evidence of positive effects of supervision on bank performance. For example, Agarwal et al. (2012) find that state banks that were examined by a federal regulator before a state regulator reported higher nonperforming loans, more delinquent loans, higher regulatory capital ratios, and lower returns on assets. Rezende and Wu (2014) find that more frequent bank

examinations are positively related to higher bank profitability through reducing loan losses.

Studies have also examined the effect of bank ownership and governance on risk taking. Laeven and Levine (2009) find evidence for both ownership and regulatory effects on risk. They find that banks with more powerful shareholders take more risk. Moreover, they find heterogeneous effects of banking regulation depending on the bank's ownership structure. Therefore, applying uniform banking regulation to heterogeneous banking institutions can have positive or negative impacts on risk-taking depending on the ownership structure. Barry et al. (2011) study the impact of shareholder characteristics on risk at European commercial banks. They find that relative to ownership by institutional investors, an increase in the equity stake of individual/family and banking institutions shareholders reduces asset and default risks. Moreover, they find no significant differences in risk taking between public and private banks. Pathan (2009) studies the relationship between bank board and management power. He finds that strong boards that better represent shareholder interests are positively related to risk-taking. However, as a CEO's power to compel board decisions increases, there is a negative impact on risk taking.

There is also a rich literature on European stress tests. For example, Spagoli (2013) studied the information value of a stress test in a crisis, and found out that disclosure of banks' stress test results not only forced banks to reduce their risk of default, but also led them to downsize unless the regulator is able to recapitalize them. Petrella and Resti

(2012) studied the 2011 European stress tests to examine how the disclosure of test results can affect bank stock prices. They found that stress tests can offer valuable information to investors and can also help mitigate bank opacity. Ellahie (2012) also studied the 2011 European stress tests to but came to the conclusion that stress test announcements "do not significantly affect measures of information asymmetry or information uncertainty for tested banks". However, he agreed that a transparent government stress test can improve the information environment in a crisis-era capital market.

The Present Paper

Similar to this paper, Eber and Minoiu (2016) assess the effects of major stress tests conducted by the European Central Bank beginning with the introduction of the Eurozone's Single Supervisory Mechanism. Using a regression discontinuity design, they find that banks subject to stress testing reduced their leverage. They deleveraged mainly through shrinking assets, rather than raising equity.

However, despite the large number of studies to date, no study has yet examined the effects of the U.S. Fed's stress tests on banks' debt to asset ratios. In addition, the main studies in this literature have focused on measuring behavioral responses for solvency risk, as opposed to liquidity risk. This paper aims to fill this gap by studying the effect of stress tests in the US on both solvency and liquidity risk. In the next section, I will present my theoretical framework.

III. Theoretical Framework

My analysis tests the hypothesis that banks undergoing the Fed's supervisory stress tests will decrease their short-term debt to asset ratios and increase their long-term debt to asset ratio, and that banks that only undergo a company-run stress test may not see a robust change in their debt to asset ratios. This hypothesis is expressed as:

$$R = f(T, A, I, L, E) \quad (1)$$

Where R is banks' risk-taking behavior; T is the action of taking the Fed's stress tests; A is the total assets of the bank holding company, which captures the size of the bank; I is whether the bank is domestic or international, indicating the size and influence of the bank; L is the banks' liabilities; and E is the banks' equity.

This general theoretical framework is used to study the effect of the Fed's stress tests on banks' risk taking behavior, specifically how banks leverage their debt after being required to taking the tests. Including the banks' asset levels and international states captures the size and influence of the bank. Including liability and equity levels helps paint a complete background of the bank's financial standing and health.

In the next section, I will turn to the data I use to test my hypothesis.

IV. Data and Descriptive Statistics

To estimate the targeted models and examine the hypothesis, I use a panel dataset comprised of two sets of quarterly data (Quarter 3 and Quarter 4, 2013). In order to capture the effects before and after the test, I use calendar quarter here instead of fiscal quarter from the companies' own definitions to avoid confusion. The targets include 572 banks that filed SEC 10Q fillings (a set of quarterly financial reports) that includes both big banks and smaller banks. The main source of my data is Wharton Research Data Services' Capital IQ program. For due diligence, to check some data and supplement my dataset, I also used SEC bank filings (Form 10-Q).

Descriptive statistics for the explanatory variables that provide general information about the banks included in my dataset are provided in table 1. How the treatment group is divided is shown in table 2. Descriptive statistics for my dependent variables are provided in table 3.

As described in Table 1, all my binary variables are marked with "*", where the value of the variable equals one when the condition of the variable is present and equals zero when the condition is absent. For example, when *International* equals one, the bank is international and have branches in other countries other than the U.S.; when *International* equals zero, the bank only has branches in the U.S. *Asset* is a continuous variable indicating the bank's total consolidated asset level. *Liability* and *Equity* are also continuous variables indicating the bank's liability and stakeholder's equity level. *Short-*

Term Debt, *Long-Term Debt* and *Total Debt* are continuous variables that indicating the different types of the bank's debt. *Treat 1* and *Treat 2* are binary variables that categorize banks into different asset levels. When *Treat 1* equals one, the bank's assets are over $10 billion and that the bank is subject to company-run stress tests. When *Treat 1* equals zero, the bank's overall assets are below $10 billion and the bank is, therefore, not subject to company-run stress tests. When *Treat 2* equals one, the bank's assets are over $50 billion and the bank is subject to the Fed's supervisory stress tests; where when *Treat 2* equals 0, the bank's overall assets are below $50 billion, and thus the bank is not required to take the Fed's stress test. As shown in Table 2, *Treat 1* and *Treat 2* are not mutually exclusive: when the assets are between $10 billion and $50 billion, both *Treat1* and *Treat2* equal 1.

Table 1: Descriptive Statistics - Explanatory Variables

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Explanatory Variable	**N**	**Mean ($Million)**	**Standard Deviation ($Million)**	**Minimum ($Million)**	**Maximum ($Million)**
Asset	1088	80884.73	343422.6	70.003	2723362
Liability	1081	75717.19	322904.6	61.62	2535668
Equity	1067	5417.882	22872.05	-0.216	232685
Short-Term Debt	1047	5561.555	31584.11	0	375880.1
Long-Term Debt	1069	7890.095	38346.83	0	548257.8
Total Debt	1047	12893.28	62163.04	0	705874.8
International*	1144	0.0926573	0.2900785	0	1
Treat1*	1144	0.2587413	0.4381347	0	1
Treat2*	1144	0.1853147	0.3887226	0	1
*** Binary variable, where a value of 1 indicates the presence of a condition and 0 indicates the absence of the condition.**					

Table 2: Treatment Categories

Asset Level ($ Billion)	Company-Run Stress Test	Fed's Supervisory Stress Test	Treatment 1	Treatment 2
Asset<10	Not required	Not required	0	0
10<Asset<50	Required	Not required	1	0
Asset>50	Required	Required	1	1

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Table 3 shows that, the average total debt to asset ratio for all banks is 9.27 percent, with average short-term portion of the debt to asset ratio at 3.17 percent and the average long-term portion of the debt to asset ratio at 6.19 percent.

Table 3: Descriptive Statistics - Dependent Variables

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Dependent Variable	**N**	**Mean**	**Standard Deviation**	**Minimum**	**Maximum**
Total Debt to Asset Ratio	1047	0.0927103	0.0793785	0	0.6824088
Short-Term Debt to Asset Ratio	1047	0.0317318	0.0498029	0	0.4880925
Long-Term Debt to Asset Ratio	1069	0.0618938	0.0650747	0	0.6222045

In the next section, I will describe my empirical modelling approach.

V. Empirical Model

I test the hypothesis that a bank with total consolidated assets over a certain threshold that is subject to stress tests (company-run or/and Fed-run) will change its debt taking behavior, using a Regression Discontinuity Design to see if there is a solid shift effect (increase or decrease) of the stress test on the bank's debt to asset ratio.

A regression discontinuity design (RDD) is a quasi-experimental design that assigns a cutoff above or below where an intervention is assigned to examine the treatment effects of that intervention. In my model design, the cutoffs are the asset level thresholds – $10 billion and $50 billion, and the interventions are the Fed's stress tests. I expect to see a clear shift effect around the cutoff point if the treatment does have a significant effect.

I use $10 billion in the bank's total consolidated assets as the cut-off point in the first regression model, and $50 billion of total consolidated assets as the cut-off point in the second regression model. The models are as below:

The first set of regression models testing banks above the $10-Billion threshold:

(1) Debt to Asset Ratio (Total debt as numerator)

$$\text{DebtAssetR} = \beta_0 + \beta_1(\text{Treat1}) + \beta_2(\text{PAsset1}) + \beta_3(\text{TreatPAsset1}) + \beta_4(\text{SqPAsset1}) + \beta_5(\text{TreatSqPAsset1}) + \beta_6(\text{International}) + \beta_7(\text{Asset}) + \beta_8(\text{Liability}) + \beta_9(\text{Equity}) + \varepsilon$$

(2) Short-Term Debt to Asset Ratio (Short-term debt as numerator)

$$\text{SDebtAssetR} = \beta_0 + \beta_1(\text{Treat1}) + \beta_2(\text{PAsset1}) + \beta_3(\text{TreatPAsset1}) + \beta_4(\text{SqPAsset1}) + \beta_5(\text{TreatSqPAsset1}) + \beta_6(\text{International}) + \beta_7(\text{Asset}) + \beta_8(\text{Liability}) + \beta_9(\text{Equity}) + \beta_8(\text{Liability}) + \beta_{10}(\text{Ldebt}) + \varepsilon$$

(3) Long-Term Debt to Asset Ratio (Long-term debt as numerator)

$$\text{LDebtAssetR} = \beta_0 + \beta_1(\text{Treat1}) + \beta_2(\text{PAsset1}) + \beta_3(\text{TreatPAsset1}) + \beta_4(\text{SqPAsset1}) + \beta_5(\text{TreatSqPAsset1}) + \beta_6(\text{International}) + \beta_7(\text{Asset}) + \beta_8(\text{Liability}) + \beta_9(\text{Equity}) + \beta_{10}(\text{Sdebt}) + \varepsilon$$

The second set of regression models testing banks above $50-billion threshold:

(4) Debt to Asset Ratio (Total debt as numerator)

$$\text{DebtAssetR} = \beta_0 + \beta_1(\text{Treat2}) + \beta_2(\text{PAsset2}) + \beta_3(\text{TreatPAsset2}) + \beta_4(\text{SqPAsset2}) + \beta_5(\text{TreatSqPAsset2}) + \beta_6(\text{International}) + \beta_7(\text{Asset}) + \beta_8(\text{Liability}) + \beta_9(\text{Equity}) + \varepsilon$$

(5) Short-Term Debt to Asset Ratio (Short-term debt as numerator)

$$\text{SDebtAssetR} = \beta_0 + \beta_1(\text{Treat2}) + \beta_2(\text{PAsset2}) + \beta_3(\text{TreatPAsset2}) + \beta_4(\text{SqPAsset2}) + \beta_5(\text{TreatSqPAsset2}) + \beta_6(\text{International}) + \beta_7(\text{Asset}) + \beta_8(\text{Liability}) + \beta_9(\text{Equity}) + \beta_{10}(\text{Ldebt}) + \varepsilon$$

(6) Long-Term Debt to Asset Ratio (Long-term debt as numerator)

$$\text{LDebtAssetR} = \beta_0 + \beta_1(\text{Treat2}) + \beta_2(\text{PAsset2}) + \beta_3(\text{TreatPAsset2}) + \beta_4(\text{SqPAsset2}) + \beta_5(\text{TreatSqPAsset2}) + \beta_6(\text{International}) + \beta_7(\text{Asset}) + \beta_8(\text{Liability}) + \beta_9(\text{Equity}) + \beta_{10}(\text{Sdebt}) + \varepsilon$$

In both set of regression models, *DebtAssetR* is the bank's debt to asset ratio which is defined as total debt over total assets, where total debt includes both short-term and long-term debt. *SDebtAssetR* is the bank's short term debt to asset ratio which is defined as short-term debt over total assets, while *LDebtAssetR* is the bank's long term debt to asset ratio which is defined as short-term debt over total assets. In this study, I use debt to asset ratio to test the effects on the overall debt over asset leverage, and I use short-term debt to asset ratio and long-term asset ratio to capture the effects of stress tests on different kinds of debt leverage.

In both models, *International* is a dummy variable where a value of one indicates that the bank is international and the value of zero indicates that the bank is domestic. This variable is used to capture the size as well as the influence, and reputation of the bank. I expect that being an international bank and having branches not only in the U.S. will decrease the bank's intention of taking more risk due to its care for reputation and influence, resulting in a negative coefficient.

Asset, *Liability* and *Equity* are all continuous variables that indicate a bank's financial situation. *Asset* is the bank's total consolidated assets; *Liability* is the bank's total liability; *Equity* is the bank's total stockholder's equity. I expect the effect of assets on the

dependent variable to be negative as larger assets will decrease the leverage ratio holding the debt unchanged. I expect the effect of liability on the leverage ratio to be positive as total debt is part of the bank's total liabilities, thus the higher the liability level the higher the debt to asset ratio. I expect the effect of equity on the leverage ratio to be negative. Since assets = liabilities + equity, holding assets constant and increasing equity will lead to a decrease in liabilities and thus a decrease in the debt to asset ratio. While holding liabilities constant, increasing equity will lead to an increase in assets and thus a decrease in the debt to asset ratio.

Sdebt and *Ldebt* are a bank's short-term and long-term debt. I expect short-term debt and long-term debt to have a negative effect on each other and thus a negative effect of short-term debt on long-term debt to asset ratio and a negative effect of long-term debt on short-term debt to asset ratio.

Treat(i) indicates that the bank's total assets are above threshold i and in the i treatment group (i=1 or 2). I expect the effect of treatment to be negative, since I expect being more regulated would lead to a less risky behavior and thus a smaller debt to asset ratio.

PAsset(i) is the bank's total assets minus the threshold assets ($10 billion if i=1 and $50 billion if i=2). I expect the effect of PAsset(i) to be positive as the size of the bank increases, it is more inclined to take riskier action to grow.

SqPAsset(i), *TreatPAsset(i)*, *TreatSqPAsset(i)* are the quadratic terms of *PAsset(i)*, linear interaction between treatment and *PAsset(i)*, and the quadratic interaction term between treatment and *SqPAsset(i)*. I use the squared term of *PAsset* to capture the changing effect of asset level as the level increases on the debt to asset ratio. I expect the effects of linear interaction and squared interaction to be positive but the effect of squared term to be negative. I expect that as the asset level increases, the effect of asset on debt to equity ratio will increase at a decreasing rate.

In the next section, I will discuss the results of my estimations.

VI. Results

After running two sets of regression models, I find jointly significant results on all models. However, the significance of coefficients on independent variables varies according to different model specifications. Overall, I find the treatment 1 effect is only significant for the long-term debt to asset ratio, while the treatment 2 effect is significant for both short-term and long-term debt to asset ratios. However, both treatments have no effect on a bank's total debt to asset ratio. Table 4 to 10 presents the results of my models.

Model (1) is significant at the 1 percent level since the F statistic is 7.80 with a P-Value equal to 0.0000. The Ramsey test shows that with a P-Value equals to 0.19, I fail to reject the null hypothesis that the model has no omitted variable bias at the 5 percent significance level. However, only one variable – *International* is significant at the 5 percent level. All other variables are insignificant at the 5 percent level. I conclude that at the 5 percent level, being in the treatment 1 group does not make a difference in a bank's total debt to asset ratio.

Table 4: Model (1) – Total Debt to Asset Ratio, Treatment 1, $10-Billion Threshold

VARIABLES	DebtAssetR
Treat1	0.0195
	(0.0388)
PAsset1	-9.92e-06
	(1.15e-05)
TreatPAsset1	1.00e-05
	(1.16e-05)
SqPAsset1	-1.23e-09
	(8.83e-10)
TreatSqPAsset1	1.23e-09
	(8.83e-10)
International	0.0575**
	(0.0271)
Asset	4.40e-06
	(7.01e-06)
Liability	-4.46e-06
	(7.10e-06)
Equity	-4.34e-06
	(7.05e-06)
Constant	0.0904**
	(0.0363)
Observations	508
R-squared	0.124

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

Model (2) is significant at the 1 percent level since the F statistic is 4.70 with a P-Value equal to 0.0000. The Ramsey test shows that with a P-Value equals to 0.2345, I fail to reject the null hypothesis that the model has no omitted variable bias at the 5 percent significance level. However, none of the variables are significant at the 5 percent level. I conclude that at the 5 percent level, being in the treatment 1 group does not make a difference in the bank's short-term debt to asset ratio.

Table 5: Model (2) – Short-Term Debt to Asset Ratio, Treatment 1, $10-Billion Threshold

VARIABLES	SDebtAssetR
Treat1	-0.0307
	(0.0325)
PAsset1	1.83e-06
	(9.30e-06)
TreatPAsset1	-2.15e-06
	(9.31e-06)
SqPAsset1	-1.87e-10
	(6.64e-10)
TreatSqPAsset1	1.87e-10
	(6.64e-10)
International	0.00955
	(0.0195)
Asset	-1.96e-06
	(4.01e-06)
Ldebt	-1.03e-07
	(1.63e-07)
Liability	2.35e-06
	(4.07e-06)
Equity	2.07e-06
	(4.07e-06)
Constant	0.0554*
	(0.0313)
Observations	508
R-squared	0.083

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

Model (3) is significant at the 1 percent level since the F statistic is 4.32 with a P-Value equal to 0.0000. The Ramsey test shows that with a P-Value equals to 0.5884, I fail to reject the null hypothesis that the model has no omitted variable bias at the 5 percent significance level. *Treat 1* is significant at the 5 percent level and *International* is significant at the 1 percent level. Being in the Treatment group 1 will increase a bank's long-term debt to asset ratio by 0.05, which is quite large in magnitude considering the

average long-term debt to asset ratio of all banks is 6.19 percent. This result is different than what I had expected. The result may be that small- to medium-sized banks are in the process of growing and thus they may need to issue bonds, lease larger offices, and do other things to boost size and business. The positive coefficient of *International* may be that being international is easy for the banks to gain short-term debt, and that in turn encourages them to use it.

Table 6: Model (3) – Long-Term Debt to Asset Ratio, Treatment 1, $10-Billion Threshold

VARIABLES	LDebtAssetR
Treat1	0.0501**
	(0.0209)
PAsset1	-1.18e-05
	(7.41e-06)
TreatPAsset1	1.22e-05*
	(7.40e-06)
SqPAsset1	-1.05e-09*
	(6.35e-10)
TreatSqPAsset1	1.05e-09*
	(6.35e-10)
International	0.0489***
	(0.0160)
Asset	6.22e-06
	(5.23e-06)
Sdebt	-2.47e-08
	(1.19e-07)
Liability	-6.70e-06
	(5.26e-06)
Equity	-6.26e-06
	(5.22e-06)
Constant	0.0351*
	(0.0193)
Observations	508
R-squared	0.080

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

Model (4) is significant at the 1 percent level since the F statistic is 7.30 with a P-Value equal to 0.0000. The Ramsey test shows that with a P-Value equals to 0.0696, I fail to reject the null hypothesis that the model has no omitted variable bias at the 5 percent significance level. However, no variables are significant at the 5 percent level, indicating that being in the treatment 2 group makes no difference in the bank's total debt to asset ratio.

Table 7: Model (4) – Total Debt to Asset Ratio, Treatment 2, $50-Billion Threshold

VARIABLES	DebtAssetR
Treat2	-0.0669
	(0.0769)
PAsset2	1.68e-06
	(4.53e-06)
TreatPAsset2	-1.59e-06
	(4.47e-06)
SqPAsset2	-0
	(5.97e-11)
TreatSqPAsset2	0
	(5.97e-11)
International	0.0532*
	(0.0299)
Asset	6.53e-06
	(7.68e-06)
Liability	-6.59e-06
	(7.77e-06)
Equity	-6.48e-06
	(7.72e-06)
Constant	0.178**
	(0.0829)
Observations	508
R-squared	0.117

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

Model (5) is significant at the 1 percent level since the F statistic is 3.52 with a P-Value equal to 0.0002. The Ramsey test shows that with a P-Value equals to 0.0263, I can reject the null hypothesis that the model has no omitted variable bias at the 5 percent significance level but I fail to reject the null hypothesis that the model has no omitted variable bias at the 1 percent significance level. The *Treat2*, *PAsset2*, linear interaction term, quadratic term, quadratic interaction term are all statistically significant at the 5 percent level, indicating that there are significant treatment and slope effects. The total effect of being in the treatment 2 group on the bank's short-term debt to asset ratio is positive, which indicates that being in the treatment 2 group has encouraged large banks to take on short-term debt. The treatment effect on the ratio for banks with $50 billion in assets is a roughly 0.0659 increase, which is large in magnitude considering the average short-term debt to asset ratio is 3.17 percent. Graph 1 also shows that there is a clear shift up around $50 billion asset level.

Table 8: Model (5) – Short-Term Debt to Asset Ratio, Treatment 2, $50-Billion Threshold

VARIABLES	SDebtAssetR
Treat2	0.0659***
	(0.0252)
PAsset2	-5.10e-06***
	(1.94e-06)
TreatPAsset2	4.76e-06**
	(1.90e-06)
SqPAsset2	-7.10e-11**
	(0)
TreatSqPAsset2	7.10e-11**
	(0)
International	0.0132
	(0.0224)
Asset	-3.19e-06
	(4.03e-06)
Ldebt	-1.03e-07
	(1.64e-07)
Liability	3.59e-06
	(4.09e-06)
Equity	3.31e-06
	(4.10e-06)
Constant	-0.0541*
	(0.0326)
Observations	508
R-squared	0.066

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

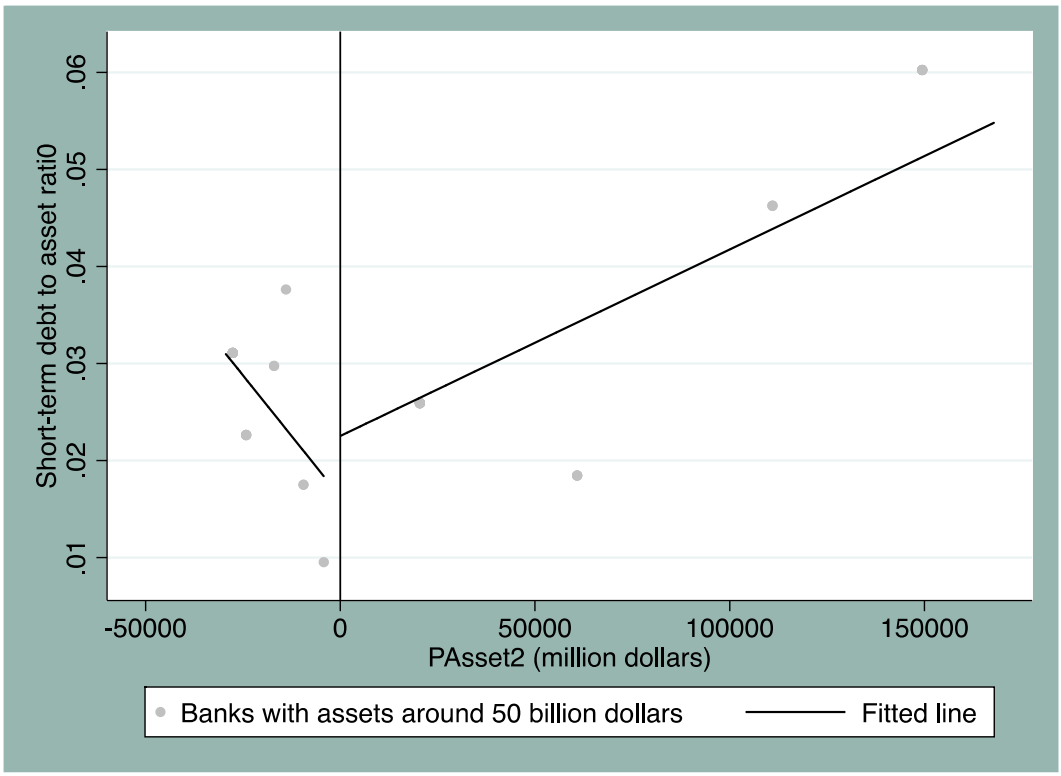

Figure 1: Short-Term Debt to Asset Ratio - Regression Discontinuity Design

Model (6) is significant at the 1 percent level since the F statistic is 4.83 with a P-Value equal to 0.0000. The Ramsey test shows that with a P-Value equals to 0.3491, I fail to reject the null hypothesis that the model has no omitted variable bias at the 5 percent significance level. *Treat2* is significant at the 5 percent level, indicating that being in the treatment 2 group decreases a bank's long-term debt to asset ratio. *International* is also significant at the 5 percent level, indicating that being international increases a bank's short-term debt to asset ratio by 0.0412, which is a moderately large influence. Compared to the effect of having international branches, the effect of *Treat2* is much larger – roughly a 0.134 decrease. Graph 2 also exhibits the large drop off at the $50 billion cut-off point. *PAsset2*, *TreatPAsset2*, *Liability* and *Equity* are all significant at the 10 percent level, but are insignificant at the 5 percent level.

Table 9: Model (6) –Long-Term Debt to Asset Ratio, Treatment 2, $50-Billion Threshold

VARIABLES	LDebtAssetR
Treat2	-0.134**
	(0.0649)
PAsset2	6.84e-06*
	(3.70e-06)
TreatPAsset2	-6.36e-06*
	(3.67e-06)
SqPAsset2	6.56e-11
	(0)
TreatSqPAsset2	-6.56e-11
	(0)
International	0.0412***
	(0.0156)
Asset	9.71e-06
	(5.90e-06)
Sdebt	-2.32e-08
	(1.18e-07)
Liability	-1.02e-05*
	(5.92e-06)
Equity	-9.76e-06*
	(5.88e-06)
Constant	0.234***
	(0.0668)
Observations	508
R-squared	0.089

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

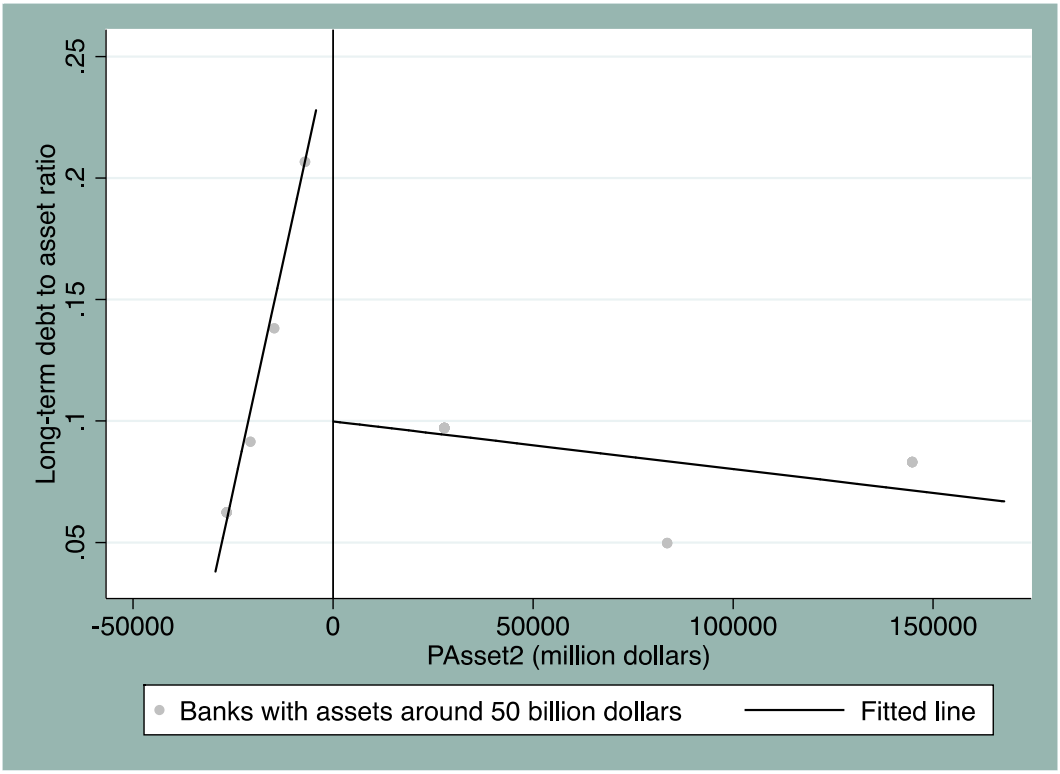

Figure 2: Long-Term Debt to Asset Ratio - Regression Discontinuity Design

All in all, for the first set of models (model 1 to model 3), the results are similar to what I expected. The effect of (qualifying for or) taking company-run stress tests does not have significant results on total debt to asset ratios and short-term debt to asset ratios. However, it does have an effect on long-term assets mainly due to the need for mid-sized banks to grow through issuing bonds and leasing new offices, among other things. For the second set of the models, the results are quite the opposite to what I expected. I find that the Fed's supervisory tests actually encourage large banks to take on short-term debt and discourages them from taking on long-term debt. All of the results are summarized in Table 10. In the next and final section, I will draw conclusion and policy recommendations from these results.

Table 10: Regression Results - All Models

MODEL	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
VARIABLES	DebtAssetR (10B)	SDebtAssetR (10B)	LDebtAsset R(10B)	DebtAsset R(50B)	SDebtAssetR (50B)	LDebtAsset R(50B)
Treat1	0.0195	-0.0307	0.0501**			
	-0.0388	-0.0325	-0.0209			
PAsset1	-9.92E-06	1.83E-06	-1.18E-05			
	-1.15E-05	-9.30E-06	-7.41E-06			
TreatPAsset1	1.00E-05	-2.15E-06	1.22e-05*			
	-1.16E-05	-9.31E-06	-7.40E-06			
SqPAsset1	-1.23E-09	-1.87E-10	-1.05e-09*			
	-8.83E-10	-6.64E-10	-6.35E-10			
TreatSqPAsset1	1.23E-09	1.87E-10	1.05e-09*			
	-8.83E-10	-6.64E-10	-6.35E-10			
Treat2				-0.0669	0.0659***	-0.134**
				-0.0769	-0.0252	-0.0649
PAsset2				1.68E-06	-5.10e-06***	6.84e-06*
				-4.53E-06	-1.94E-06	-3.70E-06
TreatPAsset2				-1.59E-06	4.76e-06**	-6.36e-06*
				-4.47E-06	-1.90E-06	-3.67E-06
SqPAsset2				0	-7.10e-11**	6.56E-11
				-5.97E-11	0	0
TreatSqPAsset2				0	7.10e-11**	-6.56E-11
				-5.97E-11	0	0
International	0.0575**	0.00955	0.0489***	0.0532*	0.0132	0.0412***
	-0.0271	-0.0195	-0.016	-0.0299	-0.0224	-0.0156
Asset	4.40E-06	-1.96E-06	6.22E-06	6.53E-06	-3.19E-06	9.71E-06
	-7.01E-06	-4.01E-06	-5.23E-06	-7.68E-06	-4.03E-06	-5.90E-06
Ldebt		-1.03E-07			-1.03E-07	
		-1.63E-07			-1.64E-07	
Liability	-4.46E-06	2.35E-06	-6.70E-06	-6.59E-06	3.59E-06	-1.02e-05*
	-7.10E-06	-4.07E-06	-5.26E-06	-7.77E-06	-4.09E-06	-5.92E-06
Equity	-4.34E-06	2.07E-06	-6.26E-06	-6.48E-06	3.31E-06	-9.76e-06*
	-7.05E-06	-4.07E-06	-5.22E-06	-7.72E-06	-4.10E-06	-5.88E-06
Sdebt			-2.47E-08			-2.32E-08
			-1.19E-07			-1.18E-07
Constant	0.0904**	0.0554*	0.0351*	0.178**	-0.0541*	0.234***
	-0.0363	-0.0313	-0.0193	-0.0829	-0.0326	-0.0668
Observations	508	508	508	508	508	508
R-squared	0.124	0.083	0.08	0.117	0.066	0.089
Robust standard errors in parentheses						
*** p<0.01, ** p<0.05, * p<0.1						

VII. Conclusions, Limitations and Policy Recommendations

Conclusion

This paper examines the effects of the Fed's stress tests on banks. My hypothesis is that, relative to banks that are not required to participate in the stress tests, banks that are required to participate in supervisory stress test will decrease their short-term debt to asset ratios, since they might want to avoid the same liquidity problem banks faced in the 2008 crisis, and that they will increase their long-term debt to asset ratios to gain the leverage they need for operations and growth in the long run. My empirical results show that banks with assets between $10 billion to $50 billion dollars are generally less responsive in terms of the debt portion to the company-run stress tests they are required to take. However, bigger banks with assets of $50 billion and above facing stricter regulations are more responsive to the stress tests the Fed has conducted on them.

The two treatment effects on total debt to asset ratios are both insignificant, indicating that neither the company-run nor the Fed's stress testing has effect on total debt to asset ratios. More specifically, compared to smaller banks, bigger banks, contrary to what I expected, are less cautious towards taking on short-term debt, but are more cautious towards taking on long-term debt. The Fed's stress tests have a positive effect on these banks' short-term debt to asset ratios and a negative effect on their long-term debt to asset ratios. Both effects are large in magnitude and statistically significant. This finding is interesting in that one of the Dodd-Frank Act's missions is to prevent things like the 2008 financial crisis from happening again and one main contributor to the 2008 crisis was that there were serious liquidity problems on the banks' side. One way to explain this

result may be that since stress test are testing banks' overall abilities in the situation of economic recession, banks have to choose more important priorities such as their tier 1 capital ratio (a percentage of a bank's risk weighted credit exposures) and other factors instead of focusing on debt to asset ratio. Moreover, it maybe that by balancing other parts of their financials and abilities, banks can cope more adequately when they are short of "cash". Another explanation may be that there might be serious moral hazard issues among the banks – banks that are covered by the Fed supervisory tests are aware that they are "too big to fail" and are important for the whole economy. And while the stress tests put a heavy focus on tier 1 capital requirements and capital flexibility, they are not that specific about the banks' short term debt versus long term debt. In this sense, banks can always find ways to game the system by adjusting to the tests requirement while at the same time doing roughly the same things they did before, only this time in the absence of huge volume of bad MBS assets in hand.

Limitations

The design of the study has certain limitations. For example, when some banks that fall into the category of being required to take either company-run stress tests or Fed-run stress tests are in fact not taking the tests for various reasons such as compliance, foreign entities, and so forth. Additionally, the "first time" the DFAST I use in my model design is 2013, instead of 2012, since the 2012 test was mainly a pilot test in which all of the medium-sized banks and some of the large banks were given exemptions for the first year, while final principles for development and distribution of annual DFAST came out in 2013, and both types of tests were actually implemented. A valuable next step would be

to use more detailed and private data to study the discrete effects of stress tests on the banks that are actually included in the tests rather than those that should technically be included but are not for various reasons. Implementing a model including the year effects would also be an interesting next step.

Policy Recommendations

The paper has two potential policy implications: First, Regulator-supervised tests and regulation of banks are generally more effective than self-supervised tests and looser regulation. However, supervised and stricter regulation requires more spending both from the Fed and the banks. Therefore, when making decisions about regulations that require more procedure and more human capital input, government (in this case, the Fed), should always do its cost-benefit analysis before actually taking action. In addition, banks that are only required to self-regulate and self-supervise may need to spend money and human capital only to calm the public and regulators while their self-regulation might not have robust effects.

Second, to more effectively tackle all bank leverage problems, the government should take banks' potential moral hazard problem closely into consideration. Banks that are "too big to fail" may default again if not monitored, so regulators should always keep in mind that these banks are smart institutions that can potentially game the regulations. Regulators should also think about potential future moral hazard problems before bailing out big banks; they should hold banks responsible for their behavior.

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