DNB WORKING PAPER

DNB Working Paper

No. 419 / April 2014

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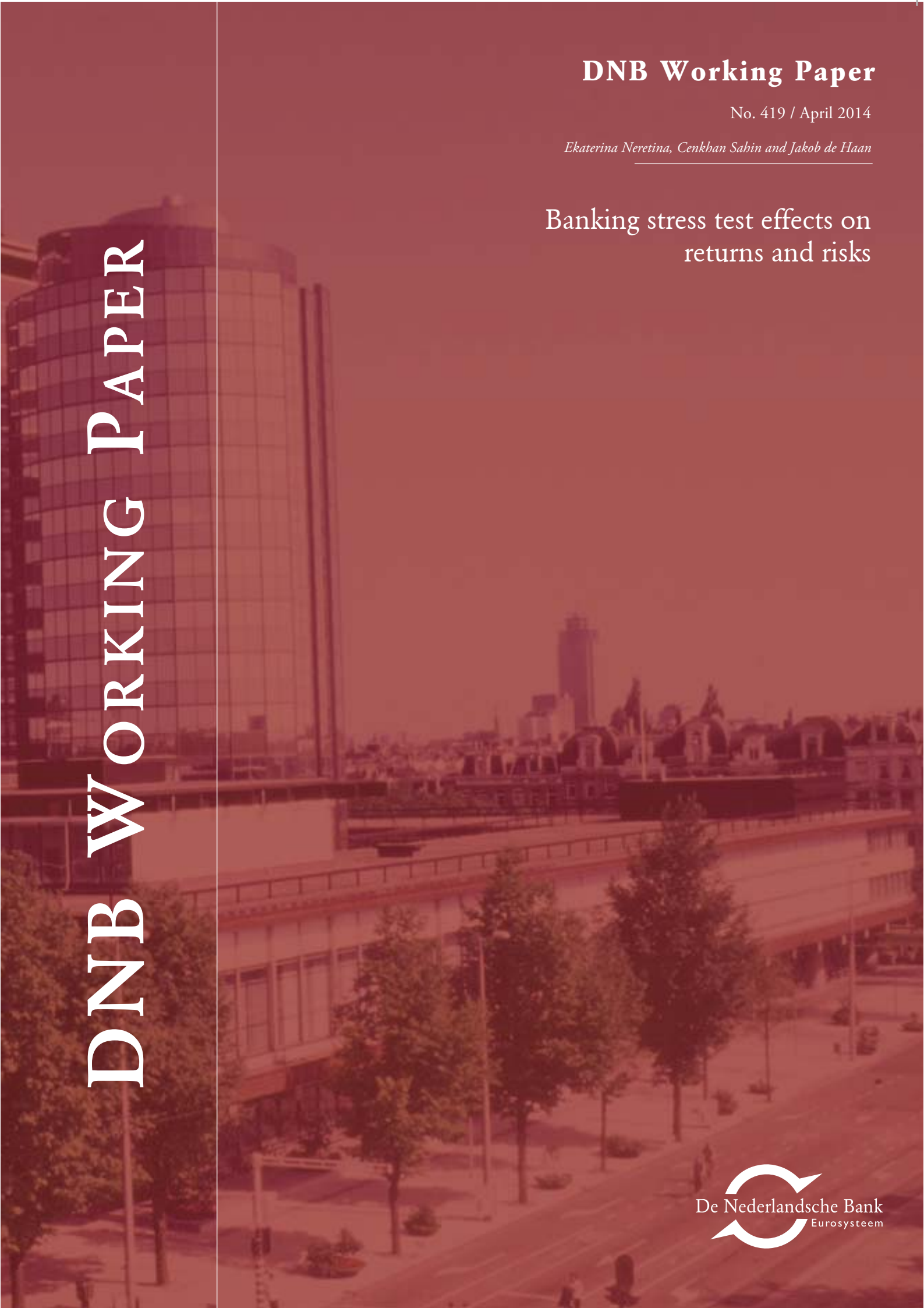

De Nederlandsche Bank
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* Views expressed are those of the authors and do not necessarily reflect official positions of De Nederlandsche Bank.

Working Paper No. 419

April 2014

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Banking Stress Test Effects on Returns and Risks*

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Abstract

We investigate the effects of the announcement and the disclosure of the clarification, methodology, and outcomes of the US banking stress tests on banks' equity prices, credit risk, systematic risk, and systemic risk during the 2009–13 period. We find only weak evidence that stress tests after 2009 affected equity returns of large US banks. In contrast, CDS spreads declined in response to the disclosure of stress test results. We also find that bank systematic risk, as measured by betas, declined in some years after the publication of stress test results. Our evidence suggests that stress tests affect systemic risk.

JEL code: G21, G28
Key words: stress tests, bank equity returns, CDS spreads, bank betas, systemic risk.

*The views expressed do not necessarily reflect the views of De Nederlandsche Bank or the European System of Central Banks. We would like to thank Viral Acharya, Rodney Ramcharan, Wolf Wagner and our colleagues at De Nederlandsche Bank and the University of Groningen for helpful comments and discussions. Any errors or omissions are our own responsibility.

1 Introduction

Bank supervisors expect banks to hold sufficient capital to cover losses under adverse economic conditions. Stress testing has become an important tool for bank supervisors to achieve that goal. In stress tests the implications for individual banks' financial positions under several macroeconomic scenarios are examined, taking the banks' exposures and business models into account. Stress tests have several characteristics (Goldstein and Sapra, forthcoming). First, they are forward looking. Second, they generally put high weight on highly adverse scenarios, thereby providing supervisors with information about tail risks. Third, common scenarios are applied to banks so that stress tests have the ability to provide more consistent supervisory standards across banks. Finally, unlike traditional supervisory exams that generally are kept confidential, the results of bank stress tests are frequently publicly disclosed in order to restore confidence and reduce market uncertainty (Federal Reserve, 2009).

This paper examines the impact of banking stress tests in the US on banks' stock prices, CDS spreads, systematic risk (proxied by their betas), and systemic risk over the 2009–13 period. The first test considered is the Supervisory Capital Assessment Program (SCAP) of the 19 largest Bank Holding Companies (BHCs).[1] The outcomes of this test were disclosed on May 7, 2009. Since then the Federal Reserve implemented two supervisory programs. The first program, the Comprehensive Capital Analysis and Review (CCAR), assesses the capital planning processes and capital adequacy of banks and has been conducted annually since 2011. The CCAR links quantitative stress test results with qualitative assessments of capital planning processes of banks. The second program stems from the Dodd-Frank Act and requires assessing how bank capital levels would fare in stressful scenarios (Federal Reserve, 2013b). The Dodd-Frank Act Stress Test (DFAST) results were publicly released on March 7, 2013.

It is widely believed that stress tests conducted in the US have provided valuable information to the market. Referring to post-crisis stress tests then Federal Reserve chairman Bernanke stated:

> "Even outside of a period of crisis, the disclosure of stress test results and assessments provides valuable information to market participants and the public, enhances transparency, and promotes market discipline." (Bernanke, 2013)

Indeed, according to Morgan et al. (2010), the disclosure of the SCAP test results caused credit default swap spreads to decline and equity returns to rise. We examine whether this result also holds for the other stress tests. Our paper adds to the literature in three ways. First, we examine the effects of all post-crisis stress tests in the US. Second, in contrast to most previous research, our analysis is not confined to the effects of stress tests on equity returns and CDS spreads but also considers the impact of stress tests on bank betas. Betas capture systematic risk based on the co-movement of returns with the overall market and are therefore particularly relevant for understanding the effects of stress tests. In addition, we study whether the change in betas is

[1] We refer to BHCs as large banks. The size of the banks varies between the SCAP and subsequent stress tests. In 2009 all banks having total consolidated assets of $100 bln or more were subject to stress testing. In subsequent years the size was $50 bln or more.

due to changes in individual bank risk, or due to changes in systemic risk following the approach suggested by Nijskens and Wagner (2011). Finally, we do not only consider the impact of the publication of the stress test outcomes, but also examine other disclosure events, such as the announcement of the stress test and the disclosure of the methodology to be used, as these may also provide information (Petrella and Resti, 2013) and (Gick and Pausch, 2012).

As will be pointed out in more detail in Section 2, our paper is related to three strands of literature. The first strand examines whether information provided by the disclosure of the outcomes of stress tests reduces the opacity of banks (Morgan et al. (2010); Cardinali and Nordmark (2011); Beltratti (2011); Ellahie (2012) and Petrella and Resti (2013)). Most (but not all) studies conclude that stress tests produce valuable information for market participants and can play a role in mitigating bank opacity. The second strand of related literature examines to what extent supervisory information should be disclosed (e.g. Goldstein and Sapra (forthcoming) and Schuermann (2013)). Several of these studies conclude that it may not always be optimal to fully disclose stress test results. The final related strand of literature examines how stress tests can be used to set capital ratios, limit capital distributions, and set-up resolution regimes in case of financial distress (BCBS, 2012).

Our findings suggest that the release of the 2009 stress test outcomes had a clear effect on equity returns in line with the results of Morgan et al. (2010). In contrast, we find only weak evidence that the CCAR and DFAST stress tests affected equity returns. However, there is strong evidence that the publication of stress test results reduced CDS spreads for all years, irrespective of banks' capital shortfalls. We find mixed results for other dates on which stress test information was released. Our analysis of systematic risk indicates that betas were affected by the publication of stress test results for nearly all stress tests. Moreover, we find evidence that the decline in betas for some years is in part driven by the correlation of the banks' stocks with the market. We interpret these findings as a decrease in systemic risk.

The paper is structured as follows. Section 2 provides a summary of related literature and outlines how our research is related to this literature. Section 3 gives an overview of the stress tests conducted in the US. Section 4 outlines our methodology and Section 5 presents our findings. Finally, Section 6 concludes.

2 Related studies and contribution

Our paper is related to three strands of literature. First, several studies examine whether bank opacity differs from that of non-financial firms in 'normal' times (cf. Morgan (2002); Flannery et al. (2004); Iannotta (2006); Jones et al. (2012) and Haggard and Howe (2012)). A good example is the recent paper by Flannery et al. (2013) who study bank equity's trading characteristics and find mixed evidence of bank opaqueness during normal times. From this perspective, some recent studies examine the information value of stress tests. Morgan et al. (2010) conclude that the disclosure of the results of the SCAP stress test suggests that market participants correctly identified which institutions had sufficient capital, but were surprised by how much capital was required for under-capitalized banks.

Stress tests have also been conducted by European supervisors and several recent papers examine whether the disclosure of the outcomes affected financial markets. Petrella and Resti (2013) find significant but modest market responses to the European Banking Authority (EBA) stress test in 2011. Ellahie (2012) studies equity and credit market data of Eurozone banks that took part in the stress tests in 2010 and 2011. His findings indicate that equity and bid-ask spreads were not significantly affected by stress test announcements but declined after the disclosure of stress test results. Cardinali and Nordmark (2011) report that the announcements of the stress test and the clarification of the methodology in 2010 were relatively uninformative to markets. In contrast, they find that the disclosure in 2011 by EBA of the stress test methodology was highly informative for all stress-tested banks. Likewise, Beltratti (2011) argues that the 2011 EBA stress test produced new information, as investors could not a priori distinguish between capitalized and under-capitalized banks.

Table 1 provides a summary of recent empirical papers on the market response to stress tests. In line with some previous papers on European stress tests, in our analysis of US stress tests we distinguish between several tests-related events, such as the announcement of the stress test and the disclosure of the methodology and the stress test outcomes. We also distinguish between banks with and banks without capital shortfalls. So our paper complements the work of Morgan et al. (2010) by documenting the effects of stress tests on equity returns and CDS spreads for stress tests conducted in the US after the SCAP. To the best of our knowledge, we are the first to document the effects of stress tests on the betas of banks.

The literature on supervisory transparency and disclosure is also closely related to our work. The central question addressed in these studies is to what extent supervisory information should be disclosed. As shown by Liedorp et al. (2013), the transparency of banking supervisors differs considerably. According to Goldstein and Sapra (forthcoming), in certain environments more disclosure is not necessarily better if one considers economic efficiency. Accordingly, the costs associated with disclosure of stress test results can be minimized in particular by disclosing aggregate, rather than bank-specific results. Also Schuermann (2013) argues that the degree of optimal disclosure may depend on the environment. During times of crisis the need for bank-specific disclosure is greater while during normal times the cost-benefit of stress testing disclosure may lean towards more aggregated information. Gick and Pausch (2012) argue that a supervisory authority can create value by disclosing the stress-testing methodology together with the stress test result. Bischof and Daske (2013) investigate the interaction between mandatory supervisory disclosure and voluntary disclosure strategies of Eurozone banks that were subject to the stress test in 2011. Their findings indicate that lower market liquidity is attributable to banks that did not voluntarily disclose their sovereign risk exposures. Banks disclosing their exposures witnessed increases in liquidity and decreases in the equity bid-ask spread.

Our paper is related to this line of literature, as we do not only examine the effects of the publication of the stress test results, but also the effects of the announcement of the stress test (Petrella and Resti, 2013) and the disclosure of the methodology (Gick and Pausch, 2012).

Finally, our paper is related to the literature on the impact of regulation of Systemically Important Financial Institutions (SIFIs). Stress tests are used to set capital ratios, limit capital distributions, and set-up resolution regimes in case of financial distress (BCBS, 2012). Bongini

and Nieri (2013) investigate the response of financial markets to the Financial Stability Board's publication of the list of institutions that are too big to fail. They quantify the value of an implicit too-big-to-fail subsidy and find that financial markets did not strongly react to the proposed new regulation regarding SIFIs. Schaefer et al. (2013) investigate the reaction of the stock returns and CDS spreads of US and European banks to several regulatory reforms including the too-big-to-fail regulation in Switzerland. These authors report significant market reactions in response to this regulation, which strongly increased CDS spreads of systemic banks, but affected equity prices only mildly.

Our study is related to this literature as we examine the systematic risk of banks. We expect the beta of a bank to decline following the publication of the results of a stress test. The information provided by the stress tests could reduce the uncertainty on bank stability and therefore would lower the overall level of risk in the industry. This would manifest itself in the form of a decline in bank betas. To study the underlying shifts in systematic risk we decompose the changes in betas into changes in the correlation of stocks with the market and changes in the relative variance following a similar approach as Nijskens and Wagner (2011). These authors study credit risk transfers of banks through issuance of CDS and CLO contracts. They disentangle the changes in betas and find that the increase in betas was primarily due to an increase in the correlation of stocks with the market. Although banks became individually less risky using credit risk transfers, systemic risk increased. As we examine the changes in betas in a similar way we can examine how stress tests have affected systemic risk.

3 Stress tests in the US

The Federal Reserve's CCAR exercises conducted in 2011–13 can be classified as micro-prudential supervisory stress tests. They are 'top down' in the sense that the Fed independently produced loss estimates using its own supervisory models. Although the Fed publishes the results of stress tests, the specification of the models used to arrive at them remains a 'black box' (Bernanke, 2013). An important reason for this is to prevent the homogenization of stress test models, as banks would over time have fewer incentives to maintain independent risk management systems and adopt the specifications used by the Fed. These tests were conducted in the aftermath of the crisis and unlike the SCAP in 2009 and the stress tests in Europe were not crisis management stress tests. The latter differ in their emphasis on solvency, current risks, and their specific 'constrained bottom-up' approach (Oura and Schumacher, 2012). For the SCAP exercise the Fed relied more on the banks' own estimates.

Although stress tests have been criticized because of insufficient coverage or their implementation strategy, they have become an important instrument in supervisory authorities' toolkit. This is true for micro-prudential (BCBS, 2012) as well as macro-prudential stress tests (Borio et al., 2013).[2] Table 2 provides a descriptive overview of the stress tests conducted in the US

[2]Macro-prudential stress testing has evolved over time. This type of stress tests is discussed e.g. by Cihak (2007), Borio et al. (2013), FSA (2009), de Larosiere (2009), Sorge (2004), and Galati and Moessner (2013). Criticism raised has led to the development of new stress testing models, such as Foglia (2009), Chan-Lau (2013), Swinburne (2007), Breuer et al. (2009), Schechtman and Gaglianone (2012), and Huang et al. (2012).

Table 1: Related studies

	Stress test	Data	Findings
Morgan et al. (2010)	SCAP 2009	Stock prices and CDS spreads.	Stress tests produce significant market reaction of stock prices. Under-capitalized banks have experienced more negative abnormal returns. CDS spreads, particularly for under-capitalized banks, decline following the release of stress test results.
Cardinali and Nordmark (2011)	EBA 2010, partly EBA 2011	Stock prices	The 2010 EU stress test was uninformative to financial markets. The methodology release of the EBA stress test in 2011 on the other hand had a clear impact on banks. Stress tests showed no effects of GIIPS-banks being more opaque than banks from Northern Europe.
Ellahie (2012)	EBA 2010, 2011	Equity and credit bid-ask spreads, CDS spreads	The 2011 stress test reduced information asymmetry (i.e. equity-credit bid-ask spreads) and increased information uncertainty (measured by equity option implied volatilities and ratio of CDS spreads) of banks.
Alves et al. (2013)	EBA 2010, 2011	Stock prices	Both European stress tests have affected the stock prices of banks. The 2010 stress test reduced the volatility in stock prices while the volatility increased following the release of the 2011 stress test results.
Petrella and Resti (2013)	EBA 2011	Stock indices, various bank balance-sheet data	Stress tests significantly affect the market and are a credible evaluation tool that reduce bank opaqueness.

Table 2: Description of US stress tests

	Purpose	Requirements	Results
SCAP 2009	Restoring confidence, identifying future conditions for banks with insufficient capital.	Banks are well-capitalized with Tier 1 capital above 6% of RWA and solvent with 4% Tier 1 common equity ratio.	Ten banks with capital gap. Tier 1 common capital increased to $759 bln. and Tier 1 common equity ratio increased to 10.4%.
CCAR 2011	Quantitative assessment of capital levels and qualitative assessment of internal capital planning processes of banks.	Banks submit capital plans to the Fed, largest 6 banks submit trading P&L statements.	Banks mostly had to lower their capital distributions, payout decreased to 15% in 2011 from 38% in 2006.
CCAR 2012	Banks that did not participate earlier are now subject to a Capital Plan Rule.	Banks are solvent with a 5% Tier 1 common ratio.	Four banks had a capital gap. Doubling of weighted Tier 1 common equity ratio.
DFAST 2013	Quantitatively assess how bank capital levels would fare in adverse economic conditions.	Financial companies with total consolidated assets between $10 bln and $50 bln are required to conduct their own stress tests.	One bank failed to adhere to the minimum of 5% Tier 1 common equity ratio.
CCAR 2013	Quantitative and qualitative evaluation of whether a bank's capital accretion and distribution decisions are prudent.	Banks have to disclose their own estimates of stressed losses and revenues. The Fed also discloses whether or not it objected to each banks capital plan.	Two banks conditionally approved, two banks not approved.

on which we focus. 'Stress test design' evolved.[3] In subsequent stress test implementations the Fed refined the hypothetical scenarios taking into account the procyclicality of the financial system and severe adverse developments on housing, equity, and asset markets (Federal Reserve, 2012), (Federal Reserve, 2013a), and (Federal Reserve, 2013b). Moreover, supervisors can now project losses and revenues independently allowing them to distinguish portfolio risks more appropriately. Another enhancement is the focus on the capital planning processes of banks where supervisors can scrutinize the need for capital above the proposed regulatory requirements.

To see how much attention stress tests received we collected news articles from a variety of news sources for the 2009–2013 period from the Dow Jones Factiva database. We searched for all news containing the words "stress test" related to the banking stress tests procedure. The constructed index of the number of news articles related to stress test events provides a crude indication of how much attention stress tests received over 2009–13. Our final list of 2201 articles contains news on individual banks, the banking industry, and the US economy. The news was filtered with all the relevant bank names and with the names of related government agencies, such as the Federal Reserve, FDIC and the US Department of the Treasury. Earnings announcements were also included into the corporate news group if they contained any discussion on the government-regulated stress test procedure. We verified all news manually for relevance.

[3]The design of stress tests also received attention in the literature. BCBS (2009) provides principles for sound stress testing. Greenlaw et al. (2012) propose conceptual principals for stress testing while Oura and Schumacher (2012) suggest operational principals. Spargoli (2012) argues that stress tests can remove information asymmetries only if supervisory authorities implement policies to fix under-capitalized banks.

Figure A1 displays the number of news articles and gives an impression of the equity and credit markets around the main stress test events. The figure suggests that the SCAP received considerable more attention than the subsequent CCARs and DFAST. The news index also reveals that stress tests were a substantial part of market sentiment in 2009–2013. The number of stress test news items made up about 10 percent of all news about the U.S. banking industry in this period. Not surprisingly, the highest frequency of news reports on this topic appeared when the stress test outcomes were disclosed. Other peaks occur when the details of the stress tests were announced and when the results for participating banks were released.

The top part of Figure A1 suggests that in response to the disclosure of stress test results credit risk of banks declined while returns display a moderate increase. In the remainder of our paper, we use an event study approach to quantify the effects of the disclosure of stress test information on market movements.

4 Data and methodology

4.1 Data

We use equity returns and CDS spreads of banks that have participated in the US stress tests over the 2009–2013 period. Data were obtained from Bloomberg. Table 3 lists the participating banks considered in our research and shows the results of the stress tests.[4] To eliminate possible disturbances caused by dividend payments, stock splits and other capital actions, we use total return indices for individual stocks. We use the S&P 500 return index as proxy for the market portfolio. In addition, we employ daily data on 5-year senior CDS spreads for a subset of the banks.[5] We employ the CDX Investment Grade Index provided by Bloomberg as proxy for a market portfolio in the CDS market. This index represents the rolling equally-weighted average of 125 of the most liquid North American CDS series with relevant rating of at least "BBB-" or "Baa3" and with 5 years maturity. In all analyses we exclude official holidays and days with limited trading.

4.2 Methodology

To examine whether stress tests have caused abnormal movements in equity or CDS markets we follow an event study methodology described e.g. in Brown and Warner (1985), Thompson (1995), or MacKinlay (1997). Figure 1 provides an overview of all the relevant stress test events. The days on which the results of stress tests are disclosed are arguably one-day events. Nevertheless, because of scrutiny we expand the event day in order to capture effects that occur after the markets close.[6] This is particularly the case when results are disclosed after markets had closed.

[4]We exclude Ally Financial as it was not publicly traded. MetLife was excluded from DFAST and CCAR in 2013, since the company sold its banking business branch to a subsidiary of General Electric, GE Capital Retail Bank. The banks included in the stress tests cover approximately 66% of total US banking sector assets.

[5]The sample for our CDS analysis is smaller as credit default swaps of some banks were not available or were hardly traded. Table A1 lists the banks in our CDS analysis.

[6]There is a case to be made for expanding the event windows. Jenkins et al. (2011) note that details of the EBA 2011 stress test methodology leaked beforehand. Although our news analysis did not yield evidence of news leakages one cannot guarantee absence of leakages. Moreover one captures, if any, lagged market responses.

Table 3: List of the banks which passed/failed the stress tests

Banks	2009	2012	2013 DFAST	2013 CCAR	SIFI
Ally Financial	-	-	-	-	d
American Express	+	+	+	-	d
Bank of America	-	+	+	+	g
Bank of New York Mellon	+	+	+	+	g
BB&T	+	+	+	-	d
Capital One Financial	+	+	+	+	d
Citigroup	-	-	+	+	g
Fifth Third Bank	-	+	+	+	d
Goldman Sachs	+	+	+	-	g
JPMorgan Chase	+	+	+	-	g
KeyCorp	-	+	+	+	-
MetLife	+	-	N.a.	N.a.	-
Morgan Stanley	-	+	+	+	g
PNC Financial Services	-	+	+	+	d
Regions Financial	-	+	+	+	d
State Street	+	+	+	+	g
SunTrust Banks	-	-	+	+	d
U.S. Bancorp	+	+	+	+	d
Wells Fargo	-	+	+	+	g

Notes: This table presents the list of the banks which passed/failed the 2009-2013 stress tests. '+' means that a bank passed the stress test without any frictions ('No-Gap' banks), and '-' indicates that a bank had a capital gap or did not receive approval for capital distributions ('Gap' banks). 'N.a.' denotes that the bank did not participate in the corresponding testing procedure. 'g'/'d' denotes that the bank is a global/domestic SIFI according to the Financial Stability Board (FSB, 2013).

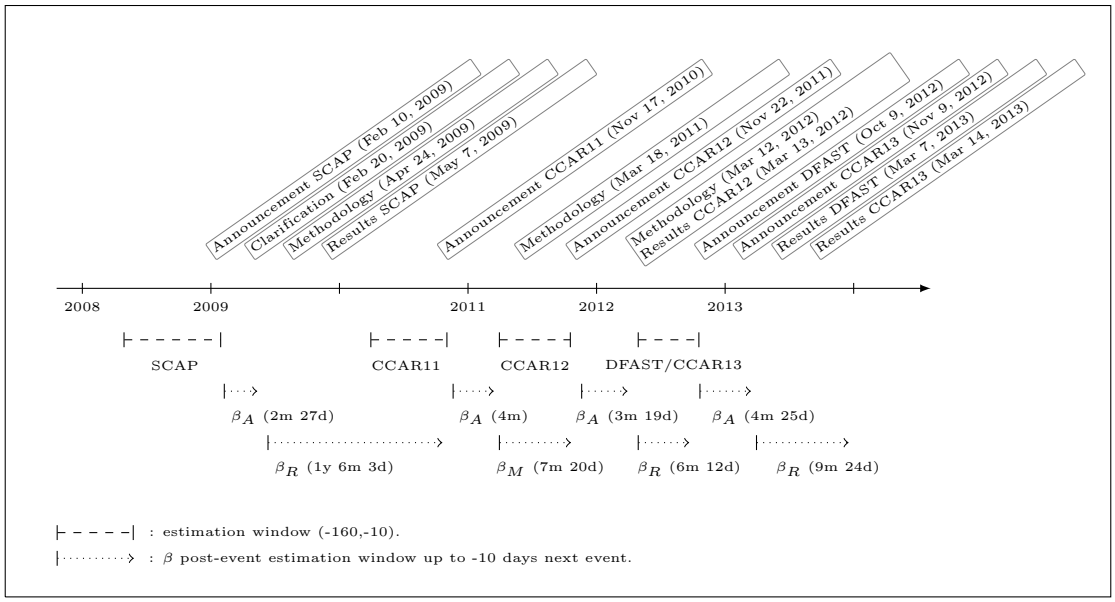
We present findings for a 3-days event window (-1,+1).[7] Our estimation window for equity returns and CDS spreads consists of 150 trading days, i.e. the (-160,-10) time interval, where $t = 0$ is the event date of the corresponding stress test. This window is sufficiently long to conduct an event study using daily data (MacKinlay, 1997) and sufficiently short to avoid overlaps with events related to stress tests in other years. When event windows are overlapping, or a single event affects multiple banks, we can no longer assume that the abnormal returns of securities are cross-sectionally uncorrelated. Figure 1 shows that the date of the methodology release and the date of the disclosure of the results of the CCAR in 2012 are particularly close. In this case the covariance between these may deviate from zero and we can no longer use the distributional results for the aggregated abnormal returns (MacKinlay, 1997). Consequently, we treat the disclosure of the methodology and the results of CCAR 2012 as a "large" event and use one dummy for both events.[8] Moreover, we use adjusted test statistics, described below, to address the correlation between time series.

To measure the impact of an event we set the abnormal return of a security as the difference between the actual (ex post) return and the normal return over the relevant event window.

[7] We have considered different event windows as well: (-2,0), (0,+2), (-2,+2), (-3,0), (0,+3), (-3,+3), (-10,0), (0,+10), and (-10,+10). The findings (available on request) did not yield additional information and consequently we only report results for the (-1,+1) time interval.

[8] In this respect our approach is similar to that of Morgan et al. (2010) who consider the clarification event of the SCAP in 2009, which actually consist of two events: Bernanke's testimony on 24 March 2009 and the release of further details about the stress test on 23 and 25 March 2009. They disentangle the effects of the events by considering how equity and bond-holders are affected. They reason that the former event mattered for both market participants but the release of the Capital Assistance Plan details mattered only for equity holders.

Figure 1: Chronology of stress test events



Normal returns are estimated using the following market model:

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + \varepsilon_{i,t} \tag{1}$$

where $R_{i,t}$ is the daily return of equity of bank i at time t, and $R_{m,t}$ is the return of a market portfolio (the S&P 500 returns index). We estimate the credit side of our analysis in a similar fashion by regressing the change in the CDS spread of bank i at time t on the change in the overall index (the CDX investment grade index).[9] The t-statistics obtained from the estimation are adjusted for event-induced volatility (Patell, 1976), volatility changing events (Boehmer et al., 1991), and cross correlation of abnormal returns following Kolari and Pynnonen (2010a). The adjusted t-statistics are employed to test our hypotheses. In addition, we use the non-parametric generalized rank test described in Kolari and Pynnonen (2010b) which is insensitive to distortions in returns distribution and to the existence of significant correlation between time series.

In order to assess the possible changes in systematic risk caused by stress test events we decompose the beta into a market correlation component and a volatility component following Nijskens and Wagner (2011). We use the following model,

$$R_{i,t} = \alpha_i + \beta_1 R_{m,t} + \sum \gamma_j AR^j + \sum \delta_k D^k + \sum \beta_k D^k * R_{m,t} + \varepsilon_{i,t} \tag{2}$$

where α_i is the bank fixed effect, AR^j is a dummy variable which equals one for the event of interest (measuring the abnormal returns associated with the event) and $j \in \{A, C, M, R\}$ denotes the announcement, clarification, methodology, and result events, respectively. D^k with $k \in \{A, M, R\}$ is a dummy variable with value one up to ten trading days of the next event. D^R

[9] See also Norden and Weber (2004) and Morgan et al. (2010).

therefore measures any mean effects associated with a result event for the post-results period. $D^A * R_{m,t}$, $D^M * R_{m,t}$, and $D^R * R_{m,t}$ are the interaction terms of interest. Their coefficients will capture the change in bank betas after the announcement events, methodology event, and after the result events, respectively.[10] Figure 1, shows the post-event estimation windows for the betas associated with the interaction terms.

Next, we decompose the changes in betas into changes in the correlation of stocks with the market and changes in the relative variance. That is, the beta can be represented by,

$$\beta_i = \rho_{i,m} \frac{\sigma_i}{\sigma_m} \tag{3}$$

where $\rho_{i,m}$ is the correlation coefficient between the equity and the market and σ_m the variance of the market.[11] The beta in (3) is the product of the correlation of a bank's equity price with the market and its standard deviation relative to that of the market. We then normalize our model in (2) by dividing the equity and market returns by their respective standard deviations. As a consequence the coefficient of the normalized returns equals the correlation of the previous series, and (3) changes to $\beta_i = \rho_i$. The regression equation is then changed to,

$$\tilde{R}_{i,t} = \tilde{\alpha}_i + \rho_1 \tilde{R}_{m,t} + \sum \gamma_j AR^j + \sum \delta_k D^k + \sum \rho_k D^k * \tilde{R}_{m,t} + \varepsilon_{i,t} \tag{4}$$

where

$$\tilde{R}_{i,t} = \begin{array}{ll} R_{i,t}/\sigma_{i,t<t_i} & \text{if t}< t_i \\ R_{i,t}/\sigma_{i,t\geq t_i} & \text{if t}\geq t_i \end{array} \quad \text{and} \quad \tilde{R}_{m,i,t} = \begin{array}{ll} R_{m,i,t}/\sigma_{m,t<t_i} & \text{if t}< t_i \\ R_{m,i,t}/\sigma_{m,t\geq t_i} & \text{if t}\geq t_i \end{array}$$

and t_i stands for the event date.[12]

5 Results

5.1 How do stress tests affect equity returns and credit risk?

We present our findings in Tables 4 and 5 and Figure A2. Table 4 shows reactions in the equity market and Table 5 shows reactions in the credit market. We discuss each market in turn, considering the announcement, clarification, methodology, and result events.

[10] Note that we exclude the clarification and methodology events of 2009 in our beta analysis as they are very close to the announcement and result release of SCAP, respectively. Similarly, we only consider the announcement of DFAST and the results release of CCAR as these are the first and last events of interest in 2013, respectively.

[11] To arrive at (3), note that individual stock beta $\beta_i = \frac{cov_{i,m}}{\sigma_m^2}$ can be represented as $\beta_i = \rho_{i,m} \frac{\sigma_i}{\sigma_m}$ using the correlation notation $\rho_{i,m} = \frac{cov_{i,m}}{\sigma_i \sigma_m}$.

[12] To identify shifts in the relative variance, σ_i/σ_m, we do the following decomposition: $\beta^1 = \beta^0 + \Delta\beta$ where the superscripts denote the beta before and after the event. Using $\beta^1 = \rho^1_{i,m} \frac{\sigma^1_i}{\sigma^1_m} = (\rho^0_{i,m} + \Delta\rho_{i,m}) \frac{\sigma^1_i}{\sigma^1_m}$ relative variance can be rearranged as $\frac{\sigma^1_i}{\sigma^1_m} = \frac{\beta^0 + \Delta\beta}{\rho^0_{i,m} + \Delta\rho_{i,m}}$ and, therefore, a change in relative variance is $\Delta \frac{\sigma^1_i}{\sigma^1_m} = \frac{\sigma^1_i}{\sigma^1_m} - \frac{\sigma^0_i}{\sigma^0_m} = \frac{\beta^0 + \Delta\beta}{\rho^0_{i,m} + \Delta\rho_{i,m}} - \frac{\beta 0}{\rho^0_{i,m}}$.

Table 4: Stock market reaction to stress tests (in %)

	All		No-Gap		Gap	
	CAR	%>0	CAR	%>0	CAR	%>0
2009						
Announcement	-.6205	44.44	-.2985	44.44	-.9424	44.44
Clarification	20.92*	100.0	10.59*	100.0	31.26**	100.0
Methodology	.1488	50.00	3.952	66.67	-3.654	33.33
Results	14.10**	77.78	11.24**	77.78	16.95**	77.78
2011						
Announcement	-2.210	27.78**				
Methodology	-1.620	16.67***				
2012						
Announcement	-.1115	44.44	.1312	53.33	-1.325***	.000**
Results	2.399	88.89	3.034**	93.33	-.7762	66.67
2013						
Announcement DFAST	1.998**	94.12				
Announcement CCAR	1.442	82.35	1.491	76.92	1.282***	100.00
Results DFAST	1.446	88.24				
Results CCAR	.8309	70.59	1.141	76.92	-.1767	50.00

Notes: *** - 1% ** - 5%, * - 10% significance level. This table presents CARs for the main stress test events over the 2009-2013 period calculated using Equation (1) with a (-1,+1) event window. We report the significance level of tests with p-value less than 0.1. When p-values for all tests (the Kolari and Pynnonen (2010a) adjusted tests and the rank test) exceed 0.1, significance is not reported.

Stock market As shown in Table 4, the *announcements* of stress tests generally had no effect on equity returns. Except for the announcement of DFAST, the responses are insignificant when we consider banks jointly. This may reflect that generally stress test announcements provide limited (quantitative) information on the way the stress tests will be conducted or how their results will be used. However, when we distinguish between banks with capital shortfalls and those without (denoted gap and no-gap in the tables), the announcement of the CCAR in 2012 and 2013 led to significant market movements.

The market's reaction to then chairman Bernanke's *clarification* in 2009 that banks would not be nationalized caused a strong upward movement in equity returns. The clarification event notably increased the CARs of gap banks by 31.26 percent as these banks were at the time considered to be at risk to be nationalized (Morgan et al., 2010). In line with Morgan et al. (2010), we find no evidence that the methodology disclosure of the SCAP has led to changes in stock prices. This is also the case for CCAR in 2011. In the other years the methodology and results were released jointly.[13]

Table 4 shows that CARs of bank equity returns in 2009 were 14.1 percent higher after the release of stress test *results*. Both gap and no-gap banks' stock prices were strongly affected. This is also shown in Figure A2. In the left panel of the figure the movement of CARs of equity returns over a 21-day period is provided where 0 denotes the result event. Equity prices increased days before the publication of the SCAP results. The figure also confirms that CARs were larger for gap banks.

[13]In 2012 the methodology and results were released on two consecutive days. As discussed in our methodology section we treat these events as a single 'large' event.

Table 5: Credit market reaction to stress tests (in bps)

	All		No-Gap		Gap	
	CAR	%>0	CAR	%>0	CAR	%>0
2009						
Announcement	-13.54**	.000***	-11.36*	.000***	-16.26**	.000**
Clarification	17.83	55.56	31.17	60.00	1.157	50.00
Methodology	-11.30	33.33	-19.61	20.00*	-.9207	50.00
Results	-81.30**	.000***	-54.71**	.000**	-114.5***	.000**
2011						
Announcement	2.871	60.00				
Methodology	-11.04**	.000***				
2012						
Announcement	8.754	70.00	6.513	57.14	13.98**	100.0
Results	-11.62*	.000***	-11.15**	.000***	-12.73**	.000*
2013						
Announcement DFAST	.2970	44.44				
Announcement CCAR	-6.172	22.22*	-6.486	20.00	-5.779	25.00
Results DFAST	-.6295	44.44				
Results CCAR	-4.586*	.000***	-3.859**	.000**	-5.495*	.000**

Notes: *** - 1% ** - 5%, * - 10% significance level. This table presents CARs for the main stress test events over the 2009-2013 period calculated using changes in CDS spreads for (-1,+1) event window. We report the significance level of tests with p-value less than 0.1. When p-values for all tests (the Kolari and Pynnonen (2010a) adjusted tests and the rank test) exceed 0.1, significance is not reported.

For stress tests conducted after 2009, the evidence is weaker. For the sample of all banks we find no evidence that the equity market reacted to the disclosure of the results of stress tests. For no-gap banks we find a significant effect in 2012. However, the magnitude of the impact is lower in 2012 than in 2009. We attribute the greater response in CARs to the higher financial turbulence in the latter period.

The findings suggest that post-crisis stress tests had a limited effect on the equity market. Arguably, during a crisis the need for credible information is greater than in calmer periods so the market may have valued the information disclosed in 2009 more (Schuermann, 2013). This reasoning is also in agreement with the lower panel of Figure A1.

Credit market As Table 5 shows, the *announcement* events only had a significant effect on CDS spreads in 2009 and in 2012 (the announcement of CCAR). Moreover, we see that Bernanke's clarification of the stress test in 2009 did not affect the CDS market. This response is expected due to the structure of the CDS agreements where any change in ownership due to nationalization would not bring additional losses to contract parties.[14]

For the *methodology* events we find mixed results. As Table 5 shows, for 2009 we find no impact on CDS spreads. However, in 2011 CDS spreads declined significantly following the release of the stress test methodology. This suggests that the release of the methodology in 2009 was less informative for the market compared to 2011. In 2011 there was no disclosure

[14] Morgan et al. (2010) do find a decline in CDS spreads following the clarification event (though only for gap banks). However, they consider CDS contracts with an MR document clause. This entails that these contracts do not suppose full coverage in case of a credit event. As we do not consider these types of contracts a possible nationalization would not affect the spreads.

of stress test results, which could have led the market valuing the information provided by the methodology disclosure relatively strongly.

As Table 5 shows, average CDS spreads dropped following the publication of the stress test *results*. The disclosure of stress test results reduced CDS spreads in all years. The strongest decline is observed after the disclosure of the SCAP outcomes when spreads declined 81.3 basis points. In contrast, the DFAST results event seems to have been uninformative to the market. The fact that CCAR in 2013 affected CDS spreads stronger than DFAST could be due to two reasons. Firstly, as Table 3 shows, all seventeen banks in DFAST received approval while in CCAR three of these banks were not approved. The market may therefore have attached more importance to the results of CCAR. Alternatively, it could be due to the underlying assumptions of the stress tests. While DFAST was conducted conditional on no change in the capital distributions, CCAR incorporated the capital plans proposed by the banks and, therefore, may have better reflected creditworthiness (Federal Reserve, 2013a).

As expected, gap banks experienced a stronger reaction than no-gap banks. Overall, the findings indicate that stress tests have provided new information to CDS markets after the crisis.

5.2 How do stress tests affect systematic and systemic risk?

Tables 6 and 7 report the results. Reported significance levels are based on panel-corrected standard errors.

Systematic risk Table 6 presents event dummies associated with the stress tests and the interaction terms with betas. We focus our discussion on these interaction terms.[15] Table 6 shows that the impact of the *announcement* effects are mixed. In 2009 the announcement of SCAP has led to an increase in systematic risk. For the remaining years there is no consistent evidence of movement in betas. Considering *results* events, in 2009 the betas were reduced following the results of the SCAP. Specifically, the decrease in systematic risk amounts to 0.2222 after the publication of results. Similarly, the beta of banks declined after the release of stress test results in 2013 (-.2223). These findings suggest that market participants expected stress test results to be worse than they ex-post turned out to be and as a consequence betas declined in 2009 and 2013.

Systemic risk Table 7 presents the estimation results for our standardized model expressed in Equation (4). We are interested in the coefficients of the interaction terms, denoted by ρ. Following Nijskens and Wagner (2011), we interpret a decline in the correlation component as a decline in systemic risk. Except from a weak effect in 2012, we see no evidence that the *announcement* events affected systemic risk of banks. However, the *methodology* release in 2011 increased ρ and contributed to the increase in beta in Table 6. For *results* events there is a decrease in the correlation of the stock series with the market for all years, suggesting that systemic risk declined. We attribute the insignificance of the corresponding beta for CCAR 2012

[15]Note, however, the consistency of the event dummies in Table 6 with the findings reported in Table 4. Equity returns in both tables are positively affected by the clarification and results events of the SCAP 2009 as well as by the DFAST 2013 announcement, while stress tests conducted in 2011–13 did not affect equity returns significantly.

Table 6: Systematic risk

	2009	2011	2012	2013
Market β	1.783***	1.433***	1.563***	1.452***
	(.0608)	(.0566)	(.0427)	(.0573)
Announcement	-.0031	-.0077	-.0002	.0042
	(.0138)	(.0053)	(.0053)	(.0034)
Announcement DFAST				.0066**
				(.0034)
Clarification	.0754***			
	(.0141)			
Methodology	-.0032	-.0057		
	(.0143)	(.0054)		
Results	.0448***		.0061	.0029
	(.0138)		(.0045)	(.0033)
Results DFAST				.0047
				(.0034)
Announcement mean effect	-.0031	.0009	.0013	.0001
	(.0038)	(.0013)	(.0013)	(.0008)
Methodology mean effect		-.0006		
		(.0010)		
Results mean effect	-.0010		.0011	.0002
	(.0022)		(.0011)	(.0006)
Announcement β effect	.9920***	.0431	.1343	-.1217
	(.1447)	(.1416)	(.1171)	(.0948)
Methodology β effect		.1207*		
		(.0723)		
Results β effect	-.2222*		-.0893	-.2223***
	(.1227)		(.0994)	(.0809)
Constant	-.0009	-.0027**	-.0023*	-.0000
	(.0024)	(.0012)	(.0013)	(.0008)
Number of id	18	18	18	17
Trading days	597	406	371	445
R^2	.4833	.6260	.6392	.4881

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

in Table 6 to the relative variance component, which could have added sufficient noise to make the overall change in beta insignificant. Overall, we conclude that the information revealed in the stress test results decreased systemic risk.

Gap vs no-gap To examine whether gap and no-gap banks were affected differently, we re-estimate our models. The results are shown in Tables A2 and A3. As a first step, we add a dummy variable and an interaction term to Equations (2) and (4) specifically for gap banks. In a separate regression we include dummy variables for both gap and no-gap banks and their interactions with the market index.[16] The resulting regressions are shown in, respectively, columns (1) and (2) in Tables A2 and A3. Columns (1) display whether the changes in betas of gap banks are different from changes in betas of no-gap banks. Columns (2) display the effects on betas of gap and

[16]We did not run separate regressions for gap and no-gap banks because in some years there were only a few banks with capital shortfalls.

Table 7: Systemic risk

	2009	2011	2012	2013
Market ρ	.7334***	.7674***	.8566***	.7463***
	(.0327)	(.0291)	(.0282)	(.0341)
Announcement	.1506	-.4591**	.1082	.2635
	(.2464)	(.2170)	(.2125)	(.2231)
Announcement DFAST				.4085*
				(.2328)
Clarification	.7271***			
	(.2509)			
Methodology	-.0244	-.2561		
	(.2511)	(.2186)		
Results	.8189***		.3159*	.2135
	(.2468)		(.1830)	(.2301)
Results DFAST				.3589
				(.2312)
Announcement mean effect	-.0293	.0349	.0366	-.0030
	(.0681)	(.0512)	(.0524)	(.0531)
Methodology mean effect		-.0072		
		(.0416)		
Results mean effect	-.0397		.0282	.0100
	(.0400)		(.0422)	(.0442)
Announcement ρ effect	.0199	-.0813	-.0874*	-.0588
	(.0661)	(.0516)	(.0521)	(.0527)
Methodology ρ effect		.0803*		
		(.0413)		
Results ρ effect	-.0634		-.1273***	-.0433
	(.0394)		(.0423)	(.0438)
Constant	-.0179	-.0879***	-.0612	-.0090
	(.0403)	(.0389)	(.0411)	(.0447)
Number of id	18	18	18	17
Trading days	597	406	371	445
R^2	.4958	.6175	.6403	.5071

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

no-gap banks. In what follows we focus our discussion on the beta effects associated with the results events.

As columns (1) in Table A2 show, changes in betas of gap banks significantly differ from changes in betas of no-gap banks in all years. As revealed by the stress test results, most banks had sufficient capital to maintain their operations under the adverse economic scenario employed, but some banks appeared to be under-capitalized. The signs in columns (1) associated with stress test results for gap and no-gap banks suggest that the betas move in opposite directions.[17]

Considering column (2), we see that the decrease in the beta in 2009 as reported in Table 6 was due to the effects on no-gap banks. The results of SCAP seem to have caused a significant decrease in betas of no-gap banks while the betas of gap banks were not affected. This finding complements the findings of Morgan et al. (2010) who show that market participants' ex ante expectations of capital shortfalls were worse than they ex post turned out to be. For the remaining years in Table A2, it turns out that the publication of the CCAR 2012 result did affect the betas of gap banks. The increase in beta amounts to .2284. This suggests that also in 2012 the betas of gap banks were affected, albeit positively. In 2013, the change in overall beta following the results of CCAR is due to both gap (-.2617) and no-gap (-.2110) banks.

Considering systemic risk for gap banks in Table A3, there is evidence that stress test results affect systemic risk also in 2009. The release of stress test results in 2009 decreased the beta of gap banks but not of no-gap banks. The decline in betas amounts to .0976. In 2012, both gap and no-gap banks' betas were affected.

6 Conclusion

As stress tests are an important tool for banking supervisors, it is important to consider their effects on stock and credit markets. We have quantified the market reactions of US stress tests performed after the start of the financial crisis by considering their effects on stock returns, CDS spreads, systematic risk, and systemic risk. We conclude that stress tests have produced valuable information for market participants and can play a role in mitigating bank opacity. Our findings indicate that post-crisis stress tests affected the CDS market strongly but had less impact on bank stock returns. Equity returns were only affected by the disclosure of the stress test results in 2012 and only for non-gap banks.

Our analysis of banks' betas suggests that the publication of stress test results has affected banks' systematic risk for all years. Stress tests contributed to diminishing systematic risk in 2009 and 2013. However, for 2012 we find some evidence that the systematic risk of gap banks increased following the publication of the results of CCAR. Studying the changes in betas we find that stress tests reduced systemic risk in 2009 (for gap banks) and in 2012 (for all banks).

Overall, our findings suggest that stress tests are a useful tool in mitigating risk in stock and credit markets.

[17] A finding in agreement with Baker and Wurgler (2013) who confirm that the equity of better-capitalized banks has lower systematic (beta) risk.

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A Additional Figures and Tables

Figure A1: Stress test news

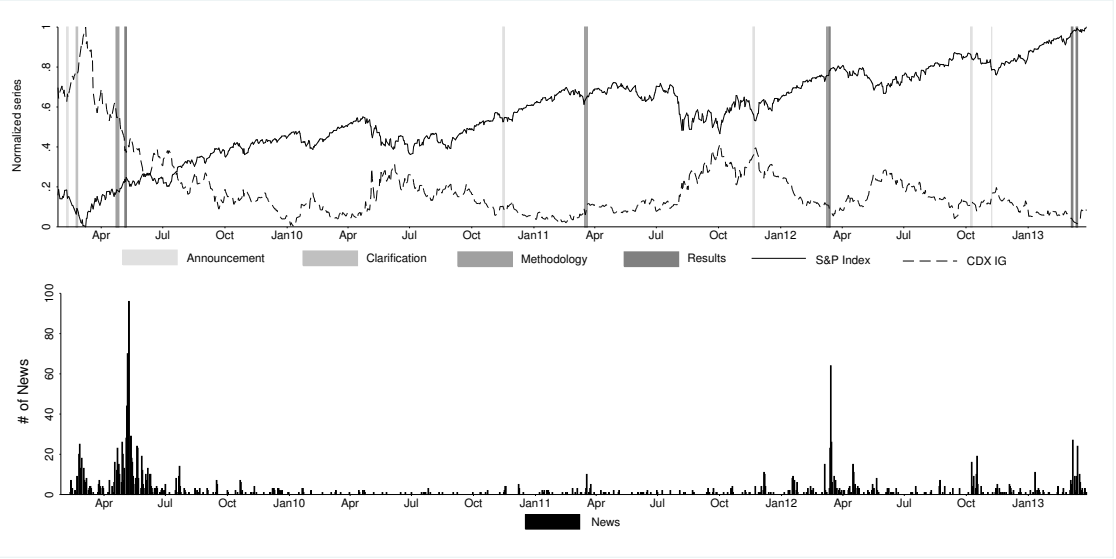

Table A1: Composition of CDS data

Banks	Number of CDS spreads						Total Obs
	2008	2009	2010	2011	2012	2013	
Ally Financial	85	238	244	251	249	169	1236
American Express	190	250	252	250	250	236	1428
Bank of America	248	252	252	252	250	250	1504
Capital One Financial	109	250	251	251	250	241	1352
Citigroup	247	250	252	252	251	251	1503
Goldman Sachs Group	207	251	252	252	252	252	1466
JPMorgan Chase	247	251	252	252	252	252	1506
MetLife	173	249	251	252	251	235	1411
Morgan Stanley	206	249	245	251	251	247	1449
Wells Fargo	185	250	251	252	249	247	1434

Notes: This table includes the amounts of non-missed and non-zero changes in 5Y CDS spreads available at the Bloomberg database for the period of 2008-2013.

Figure A2: CARs of equity returns and CDS spreads of US banks

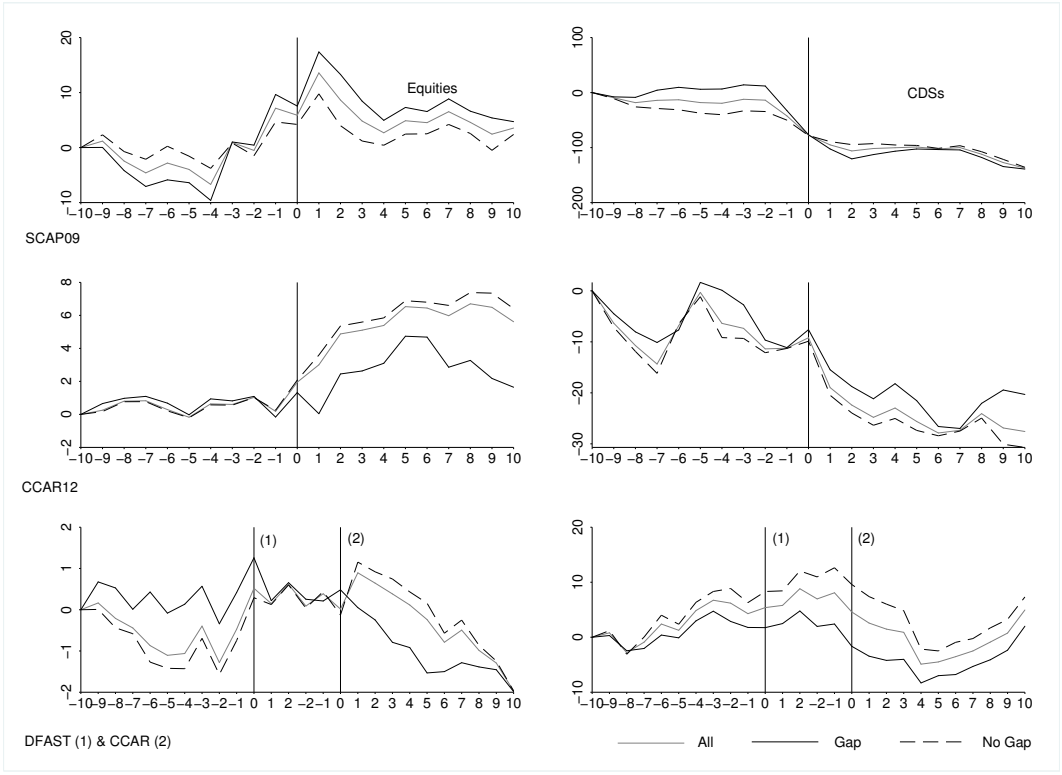

Table A2: Systematic risk gap and no-gap banks

	2009		2012		2013	
	(1)	(2)	(1)	(2)	(1)	(2)
Market β	1.783***	1.783***	1.563***	1.563***	1.465***	1.465***
	(.0608)	(.0608)	(.0426)	(.0426)	(.0565)	(.0565)
Announcement	-.0031	-.0031	-.0002	-.0002	.0041	.0041
	(.0138)	(.0138)	(.0053)	(.0053)	(.0033)	(.0033)
Announcement DFAST					.0066**	.0066**
					(.0033)	(.0033)
Clarification	.0754***	.0754***				
	(.0141)	(.0141)				
Methodology	-.0032	-.0032				
	(.0143)	(.0143)				
Results	.0448***	.0448***	.0061	.0061	.0029	.0029
	(.0138)	(.0138)	(.0045)	(.0045)	(.0033)	(.0033)
Results DFAST					.0055*	.0055*
					(.0033)	(.0033)
Announcement mean effect	-.0031	-.0031	.0013	.0013	.0001	.0001
	(.0038)	(.0038)	(.0013)	(.0013)	(.0008)	(.0008)
Results mean effect 'Gap'	.0008	-.0007	.0004	.0014	.0000	.0003
	(.0019)	(.0028)	(.0009)	(.0014)	(.0005)	(.0007)
Results mean effect 'No Gap'	-.0014	-.0014	.0010	.0010	.0003	.0003
	(.0019)	(.0019)	(.0010)	(.0010)	(.0007)	(.0007)
Announcement β effect	.9922***	.9922***	.1343	.1343	-.1077	-.1077
	(.1447)	(.1447)	(.1171)	(.1171)	(.0934)	(.0934)
Results β effect 'Gap'	.2105**	-.1170	.3813***	.2284*	-.0507	-.2617***
	(.1007)	(.1540)	(.0835)	(.1300)	(.0488)	(.0837)
Results β effect 'No Gap'	-.3275***	-.3275**	-.1529	-.1529	-.2110**	-.2110***
	(.1070)	(.1070)	(.0982)	(.0982)	(.0819)	(.0837)
Constant	-.0018	-.0012	-.0023*	-.0023*	-.0001	-.0001
	(.0026)	(.0026)	(.0013)	(.0013)	(.0008)	(.0008)
Number of id	18	18	18	18	17	17
Trading days	597	597	371	371	445	445
R^2	.4836	.4836	.6401	.6401	.4927	.4927

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

Table A3: Systemic risk gap and no-gap banks

	2009		2012		2013	
	(1)	(2)	(1)	(2)	(1)	(2)
Market ρ	.7334***	.7334***	.8566***	.8566***	.7491***	.7491***
	(.0327)	(.0327)	(.0282)	(.0282)	(.0336)	(.0336)
Announcement	.1510	.1510	.1082	.1082	.2533	.2533
	(.2467)	(.2467)	(.2125)	(.2125)	(.2292)	(.2292)
Announcement DFAST					.4101*	.4101*
					(.2289)	(.2289)
Clarification	.7267***	.7267***				
	(.2512)	(.2512)				
Methodology	-.0243	-.0243				
	(.2513)	(.2513)				
Results	.8196***	.8196***	.3159*	.3159*	.2124	.2124
	(.2470)	(.2470)	(.1830)	(.1830)	(.2262)	(.2262)
Results DFAST					.4094*	.4094*
					(.2273)	(.2273)
Announcement mean effect	-.0292	-.0292	.0366	.0366	-.0019	-.0019
	(.0681)	(.0681)	(.0524)	(.0524)	(.0523)	(.0523)
Results mean effect 'Gap'	.0029	-.0382	.0195	.0445	-.0080	.0076
	(.0285)	(.0453)	(.0323)	(.0496)	(.0326)	(.0480)
Results mean effect 'No Gap'	-.0412	-.0412	.0250	.0250	.0156	.0156
	(.0396)	(.0396)	(.0427)	(.0427)	(.0448)	(.0448)
Announcement ρ effect	.0198	.0198	-.0874*	-.0874*	-.0537	-.0537
	(.0661)	(.0661)	(.0521)	(.0521)	(.0518)	(.0518)
Results ρ effect 'Gap'	-.0686***	-.0976***	.0331	-.0997**	.0166	-.0355
	(.0174)	(.0414)	(.0261)	(.0472)	(.0238)	(.0456)
Results ρ effect 'No Gap'	-.0290	-.0290	-.1328***	-.1328***	-.0520	-.0520
	(.0392)	(.0392)	(.0426)	(.0426)	(.0438)	(.0438)
Constant	-.0175	-.0175	-.0599	-.0599	-.0119	-.0119
	(.0425)	(.0425)	(.0412)	(.0412)	(.0446)	(.0446)
Number of id	18	18	18	18	17	17
Trading days	597	597	371	371	445	445
R^2	.4966	.4966	.6403	.6403	.5099	.5099

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

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