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MASTER'S THESIS

Impact of Stress Testing on Bank Risk

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Declaration of Authorship

I hereby proclaim that I wrote my diploma thesis on my own under the leadership of my supervisor and that the references include all the resources and literature I have used. I also proclaim that this thesis has not been used to obtain the same or any other degree.

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Prague, May 15, 2015

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I am grateful to all those who supported me and thus made the writing of this work possible. I am also very grateful to Doc. PhDr. Adam Geršl, Ph.D. for his supervision and timely and productive feedback.

Abstract

This thesis studies the impact of macro stress testing on the riskiness of the participating banks. We use a dataset on 48 banks participating in either or both of the 2010 and 2011 EU exercises performed by the CEBS/EBA and 17 peer banks that did not participate. We find that early announcement of the 2010 stress test led to a temporary capitalization increase for the participating banks. We also find that disclosure of the 2011 exercise results caused a decline in capitalization for the participating banks. The results indicate that the way stress tests are prepared and communicated can strongly influence how banks react in terms of capitalization levels.

JEL Classification	G21, G28
Keywords	Stress tests, Bank capitalization, Bank risk

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Abstrakt

Tato práce zkoumá dopad makro stres testů na rizikovost účastnících se bank. Pro analýzu využíváme soubor 48 bank účastnících se alespoň jednoho ze stres testů které v letech 2010 a 2011 v EU provedla CEBA/EBA a 17 bank které se neúčastnily. Zjistili jsme, že brzké oznámení stres testu z roku 2010 vedlo ke krátkodobému navýšení úrovně kapitalizace účastnících se bank. Také jsme zjistili, že zveřejnění výsledků stres testu z roku 2011 způsobilo pokles úrovně kapitalizace účastníků. Výsledky naznačují, že způsob, jakým jsou stres testy připraveny a komunikovány, může znatelně ovlivnit dopad na kapitalizaci účastnících se bank.

Klasifikace G21, G28

Klíčová slova Stress testy, Kapitalizace bank, Riziko bank

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Résumé

Cette thèse étudie l'impact des macro stress tests sur le degré de risque des banques participantes. Nous utilisons un ensemble de données sur 48 banques participant à l'une ou les deux exercices de l'UE de 2010 et 2011 effectués par le CECB/EBA et 17 banques de pairs qui ne participent pas. Nous trouvons que l'annonce précoce de stress test de 2010 a conduit à une augmentation de la capitalisation temporaire pour les banques participantes. Nous trouvons également que la communication des résultats de l'exercice de 2011 ont causé un déclin de la capitalisation pour les banques participantes. Les résultats indiquent que les manières stress tests sont établis et communiqués peuvent fortement influencer la façon dont les banques réagissent en termes de niveaux de capitalisation.

JEL Clasification G21, G28

Mots clés Stress tests, Capitalisation bancaire, Risque bancaire

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Master Thesis Proposal

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Proposed Topic:

Bank Responsiveness to Calls for De-risking: The Case of EU Stress Testing

Motivation:

In order to maintain a well functioning and stable banking industry, an effective regulatory framework is of crucial importance. Recent financial and sovereign debt crises, however, have shown that with changes in the industry, regulation needs to adjust as well in order to contain newly emerging risks and threats. This paper will examine the current situation, focusing on the determinants of bank risk-taking behavior. Specifically, we will estimate bank reactions to pressure to take less risk from different channels.

The aim of the paper is to determine whether the banks are influenced by the three following factors: new information about their risk profile and exposures; official but not binding warning by a regulatory authority; pressure from shareholders. With this information it would be possible to adjust current regulatory and supervisory trends and utilize those channels that work the strongest. In order to test this issue empirically, I will utilize the latest EU-wide stress test results and recommendations published by the European Banking Authority (2011).

So far, there has been a decent body of literature on the topic of supervision trying to determine which approach is the most effective. The majority of this literature examines the influence of supervisory approaches on different measures of the banking performance and stability (see eg. Barth, Caprio, & Levine, 2006, 2012, 2013; Cihak & Demirguc-Kunt, 2012; Etzioni, 2009; Chortareas, Girardone, & Ventouri, 2012; Pasiouras, Tanna, & Zopounidis, 2009). The aim of this paper, however, is to decompose this connection and only scrutinize its first part - the question of how banks respond to different sources of influence, leaving the specific impact of this influence on effectiveness and stability aside. Similar approach was used by Bischof and Daske (2012), who analyzed the effect of information disclosure rules on bank risk-taking behavior.

Hypotheses:

1. Hypothesis #1: The EU-wide stress test performed by the European Banking Authority in 2011 had a significant impact on bank behavior.
2. Hypothesis #2: The reaction of shareholders and the test score were significant determinants of the banks response.
3. Hypothesis #3: Ceteris paribus on the test result, the non-binding recommendation did not affect the bank behavior.

Methodology:

In order to estimate the issue at hand, I will use three primary sources of data. Firstly, the results of the 2011 stress test by the EBA which contain data on 91 banks operating in the EU. This source will provide information among other on the individual bank results in different scenarios and their exposure to sovereigns. Secondly, the Bankscope database with data on individual banks and the development of their capital and risk structure after the stress test. Thirdly, I will use Bloomberg or other financial tool to obtain historical bank stock prices. With this data I will use regression models to determine the significance of different influence channels.

The power of shareholders will be estimated as the effect of stock price change on banks' own capital structure. This approach works with the underlying assumption that upon surprisingly bad results the market would "punish" the bank and its price would drop which would trigger remedial measures in banks riskiness to counter act this downswing. For this purpose, I also use the contributions of Wolff and Angeloni (2012) and Wolff (2011) who test the influence of stress test results on bank stock performance.

The influence of official recommendations and the information on bank riskiness itself will be estimated together. In this case I will regress bank response on its stress test results and recommendation category (in case it was issued a recommendation). The expectation is that in case the recommendation itself is influencing bank behavior, it will be a significant determinant of the response on the top of bank score which contains information on the actual risks.

Expected Contribution:

Contrary to much of the current literature, we will analyze only the first part of the regulation-outcome event chain. I will only focus on how banks respond to different sources of pressure which will enable a more detailed view on this matter. Moreover, I will estimate the results based on the latest available information and therefore the analysis will account for any structural or institutional changes which might have taken place during the Great recession. With this information, it will be clearer, whether it is effective to focus on ensuring sufficient transparency of the banks, issue official warnings or simply provide them with additional information about their exposures and possible threats.

Outline:

1. Introduction and motivation
2. Banking supervision theories (private and public supervision concepts and different ways to influence bank behavior) and introduction to stress testing
3. Data, its sources and descriptive statistics
4. Methodology used for the analysis, its advantages and disadvantages
5. Results and robustness checks
6. Conclusion of my main findings and the implications, suggestions for further research

Core Bibliography:

Barth, J. R., Caprio, G., & Levine, R. (2006). *Rethinking Bank Regulation: Till Angels Govern*. New York, NY: Cambridge University Press.

Barth, J. R., Caprio, G., & Levine, R. (2012). *The evolution and impact of bank regulations* (No. 6288).

Barth, J. R., Caprio, G., & Levine, R. (2013). *Bank Regulation and Supervision in 180 Countries from 1999 to 2011* (No. 18733).

Bischof, J., & Daske, H. (2012). Mandatory supervisory disclosure, voluntary disclosure, and risk-taking of financial institutions: Evidence from the EU-wide stress-testing exercises.

Cihak, M., Demirguc-Kunt, A., Peria, M., & Mohseni-Cheraghlou, A. (2012). *Bank regulation and supervision around the world: a crisis update* (No. 6286).

Etzioni, A. (2009). The Capture Theory of Regulations - Revisited. *Society*, *46*(4), 319–323.

EBA. (2011). *2011 EU-wide Stress Test Aggregate Report*.

Chortareas, G. E., Girardone, C., & Ventouri, A. (2012). Bank supervision, regulation, and efficiency: Evidence from the European Union. *Journal of Financial Stability*, *8*(4), 292–302.

Pasiouras, F., Tanna, S., & Zopounidis, C. (2009). The impact of banking regulations on banks' cost and profit efficiency: Cross-country evidence. *International Review of Financial Analysis*, *18*(5), 294–302.

Wolff, G. B. (2011). *Is recent bank stress really driven by the sovereign debt crisis?* (No. 2011/12). Brussels.

Wolff, G. B., & Angeloni, C. (2012). *Are banks affected by their holdings of government debt?* (No. 2012/07). Brussels.

Development & changes after the writing of the thesis:

Over the course of writing of the thesis, the hypotheses have been slightly adjusted. Given the lack of research on the topic of stress test influence on banks, we focused on this specific link. Therefore, we slightly shifted our main focus from the responsiveness of the banks to the impact of the stress tests. Finally, we have included the 2010 stress test which enabled us to fully utilize the power of panel data estimation.

Author **Supervisor**

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Acronyms

BCBS	Basel Committee on Banking Supervision
CCAR	Comprehensive Capital Analysis and Review
CEBS	Committee of European Banking Supervisors
CEE	Central and Eastern Europe
CRD IV	Capital Requirements Directive
CRR	Capital Requirements Regulation
DFA	Dodd-Frank Wall Street Reform and Consumer Protection Act
EBA	European Banking Authority
EC	European Commission
ESRB	European Systemic Risk Board
FE	Fixed effects model
FRB	Federal Reserve Board
GDP	Gross domestic product
IRB	Internal rating based
P&L	Profit & loss statement
p-OLS	Pooled ordinary least squares model
RE	Random effects model
RWA	Risk-weighed assets
SCAP	Supervisors Capital Assessment Program
VAR	Value at risk model

Introduction

Since the onset of the Great Recession, banking regulation has become an increasingly dynamic and complex field. Many of the former strategies have been invalidated or are now considered as incomplete or inefficient. This impulse forced the authorities to bring forward new approaches and tools to achieve their goals. Macro stress testing is one of the tools that experienced the biggest expansion and today it is regularly used to obtain information about the resilience of banking systems around the world. This thesis examines the impact stress testing exercises on the riskiness of the participating banks.

The authorities do not state impact on capitalization (and subsequently risk profiles) among one of the aims of the exercises and little attention has been paid to the link until now in the academic literature. One of the primary goals of banking regulation, however, is ensuring financial and monetary stability (Spong, 2000) and stress testing is one of the tools the authorities use to achieve this goal. Therefore, it is important for us to know how the exercises themselves affect banking stability and riskiness. Moreover, if there are positive and/or negative influences, we should know what triggers and affects them so that we can operate with them consciously.

To study this relationship, we empirically analyze the results of the 2010 and 2011 stress tests performed in the EU and their impact on bank capitalization. Given the fact that academic literature mostly focused on the reaction of the markets, this work presents the first empirical analysis of the influence on capitalization levels.

According to our results the banks stress tested in 2011 experienced a decrease in capitalization in comparison to the banks that did not participate. This is consistent with the research on market reaction which indicates that the exercise has been viewed negatively owing to lack of scenario credibility and commitment by the authorities. By increasing the cost of financing, this caused a real shock to the banks and further decreased their capitalization in the turbulent times.

The bank themselves also intentionally adjusted their portfolios during the 2010 stress test. Decreasing their riskiness before the stress test and reversing this change afterwards enabled them to achieve better result but potentially destabilized the banking sector. Changes in the methodology prevented the banks to repeat this strategy in 2011 which suggests that the EBA continuously strives to improve the

exercise. This is especially valuable since, as we have seen, these changes play a crucial role in determining the exercise's impact on banks' capitalization.

The results are particularly interesting since they offer the first assessment of the impact of macro stress testing on bank riskiness. While the thesis raises a number of questions that it does not answer, we identify several channels which are worth noting and we start developing arguments for their theoretical understanding. This, in turn, provides a basis for further research that will help fully clarify the impact of stress testing and enable the authorities to use it with maximum efficiency while minimizing its drawbacks. The ability to optimize the process is then especially valuable at times of crises, such as the year 2011 when instead of stabilization the stress test delivered another hit to the banking sector.

The rest of the thesis is organized as follows. The next section discusses basic theories and facts regarding banking regulation and stress testing. Section 2 presents the results of research previously conducted on this topic and discusses our hypotheses. Section 3 describes the data and methods used. Section 4 analyzes the impact of macro stress testing on risk profiles of the participating institutions. Finally, section 5 concludes.

1 Theoretical Background

1.1 Why Do We Regulate

Today, banks are the cornerstone institutions of our economies. Through economies of scale they help allocate capital efficiently and thus optimize the wealth generation in societies. In general, we can recognize four essential contributions that help achieve this goal.

Firstly, banks aggregate small amounts of short term capital, which are then transformed into larger amounts of long-term capital. Through this mechanism, we overcome the otherwise very problematic issue of matching lenders and borrowers. We could speak of this issue as of a special case of double coincidence of wants,[1] where as a borrower you need to find a lender who is both willing to lend you the required sum and willing to wait long enough for you to repay.

Secondly, banks enable economies to operate faster and facing lower transaction costs by facilitating payment systems (Cirasino & Garcia, 2008). The payment systems provide safe monetary transfers and reduce webs of bilateral contracts to simple contract of the end counterparties.

Thirdly, the large amounts of deposits and loans enable banks to gather extensive amounts of data on both their counterparties and the economy overall. Through this information they can reliably estimate default probabilities and use interest rate margins to compensate for the losses.

Lastly, large portfolios of diversified investments provide opportunity to overcome risk-aversion and operate as a risk-neutral agent on the markets who generates additional value and promotes growth (Crockett, 2011).

These functions, however, place banks in a unique situation where they don't just provide goods or services – they have become a necessary condition that enables goods and services provision in the economy as a whole. With gradual creation of

[1] Double coincidence of wants and needs is a concept from economies without money where economic agents are required both to find a product they desire to buy and have something the counterparty will accept in exchange

this unique position, governments started to regulate the industry in order to ensure provision of these essential services. These regulations are aiming to counterbalance a wide array of inherent threats and problems that are connected to banking. Following the lead of Groenwegen, Spithooven, and van den Berg (2010) we identify four primary issues that threaten proper functioning of the economy:

Natural monopolies. For companies that base their existence on scaling their business in terms of capital, data, and customers, the threat that one player becomes too powerful it never too distant. In a simplified framework, the size would give the biggest institution competitive advantage and it would consequently use this advantage to put all its competitors out of business, while no new market entrant could threaten this position because they would not have the economies of scale. Absent competitive pressure this monopoly player could then raise margins at the cost of overall welfare.

Externalities. Firstly, default of one bank can have a significantly negative effect on other banks directly through interbank market operations. Secondly, given imperfect information on the side of depositors and high level of interconnectedness, such situation can cause unsubstantiated panic and lead to mass deposit withdrawals (bank run). Working together, these two forces can transform any single-bank problems into a banking crisis which damages the economy both directly through banks' defaults on their obligations and systemic inability to efficiently allocate credit.

Imperfect information. Depositors do not have the ability to reassess the banks' riskiness with ever transaction and determine whether the price (usually in form of an interest rate) is adequate. Therefore, regulators offer guarantees which reduce the uncertainty and eliminate or at least mitigate this transaction cost.

Public goods. Regulation itself could be seen as a public good as we cannot exclude others from its benefits and the effect it has on one party does not in any way reduce the effect on other parties. In case of public goods it is irrational for any individual player to generate this benefit, because while he bears the costs, all other parties could only enjoy the benefits at no cost. Therefore, a central player has to intervene and provide the good.

1.2 Theories Behind Bank Risk-taking

We have established that banking plays a key role in today's economies and that this generates an array of threats to the stability and efficiency of the economy which the regulators try to mitigate. In this section, we specifically focus on one of the sources

that generate some of the failures – excessive risk-taking and the mechanisms that allow and promote it.

In order to mitigate the principal-agent problem, it is common to offer bank executives compensation packages tied to the performance of the bank. Bebchuk and Spamann (2010) note that the very common equity-based rewards motivate executives to take excessive risks since they enjoy the benefits but do not suffer the downside. Similar results are presented by Chen, Steiner, and Whyte (2006) who specifically focus on the impact of stock options and Guay (1999) who finds that incentive schemes influence firms' stock-return volatility.

When we move our focus to the bank as a whole, we discover that it finds itself in a situation not unlike the executives. With the limited liability concept in place, the downside of any investment is limited for the shareholders. This motivates the banks to increase their risks and leverage to maximize the potential profits which are not limited (Blum, 2002; Burakov, 2014). Historically, we have witnessed other concepts such as unlimited liability or double liability which decreases bank risk-taking but they have been mostly abandoned (Grossman, 2001). Government guarantees and deposit insurance schemes also fuel this asymmetry by effectively covering the cost of bank failures by taxpayers' money.

Furthermore, the limited liability concept is not strictly restricted to the financial realm. Some question whether it is right that no high-level executive was successfully prosecuted in response to the recent economic meltdown, especially in contrast to the past crises where the top figures of the financial world were commonly successfully prosecuted (Rakoff, 2014).

1.3 Regulation

Today, in an attempt to provide solutions for these problems, curtail the risk, and ensure economic stability, governments use an interventionist approach which makes banking the most regulated of all industries (Chortareas et al., 2012). Yet, we are still witnesses to recurring economic crises that hinder our economies and have a severe impact on our well-being (Laeven & Valencia, 2012). Although the regulations are not 100% effective, most of the world's economies are still pursuing this approach and trying to fix its issues rather than leaving all work to the invisible hand of market.

In this section we present a brief description of the most discussed and used regulatory tools that have been used over the course of the last few decades. Rather than exhausting all approaches, we try to outline the most common approaches that

are used by regulators and supervisors to influence banks. For each of the approaches we also the state economic rationale and discuss its advantages and setbacks.

Gaining prominence with the introduction of the Basel Capital Accord (BCBS, 2004), capital requirements have become the cornerstone of bank regulation. By putting equity at risk, they promote more prudent behaviour and decrease the incentives for gambling where gains are internalized and losses externalized (French et al., 2010). On the other hand, it is costly as it decreases the banks' capacity to create liquidity and, consequently, access to credit (Van den Heuvel, 2008). Some authors point out that capital requirements can be pro-cyclical (Heid, 2007) or require additional tools such as leverage ratio restriction and liquidity requirements (Blum, 2008; Morris & Shin, 2008). A paper by Schuermann (2014) even claims that due to opaqueness and possibility of asset substitution in banking stress tests are the optimal complement to capital requirements. Yet, despite all the criticism and downsides, Admati et al. (2010) claim that bank equity is not that costly and suggest that a significant increase in equity requirements would lead to large social benefits.

Historically, some of the most used regulations were activity restrictions. They were aiming to separate the more risky banking activities from the traditional commercial banking to prevent risk contagion from the former to the latter (the Glass-Steagall Act is the best known example of such policies). The value of this separation was further amplified by the introduction of deposit insurance schemes which presented a severe moral hazard issue. With insurance, the banks were protected from the greatest costs of failure and thus they could take on more risk. Despite the fact that for almost half a century activity restrictions succeeded to prevent any significant crises in the US, it was ultimately abandoned in 1999 due to an increased pressure from the banks who claimed it was too costly in terms of efficiency and that it disregarded the increasing complexity of the markets (Baradaran, 2014). Also, some authors claim that activity restrictions could actually harm the banking system as they limit diversification on the side of banks (Uhde & Heimeshoff, 2009).

Deposit insurance, on the contrary, has stayed and is currently expanding. Its original intention of this policy was to prevent bank-runs that plagued the world during the Great Depression. Some current research, however, points out that it actually adversely impacts bank stability due to its positive effect on moral hazard, especially so in countries with less developed institutions (Demirgüç-Kunt & Detragiache, 2002).

In the recent years, one of the trends that we have witnessed is a partial return back to private monitoring by the markets. The regulators facilitate this by enhancing the

transparency and disclosure of information by banks. Beck, Demirguc-Kunt, and Levine (2006) note that it facilitates "efficient corporate finance and ... integrity of bank lending" (p. 27). The downside, however, is that the incentives to monitor banks are significantly decreased by the deposit insurance schemes. One of the currently expanding instruments of data gathering and verification is also the one we focus on – stress testing.

1.4 Stress Testing

Stress testing represents an improvement to the methodologies and data gathering techniques and supports the final regulatory decisions. According to Quagliariello (2009), stress tests are defined as "... quantitative tools used by banking supervisors and central banks for assessing the soundness of financial systems in the event of extreme but still plausible shocks (macroeconomic stress tests). They are also an important management instrument for banks since they provide financial institutions with useful indications on the reliability of the internal systems designed for the measurement of risks (microeconomic or prudential stress tests)" (p. 1). Although this definition captures the general idea, it is also important to remember that there are other aspects of stress testing that lead to variations.

In the end the underlying idea of stress testing is that it should uncover any systemic or institutional fragility and enable the institutions or the regulator to remedy it in time by strengthening the system foundations. Generally, the foundations are represented by capital requirements (EBA, 2014b).

Generally, stress tests are performed on two levels. The micro stress tests focus on individual financial institutions and evaluate their stability. The outcome is very valuable to the management, but can be unreliable if the bank is examined in isolation and feedback loops are disregarded. Therefore, regulators and international institutions perform macro stress tests which focus more on the system as a whole and take into account links between institutions and systemic fragilities. Furthermore, macro level testing can be either based on an analysis of individual borrowers (bottom-up approach) or an analysis of portfolios that are assumed homogeneous (top-down approach). Overall, the micro and macro approaches are complementary and should not be relied upon individually as they can omit crucial information.

On the macro level, regulators perform the tests by specifying possible adverse scenarios which are provided to the banks. The banks then have to test these scenarios and provide information on what would be their standing in such a case, which is then scrutinized and serves a range of purposes. Firstly, the regulators assess

whether the capital, liquidity, lending levels etc. are consistent with orderly functioning of the economy and in case of any problems step in to remedy these issues. Secondly, such exercise helps them better understand the market dynamics and thus generate more efficient rules. Thirdly, in case of information disclosure stress tests help inform investors and analysts and thus promote market discipline through monitoring by private counterparties. Finally, disclosed information can have positive impact on stabilization of the markets in case there is uncertainty among the institutions or overall bad mood (Jobst, Ong, & Schmieder, 2013).

The first consistent stress-testing was, however, on the micro level and emerged in the 1990s when large financial institutions used it as a complementary tool to other risk measures such as value at risk to asses and manage own institutional risks (Quagliariello, 2009). This way banks tested the impact of any potential event they could come up with. Only in 1996 regulators started focusing on this tool, too, with the amendment to Basel I which aimed to incorporate market risk in banks' regulatory capital calculations (BCBS, 2005).

Basel Committee on Banking Supervision (2002) in its technical guidance document specifically requires banks to use micro stress tests as a precondition for determining own risk-weights of assets:

> *"An IRB [internal rating based] bank must have in place sound stress testing processes for use in the assessment of capital adequacy. Stress testing must involve identifying possible events or future changes in economic conditions that could have unfavourable effects on a banks' credit exposures and assessment of the banks' ability to withstand such changes. Examples of scenarios that usefully could be examined are (i) economic or industry downturns; (ii) market-risk events; and (iii) liquidity conditions" (p. 74-75).*

The effect that Basel is trying to capture is predominantly a direct impact on single institution caused by a decrease in market rating (resulting in changed capital requirements due to change in risk-weighted assets).

As early as 2000 the regulators recognized that rapid growth and innovation of the sector call for a more complex solution and started looking into the possibility of micro level results aggregation (Committee on the Global Financial System, 2000). Also Goodhart (2006) noted before the crisis that micro approach by itself is not sufficient, because any deterioration in market condition would affect the bank not only directly but also indirectly through other market participants such as capital

providers or customers. Therefore, he recommended implementation of a model which would test the whole banking system, taking into account all the inter-linkages and possibly even connections to the real economy. In this, he confirmed the views of Hellwig (1995) who warned that microecnonomically sound institutions may still form a fragile system if there is high amount if interbank borrowing.

Although most of the G-10 countries started using stress tests as early as 2001 (Quagliariello, 2009), only with the recent crisis stress testing became prominent and received wide attention from the regulators. With this recognition as a powerful regulatory instrument came also methodological improvements dealing with insufficiencies that decreased the efficiency earlier tests (e.g. inclusion contagion and liquidity or testing of complex shock scenarios). Despite the upgrades, however, recent versions of the exercises still attract lots of discussion and many authors point to insufficiencies that prevent regulators from achieving the desirable outcome (Cerutti & Schmieder, 2014). Carosio (2009) even stated that "... [n]otwithstanding the undeniable advances of the methodologies and applications, it is fair to say that the framework has not yet reached a steady state. Almost all contributors very openly claim that the challenges for stress-testing are still significant and there is room for further developments" (p. xxii).

The crisis developments were also reflected in one of the major documents that Great recession gave rise to – Basel III capital accord. The BCBS (2009) noted in a preliminary report on sound practices in stress testing, that while stress tests had been performed by banks, they were unable to foresee the losses and offer guidance on how to prevent this situation in the future. They identified four key aspects that need to be addressed: (i) the banks should integrate stress testing in their overarching risk management processes as opposed to performing it separately in an isolated manner or for selected departments/business lines (this also enables flexible action which takes into account aggregate risks across the institution including potential feedback loops); (ii) reliance on historical data should be limited as they tend to get unreliable with prolonged periods of growth or stability; (iii) stress scenarios need to be re-constructed, accounting for longer lasting, more severe conditions with potential amplification effects; (iv) specifics of each product should be evaluated and taken into account in order to prevent serious miscalculations such as was the case of structured products and leveraged lending during the crisis. These recommendations were then incorporated even in the final Basel III document (BCBS, 2011).

Currently, the two most prominent stress testing initiatives are those of the US and European Union. In the US, mandatory regular stress testing has been introduced by

the Federal Reserve Board (FRB) in 2009 as a reaction to the crisis. In the Supervisory Capital Assessment Program (SCAP) banking institutions with assets over $100 billion were required to project revenues and losses under a) scenario that was agreed upon as a probable by the economists and b) adverse scenario with stronger impact. Later, the Dodd-Frank Wall Street Reform and Consumer Protection Act (DFA) introduced annual testing performed by the Financial Stability Oversight Council in 2010. Under this Comprehensive Capital Analysis and Review (CCAR) all banks and nonbank financial companies take part in this exercise, but they also need to carry out own stress test twice a year (quarterly for systemically important institutions). In the case of the US, DFA leaves discretion to regulators who decide how much data will be released or if the exercise will be focused on each individual bank or rather banking sector resilience as a whole (Goldstein & Sapra, 2013).

In the EU, stress testing is performed by the EBA[2] in cooperation with ESRB in order to "… assess the resilience of financial institutions to adverse market developments, as well as to contribute to the overall assessment of systemic risk in the EU financial system" (EBA, n.d.). The EBA has performed 4 EU-wide stress tests complemented by several other exercises (EU-wide Transparency exercise, EU Capital exercise) up to date with the latest stress test results disclosed in October 2014. In the latest round 123 EU (Eurozone, non-Eurozone and Norwegian) banking groups were covered and up to 12,000 data points including the P&L, RWAs, sovereign exposures, credit risk and composition of capital were disclosed for each of them (EBA, 2014a).

Perhaps the most followed outcome of the test is the common equity tier 1 capital ratio under the adverse scenario:

$$Capital\_ratio = \frac{Common\_equity\_tier\_1\_capital}{Total\_risk\_exposure}$$

where total risk exposure equals to risk weighted assets of the bank as defined by the Capital Requirements Regulation and Directive IV (CRR/CRD IV) adopted in 2011 by the Commission. In case the bank score in the adverse and baseline scenario falls below 5.5% and 8%, respectively, immediate action is undertaken with the intention to remedy this weakness. Given the construction of this indicator, there are ways the bank can influence it. Either the bank raises additional capital or it decreases the amount of total risk exposures. As (BCBS, 2014) notes, while smaller banks tended

[2] In 2011 the EBA replaced the Committee of European Banking Supervisors

to increase both the exposures and the capital over the past years, the internationally active banks used both of these instruments to improve their capitalization.

Despite the undeniable advance during the post-crisis period, stress testing is still a centrepiece of a heated debate and many authors pinpoint further deficiencies to the framework. Cerutti and Schmieder (2014) warn that the since the current tests are based on consolidated financials, they are unable to capture the true nature and detail of their distribution. This may be especially a problem in case the bank needs to move liquidity to other regulatory jurisdiction but the regulators limit these flows (ring-fencing). Examples of this behaviour have already been observed during the crisis when the host regulators, who were trying to protect their market, unilaterally restricted capital outflows.

Level of information disclosure, which is currently very high for both the US and EU regulators, is discussed in Goldstein (2014) who claims that although the literature has presented some benefits, regular disclosure also presents setbacks. In his theory banks get swayed into focusing on passing the exercise, rather than engage in prudent risk-taking behaviour. Also, he notes that testing just few scenarios does not provide sufficiently precise view of the sector. While there are many variables (and their) combinations that can negatively affect the banks, only one or two (in the EU and the US, respectively) adverse scenarios are being tested. Finally, he warns that despite the unpredictability of crises (see for example the black swan event concept popularized by Taleb [2007]), the scenarios are generally based on historical events (see also e.g. Steinhauser, 2014).

Third issue had been debated extensively before the last two EU stress test rounds and touches the topic of political correctness. The critique emphasizes that the stress scenarios fail to tackle politically sensitive topics such as Greek sovereign default for the 2011 exercise and escalated impact of the Crimean crisis or EU-level deflation for the 2014 exercise (Jenkins & Murphy, 2011; Steinhauser, 2014). Indeed, the authorities have incentives not to include such scenarios. The inclusion would signal to the markets that they are perceived as possible and thus implicitly increase their probability through the self-fulfilling prophecy mechanism. Although the EBA tried to solve this issue by disclosing large amounts of information which potentially enable recreation on modification of the scenarios (Jenkins & Murphy, 2011), it is unclear whether the analysts have sufficient capacity to perform such analysis – and if they do, why stress testing shouldn’t be replaced by simple regular information disclosure since the authorities are constrained from presenting a scenario which would truly represent a relevant downturn.

2 Literature Review & Hypotheses

As we have shown, banks have no shortage of reasons to take on excessive risks. Equity based compensation schemes promote short-sighted decisions (Bebchuk & Spamann, 2010), banks as a whole, shielded by limited liability of shareholders and government deposit insurance schemes, have incentives to take excessive risks due to internalization of profits and externalization of losses (Burakov, 2014), and contrary to previous crises there have been almost no legal consequences to the high level executives who took part in the Great Recession (Rakoff, 2014).

The manifestation are the 147 banking crises that we experienced between the years 1970 and 2011 (Laeven & Valencia, 2012) which significantly hit the economies and decreased the output (Hoggarth, Reis, & Saporta, 2002). The impact was especially strong for less developed countries which don't have the required flexibility or institutions for efficient use of fiscal and monetary policies to mitigate the fiscal outlays connected to bank recapitalization (Laeven & Valencia, 2012).

The process of bank failure can be seen as a natural genesis of the market that promotes survival of the fittest and disposes of the inefficient players (see e.g. Stiglitz [Evans-Pritchard, 2009] and Fama [2014] who promote the idea that banks during the Great recession should not have been supported). The general consensus shaping today's regulation, however, is that the rules should be different due to a crucial role of banking in the economy, its vulnerability and extensive externalities. Therefore, the research focuses very intensively on determinants of risk-taking in banks and potential ways to influence this behaviour.

2.1 General Market Influence on Risk-taking

Firstly, overall effects of supervision on risk-taking are scrutinized. The general level and strength of supervision has proven to be a concern for banks which use their cross-border mergers and acquisitions to shift risks to less supervised countries (Buch & DeLong, 2008). In other words, countries with relatively higher deposit insurance and less strict regulation do *ceteris paribus* attract more risky bank operations.

The government regulation itself, however, is not the only variable we have to take into account when we are trying to assess the final impact. Research shows that there

are other characteristics of the markets and banks that have significant influence on the risk-taking behaviour.

Laeven and Levine (2009) show that ownership structure and private monitoring can be significant factors in predicting the riskiness of banks. They find that different ownership structures lead to different reactivity to government regulations and risk appetite. According to their findings, depending on the ownership structure, the same regulation can either encourage or decrease bank riskiness. Specifically, diversified owners (those with only a minor stake in the company) are much more prone to supporting higher risk levels than owners with substantial interest in the bank. The results are confirmed by the findings that higher shareholder concentration ratios lead to decreased risks (García-Marco & Robles-Fernández, 2008). Proposed explanations for this phenomenon are twofold. Either, the diversified owners deliberately maximize the expected return on their portfolio by increasing individual risks, or they are not able to control the bank efficiently and unwillingly allow the managers to increase risk.

Bank size is another characteristic that can influence the impact of regulation. Using data on 546 banks in CEE Agoraki, Delis, and Pasiouras (2011) show that although capital requirements generally curb the risk levels, this effect is diminishing with bank size. Finally, according to their results the biggest banks tend to take on even more risk with increasing capital requirements. The size of the bank can also have a direct effect, as was shown in paper by García-Marco and Robles-Fernández (2008) who show that small banks generally assume lower risk levels.

Other strain of research shows that even general market characteristics such as competition can affect bank risk-taking. For example, Schaeck, Cihak, and Wolfe (2009) find more competitive banking systems to be associated with lower crisis probabilities. The evidence for this claim, however, is not entirely persuasive as other authors claim that more competitive markets force banks to take on more risk (Dick, 2006).

2.2 Capital Requirements

Of the specific rules applied around the world by regulators, capital requirements are perhaps the most discussed one. Although this has been one of the main instruments of bank regulation over the past decades, academics have not yet come to a definitive agreement on their overall effect on the stability or fragility of banking systems.

On the one hand, Blum (1999) argues that increasing capital requirements pressures banks to increase their risks for two reasons. Firstly, due to decreased profits in the future and limited liability the bankruptcy is less costly. Secondly, increasing regulatory capital may lead to an increase in marginal return on risk. Further, Hakenes and Schnabel (2011) show that current form of regulation – Basel II – is putting smaller banks into disadvantage as they cannot afford creation of internal rating model.[3] Consequentially, they have to take on higher risks in order to make up for this disadvantage.

On the other hand, the opinion that shapes the current practice is that capital requirements bolster banking sectors' stability and decrease the overall risk (let Basel regulations, which are working with capital requirements extensively, be the proof of this statement). They do so through increasing shareholders' stake in the banks and exposing them to higher potential loss in case of bankruptcy. Also, in case of failure of one of the institutions, the capital can be used to reimburse stakeholders and limit contagion to other banks. Along these two traditional reasons, Morrison et al. (2005) also add third way in which increased capital promotes soundness of banking markets. They show that it solves the adverse selection problem and "discourages unsound and unreliable institutions from setting up operations."

Furlong and Keeley (1989) in their model show that increases in regulatory capital reduce the incentives to take on asset risk. Despite some reservations towards the specifics of capital requirements implementation (especially the weight assignment under Basel I), Altman and Saunders (2001) claim that capital requirements are "a step in the right direction." In their analysis of 143 countries, Cihak, Demirguc-Kunt, Peria, and Mohseni-Cheraghlou (2012) conclude that the occurrence of a systemic crisis in years 2007-2009 was significantly correlated with less stringent capital definitions lower capital adequacy ratios and more freedom for banks in actual computation of these ratios.

Slightly different point of view is offered by Milne (2002) who claims that one channel of effect has long been neglected. According to his theory, capital requirements don't necessarily only work as an *ex-ante* mechanism by generating a simple constraint for banks. Banks in his model are forward-looking optimizers who take into account a potential *ex-post* regulatory retaliation in case of capital

[3] Under Basel II, banks have a choice of methodologies to determine risk-weighted assets. Large banks can get additional option by developing own internal rating model which allows them to optimize between the different approaches.

requirements breach. In this view, banks that are not on the verge of bankruptcy have strong incentives to increase capitalization in order to reduce the risk of violating the rules. Further, Lindquist (2004) shows on a sample of Norwegian savings banks that with the increased size of their capital buffer the broad risk (represented by variation in previous profits) of the bank declines.

2.3 Stress Testing

In line with the theories of Milne (2002), who says that banks are trying to avoid *ex-post* punishment for breach of regulations, the authorities are striving to come up with ever new ways of how to efficiently enforce their rules. One of the newly emerged methods is a system-wide stress testing.

Further, when information is publicly disclosed the stress tests reveal banks' resilience including levels of regulatory capital (as is the case for EBA's 2010, 2011, and 2014 exercises). Through this mechanism, they decrease uncertainty on the markets and enable investors and analysts to make more informed decisions and reward or punish banks for their results (Flannery, Kwan, & Nimalendran, 2013).

Petrella and Resti (2013) scrutinized this effect and discovered a significant reaction of the stock markets to the new information, thus rejecting the "irrelevance hypothesis" which claims that due to political constraints the 2011 EBA stress test was unable to capture any real adverse scenario (e.g. sovereign default of Greece which was in a very difficult situation at that time) and thus could not possibly bring any new information to the markets (Jenkins & Murphy, 2011). This result, confirming the value-added of the exercise, could be also explained by the fact that the newly disclosed information was not available and could not be produced based solely on the publicly available sources before the test (Petrella & Resti, 2013).

An event study conducted by Candelon and Amadou (2015) focused on the effects of individual stress tests. According to them the market reaction was always significantly positive in the EU with only one exception – the 2011 stress test. They claim that enhanced disclosure does not help as long as the EBA estimates of sovereign losses are still lower than the market estimates.

Langley (2013) shows that the exercises can significantly affect the market confidence. He argues that this was the case for the 2009 SCAP which stabilized the US markets. On the other hand, the exercises performed in the EU failed to deliver similar impact.

Ellahie (2013) argues that the EU exercises fulfilled their aim to reduce opacity in the banking sector and provide relevant and timely information. He, however, claims that the results published after the 2011 exercise led to a significant increase in uncertainty in both short- and long-term due to the banks' doubtful health and lack of determination of the authorities to actively solve the uncovered problems.

Gick and Pausch (2012) and Goldstein (2014) focus on the specific setup of stress-testing exercise. They point to the fact that the level of information disclosure is paramount and they encourage regulators to provide as much information as possible in order to enable investors and analysts to test their own personalized scenarios. In this way the regulators can overcome the political rigidity that doesn't allow them to prepare 'worst case scenarios' because they could cause panic on the markets.

These hypotheses describing market reaction to stress tests currently form the majority of academic literature scrutinizing the impact of stress tests. Despite the fact that market reaction is not our focus, they will be of great use to us. Since a drop in stock price induces an increase in equity financing cost (Yang & Tsatsaronis, 2012) and thus a real adverse shock to the bank, we can establish a link that leads from a stock price decrease to decrease in capitalization due to lower profits/higher losses.

In order to go one step further, we also analyze some other streams of information indicating that banks are also directly incentivized to take action and adjust their capitalization and risk profiles in reaction to the stress tests.

A PricewaterhouseCoopers survey (2014) points out that the stress test results are a valuable asset to the bank and should be leveraged in decision-making. While this is not a common practise yet, some banks already report using them to define their future strategies, especially in terms of risk appetite (and, consequently, their capitalization levels).

Finally, Goldstein and Sapra (2013), and Goldstein (2013) warn that high levels of information disclosure can have an adverse effect on the banking sector. Since the banks operate in a second-best environment with opaque risks that are difficult to verify, they may incline to inefficient solutions that help them improve their immediate capitalization and thus pass the test. They claim that the banks should not have access to the full methodology to prevent them from preparing themselves for the stress test and that a disclosure of only the aggregate results (as opposed to bank-by-bank results) should be considered as a way to decrease this risk.

2.4 Hypotheses

This paper provides a broader empirical analysis of the impact of stress tests on banks' actual capitalization levels and risk profiles. Thanks to the construction of our models, we will provide an implicit test of some of the claims about the market reactions. Our aim, though, is mainly to test some new hypotheses that have not been scrutinized by the academic literature yet. In order to tackle this general issue, we decompose it into smaller components as stated in the following hypotheses:

> *H1: Stress tests force banks with worse results to increase their capitalization levels.*

There are two potential channels of transmission that could compel risky banks to increase their capitalization. The banks can adjust their capitalization levels based on direct acquisition of new information about the sector or due to to the pressure exerted by the authorities.

On the one hand, the results are unlikely to reveal relevant new information to the banks about themselves as their internal models and own sources provide data that are far more detailed. On the other hand, the banks have limited information about their competitors and potential counterparties, the overall state of the sector, and the amount of available capital. With the individual results published, banks can uncover fragility at the industry level or in one of their counterparties. In that case, they are incentivised to adapt to those new risks. This is in line with a survey by PricewaterhouseCoopers (2014) where most banks reveal that the results provide useful insights which could be used for decisions on the amount of risk taken by the banks.

Banks that achieved low levels of capitalization in the adverse scenario and thus found a lot of vulnerabilities would then try to remedy this state and counterweigh the new negative information that was revealed. Banks with high levels of capitalization, on the contrary, would be encouraged by the confirmed strong position and could either preserve or even increase their riskiness.

Secondly, through the stress tests the banks receive information about the authorities and their expectations. By specifying what is defined as "extreme but plausible variations in one or more risk factors" (EBA, 2011b, p. 45) the regulators uncover their forecasting results and the scope of possible downturn. Through setting capital adequacy limits they show what an acceptable capitalization in such a situation is. This helps the banks estimate the expectations of the authorities and puts pressure on

those that do not comply yet. In 2011 this principle was even institutionalized and the EBA tracked and commented on the results of the banks that did not pass or only passed barely (EBA, 2012).

On the other hand, Petrella and Resti (2013) show that the markets reacted to the results published after the 2011 stress test and rewarded banks that had higher levels of Core Tier 1 capital under the stressed scenario with abnormal returns. This would mean a comparative loss for the banks that scored lower and thus a decrease in capitalization. We, however, believe that the two former channels grasp the situation better and thus banks with worse results should increase their capitalization after the results disclosure.

Immediate changes in capitalization in reaction to the stress test results publication, however, are not the only possible channel of propagation. With the stress test announcements in advance and limited follow-up measures, the banks have space to prepare themselves and re-adjust the capitalization after the stress tests if that suits their strategies. To examine this case, following hypotheses are analyzed:

> *H2: Banks anticipate stress tests and adjust their risk profiles so that they achieve better result;*
>
> *H3: Banks reverse the adjustments afterwards.*

The motivation for this seemingly unreasonable conduct is public perception and marketing. Every bank that holds less than 100% of their deposits in reserves faces the risk of a bank run which may become a self-fulfilling prophecy. Jussim (2012) shows that in case of a negative signal about the bank's situation it is rational for depositors to withdraw their funds. Moreover, according to game theory model by Diamond and Dybvig (1983), it is rational to try and be among the first to withdraw the money and to do so even if one knows that the negative signal was in fact not truthful.

Therefore, in order to prevent such situation it is crucial to maintain an image of a strong and stable brand. Frandsen, Hiller, Traflet, and McGoun (2013) write in their study that for "money [to be] saved, customers must think that the bank is secure and their money will be there when they want it" and Bulsara, Desai, and Miniaoui (2015) identify safety, band perception, and risk appetite as three of the key factors influencing the depositors when they invest their money. Furthermore, globalization of the markets and increasing competition motivate banks to always present themselves as safer than their peers – and one of the most conspicuous comparisons

are stress tests where banks are scrutinized by the authorities based on common rules and unified scenarios of economic downturn.

That puts the banks in a situation well described by the prisoner's dilemma. Each of them is incentivized to try and have better results than the competitors. Since the situation is symmetrical, everybody increases capitalization but in the end nobody gets an edge over the competitors and everybody ends up worse off. Similar reasoning was presented in Goldstein (2013) who warns that banks can behave inefficiently while they try to 'game' the stress test by adjusting their exposures.

Although the initial intention of the banks is stabilization in this case, the ultimate situation would be one with increased volatility. With each stress test they would be pushed to temporarily decrease their risk to achieve better result. Finally, this situation could even lead to a chain reaction in which all the subjects are trying to get rid of risky assets which cause the assets to lose their value even faster and the last one suffers as it has a portfolio of illiquid assets whose price dropped massively.

The current consumer protection policies in Europe try to prevent such scenarios and calm the markets. The deposit insurance adopted after the crisis years by the EU grants each account holder coverage up to € 100 000 per bank within 7 days (European Commission, 2010). Consequently, importance of safety of the banks *per se* is probably not so important for most small depositors and banks do not need to fight so fiercely to please the depositors. On the other hand, the EU banking sector has been growing rapidly with its assets reaching as much as 334% of EU GDP and some argue that the individual countries responsible for bank resolutions are simply too small to fulfil such commitment (Pagano et al., 2014, p. 4).

But was it indeed possible for the banks to expect the stress tests in advance? At the least, for the 2010 stress test they had a month between the official announcements and the date from which the balance sheets were taken (balance sheet date). The exercise was officially announced on December 3rd and the balance sheet date was December 31st. For the 2011 exercise the announcement was delayed to January, which might have had an effect on this channel, but even in this case the banks could have followed the EU negotiations and some other signals that could help them predict the exercise. We hope to get further clarification of the situation from our results.

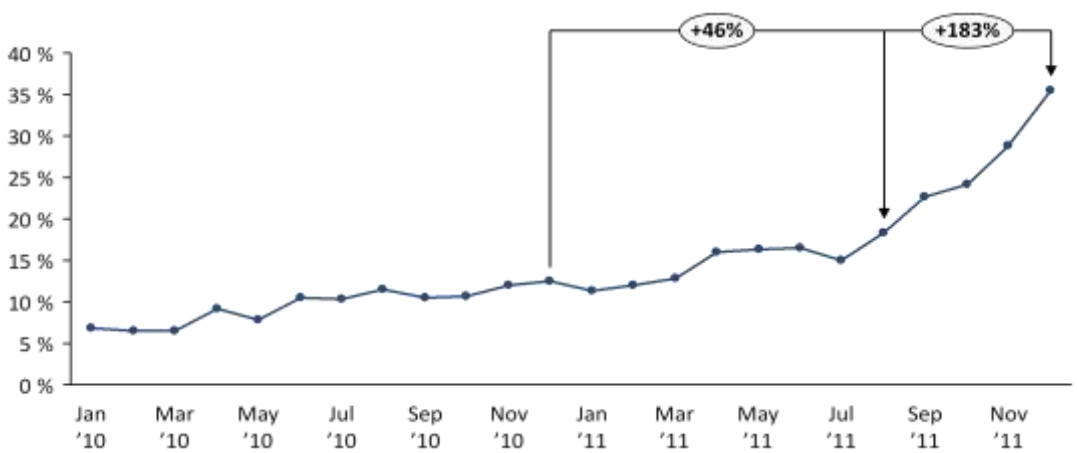
H4: The results of H1, H2, and H3 will be the same for both the 2010 and the 2011 stress tests.

Analyzing data from the two stress tests provides a valued opportunity to test the hypotheses separately for each of them and interpret the results in the light of their differences. Both of the stress tests were performed with only one year gap and on a very similar set of banks. Despite that, there are crucial technical and qualitative differences between the two cases which could potentially prompt differing reactions.

Firstly, the 2010 exercise only presented very humble amount of information about the results. One year later, thousands of data points for each bank including detailed exposures were revealed (Enria, 2011).

Secondly, the latter exercise could be seen as more strict. The already stressed scenario from the end of 2010 was intensified and the threshold was defined in terms of Tier 1 capital as opposed to Core Tier 1 capital[4] in year 2011 (EBA, 2011e). Despite that, some doubts have emerged, whether this tightening was sufficient. As Candelon and Sy (2015) point out it is not clear whether the scenarios reflected sufficiently the demise in market conditions where yields on Greek bonds were growing rapidly (by 46% between the date of stress test announcement and results publishing and by 183% annually as seen in Figure 1).

Figure 1: Greece government bond 10-year yields



Source: Bloomberg (2015).

Note: Figure displays closing values of the first day of each month.

[4] Core Tier 1 capital is based on the Capital Requirements Directive and is constructed by taking Tier 1 capital and deducting hybrid instruments including preference shares. Government support is recognized in Core Tier 1 capital. At the beginning of 2011 the deducted hybrid instruments accounted in total for 17% of Tier 1 capital for the stress tested banks.

In order to discern the effects of the first and second stress test, we will include separate variables for each of them in our models. Then, in case the hypotheses 1-3 are answered differently for the two exercises, we will seek whether some features of the bank reactions are based on the specifications of the stress test. That could help us understand the relationship more thoroughly and evaluate the potential impact of other changes to the qualitative and quantitative aspects in the future.

It is important to note that in this paper we use two notions interchangeably. Firstly, it is the level of capitalization and stress test results which, for the sake of this study, are called good in case of high values and bad in case of low values. Secondly, it is the riskiness of the banks (both to themselves and the markets). In this, we follow the regulatory point of view which is trying to achieve higher (better) capitalization to strengthen the market resilience and reduce both overall and individual risk (see e.g. Berger, Klapper, & Turk-Ariss, 2008; French et al., 2010; Greenspan, 2010).

The two factors that we omit through this simplification are: a) from bank's point of view, higher levels of capitalization do not necessarily mean 'better capitalization' owing to the fact that they limit liquidity creation and with it profitability (Diamond & Rajan, 2000); b) despite regulators extensively using regulatory capital ratios as a tool to mitigate risks, the link is still being disputed by some who claim that it may vary significantly among banks (Laeven & Levine, 2009) or even have the exact opposite impact (J. Blum, 1999).

3 Data & Methodology

3.1 Data

In order to provide reliable estimates, we collected data from a number of sources and we aimed to obtain the widest possible range of observations available at the date of writing. Crucial element which enables us to study the impact of stress tests are the results of the two exercises performed in the EU in years 2010 and 2011 by the EBA (until the end of the year 2010 known as the Committee of European Banking Supervisors). One more stress test predated the two (in 2009) but the results were not published and thus it could not be included in our study. Each of the two provides results for 91 banks (there were changes among the participating banks but the majority of the set remained the same). Although a range of data points was published (especially in 2011), our attention is primarily with the information on banks' capitalization levels during the over the adverse periods.

The 2010 stress test was announced in December 2009 and took place the following year with the results being published in July only 15 days after the methodological note was published. 91 major banks and banking groups from the EU participated, covering over 65% of EU banking sector in terms of total assets (CEBS, 2010c).

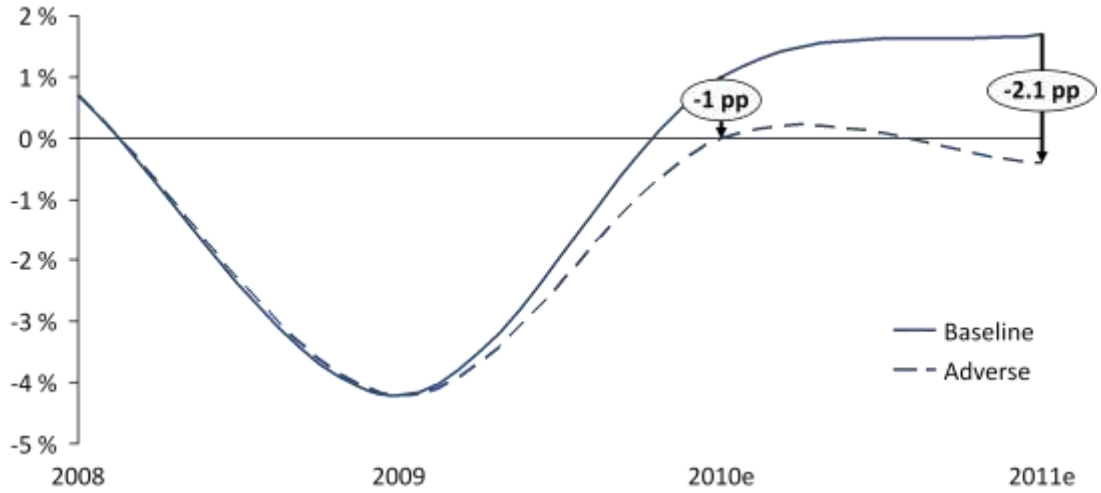
On top of the aim to scrutinize the sector resilience, it also focused on public support dependence and the ability to absorb further shocks on credit and market risks. The exercise was performed on a "bottom-up" basis, thus focusing on individual banks and not aggregating on the level of portfolios.

Main features of the adverse scenario were: a) general economic downturn, mostly pronounced by a total 3 percentage point decrease of GDP in EU over the two years compared to EC's predictions (Figure 2); b) worsening of overall market conditions as a result of sovereign shock and sovereign exposure valuation haircut (Figure 2).

With the adverse scenario causing total of 566bn € losses, average Tier 1 ratio decreased more than a percentage point over the two years from 10.3% to 9.2% which is, however, still above both exercise threshold 6% and minimum 4% required by the regulators at that time. The good average state is partly owed to 197bn € support capital from governments provided until July 2010 (CEBS, 2010d). Due to high differences among the individual entities, however, seven institutions failed to

maintain their Tier 1 capital above 6% over the two stressed years, totalling 3.5bn € shortfall (CEBS, 2010b).

Figure 2: GDP growth under adverse scenario, 2010



Sources: 2010 EU-wide stress test (CEBS, 2010b).

Table 1: Valuation haircuts to sovereign debt holdings, 2010

Country	Haircut value
Austria	5.6%
Belgium	6.9%
Cyprus	6.7%
Finland	6.1%
France	6.0%
Germany	4.7%
Greece	23.1%
Ireland	12.8%
Italy	7.4%
Luxembourg	6.9%
Malta	6.4%
The Netherlands	5.2%
Portugal	14.1%
Slovakia	5.0%
Spain	12.0%
Slovenia	4.2%
Denmark	5.2%
Sweden	6.7%
UK	10.2%
Czech Republic	11.4%
Poland	12.3%
Other non-euro area EU	11.8%
EU average	**8.5%**

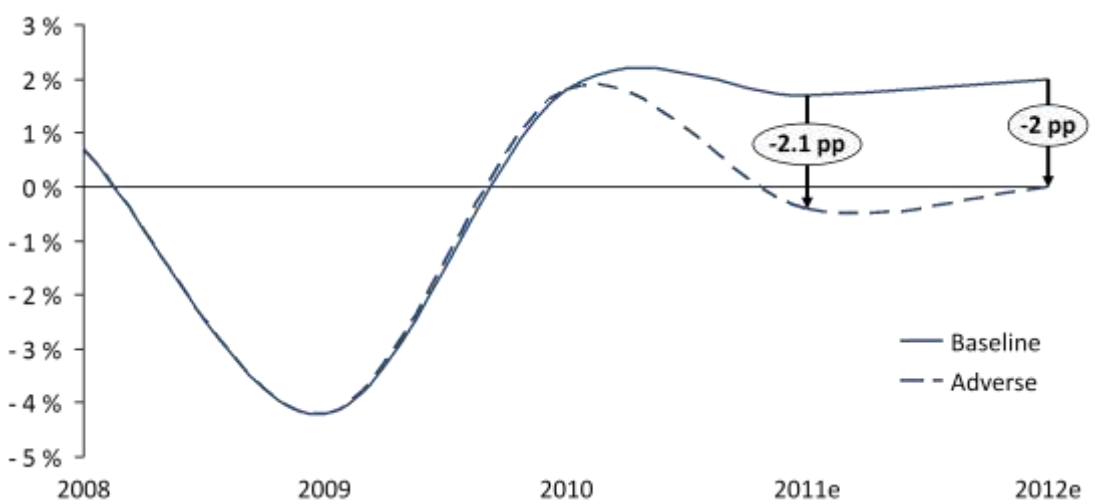
Sources: 2010 EU-wide stress test (CEBS, 2010b)

The second of the two exercises built extensively on the previous one, but as the EBA itself noted, "... [it] took into account areas where improvements compared to the 2010 exercise were deemed necessary as a result of a 'lessons learnt' analysis conducted by the EBA and all the involved authorities in the aftermath of the 2010 exercise" (EBA, 2011c, p. 2). It was announced in January 2011 with the results published in July, again covering 91 banks and banking groups and around 65% of total EU banking assets (Forssbaeck & Oxelheim, 2014).

The first change compared to the previous year is that the 2011 exercise introduced more stringent rules. Firstly, to isolate only the most liquid assets, the threshold was defined in more restrictive Core Tier 1 capital which is defined as "Tier 1 net of deductions of participations in financial institutions and ... hybrid instruments including existing preference shares" (EBA, 2011a, p. 27). The new 5% threshold is then consistent with the fact that Tier 1 capital was approximately 117% of Core Tier 1 capital during the exercise. Yet, the EBA stated that institutions scoring between 5% and 6% are still vulnerable and national authorities should take remedial steps to help strengthen their capital positions (EBA, 2011d).

The adverse scenario was again focusing primarily on credit, market, and sovereign risks. Through combination of EU shocks, global demand shock originating in the US, and USD depreciation EU GDP growth was expected to decrease by total 4 pp from the EC forecast compared to 3 pp previous year (Figure 3).

Figure 3: GDP growth under adverse scenario, 2011



Sources: 2011 EU-wide stress test (EBA, 2011b)

Average Core Tier 1 capital ratio decreased over the simulated two years from 8.9% in 2010 (including government support totalling 160bn €) to 7.7% in 2012. Eight banks failed to sustain their capital above the 5% limit and together amount to 2.5bn € shortfall. Sixteen more banks were categorized as 'barely passed' with the result between 5% and 6% (EBA, 2011a).

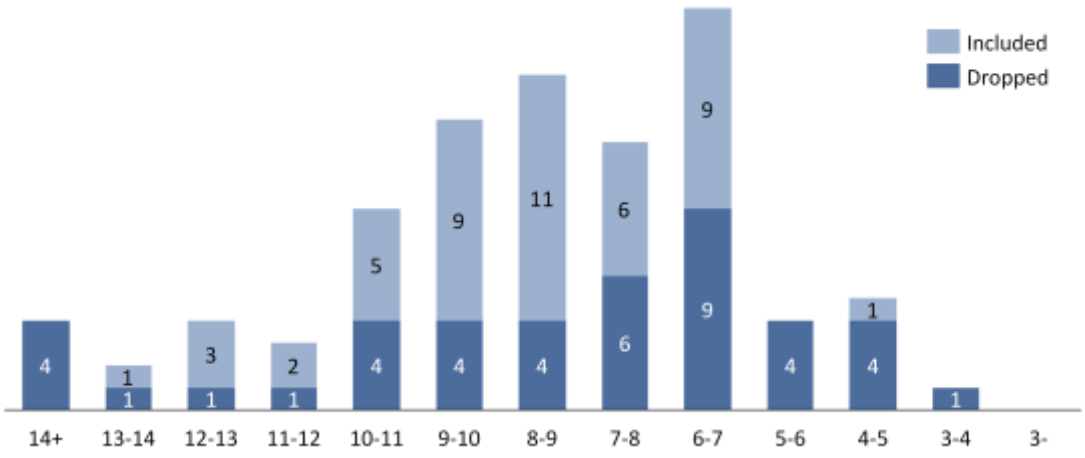
Apart from the stress test methodology, the 2011 exercise distinguished itself by one more feature – it served as a massive source of information. While in 2009 the results were not published at all and in 2010 only 149 data points per bank were released, in 2011 3,400 data points per bank were released in a unified format, with a clear intention to make their analysis as simple as possible.

Regarding the remainder of our dataset, the detailed information on each of the banks, their size, profitability, activities, and changes in regulatory capital were obtained from the BankScope database which provides the most comprehensive coverage concerning banks' financial statements. To accommodate the frequency and amount of missing values in BankScope, the final dataset that we use for our estimations spans over 5 years from first half of year 2009 to the second half of year 2013 with a 6-monthly frequency. By including observation before and after the stress tests we hope to avoid the risk of radical changes at the edges of the dataset which could negatively affect the results. Finally, information on macroeconomic conditions in the EU and the individual countries were retrieved from Eurostat.

The following estimations use data on 65 banks. Firstly, there are 48 banks that took part at least in one of the stress tests and for which the data on their financial statements are available and complete. Secondly, to account for trends within the industry which could potentially cause the type II error[5], we also include 17 institutions that did not take part in either of the exercises. To choose a relevant sample, we only consider banks that sustained total assets above 25bn € over the years 2009-2013 (that is the size of the smallest bank in our dataset that took part in at least one stress test). Also, seeking a control sample as close as possible to the banks that participated in the stress tests, we limit ourselves to those classified by BankScope in the following specializations: a) Savings bank, b) Specialized governmental credit institution, c) Cooperative bank, d) Commercial bank, and e) Bank holdings & holding companies.

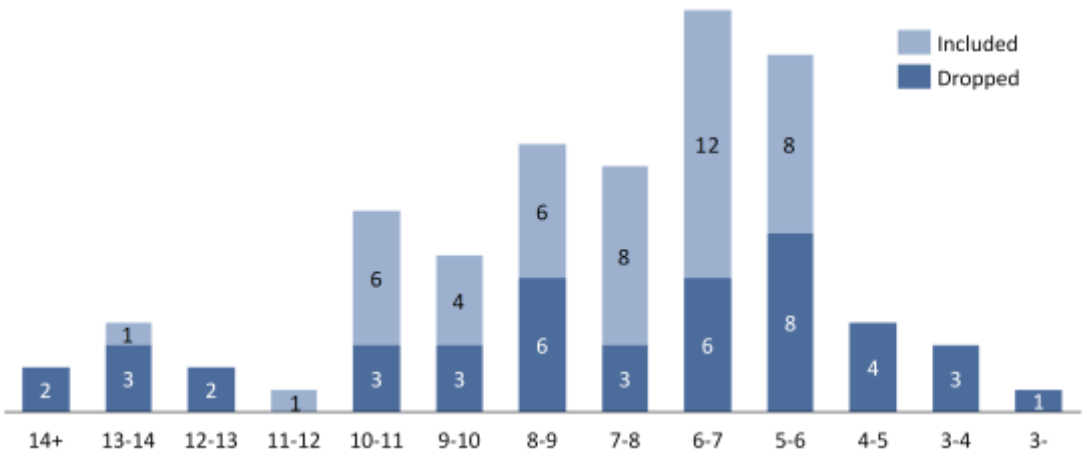
[5] Failure to reject a false null hypothesis.

Figure 4: # of banks by 2010 stress test result (Tier 1 capital ratio, %)



Sources: 2010 EU-wide stress test (CEBS, 2010a)

Figure 5: # of banks by 2011 stress test result (Core Tier 1 capital ratio, %)



Sources: 2011 EU-wide stress test (EBA, 2011d)

Note: The absolute values are not comparable for both figures, since the values are in Tier 1 capital ratio and Core Tier 1 capital ratio for the years 2010 and 2011, respectively.

Given the high number of banks that did not provide complete information over the whole period, we need to be cautious about pre-selection bias in the dataset. Especially smaller banks with extreme scores (either with very high capitalization or very low capitalization) had missing values in the dataset or went bankrupt over the period (see Figure 4 and Figure 5). Fortunately, due to the nature of the research this should not cause any bias. Firstly, smaller banks with critically low capitalization are less likely to have the capacity and flexibility to react adequately to outside incentives such as stress tests. Secondly, banks with high capitalization could ignore the results as they are already beyond a critical value where banks are considered to be completely safe and minimum capital requirements are thus not an active restriction.

Therefore, the inclusion of the extreme values in the sample could distort the results and their exclusion helps isolate the analyzed effect. On the other hand, we can expect that the results will suffer slightly due to decreased variation in the variables.

Finally, we had to perform minor changes in the dataset in order to negate the effects of significant one-off changes that could distort our estimates. Namely, there were several banks that took part in major restructuring deals which altered their risk profile and consequently required a one-off change in regulatory capital. Hypo Real Estate was recapitalized and nationalized by Germany (Buder, Lienemeyer, Magnus, Smits, & Soukup, 2011), Dexia sold its Luxemburg unit as a part of its resolution plan (Bodoni, 2012), Bank of Ireland sold its securities division to reduce exposures (Brennan, 2011), and Allied Irish Plc. and SNS Bank N.V. which were nationalized by the Irish government in 2011 and 2013, respectively (Enrich, 2011; Van Gaal & Van Der Starre, 2013). These extreme observations of capitalization change were replaced by the average of the change in the previous and following periods.

3.2 Methodology

In order to choose the optimal model specification which will provide efficient and unbiased estimates for our panel data, we will be choosing between Fixed Effects model (FE), Random Effects model (RE), and pooled Ordinary Least Squares model (p-OLS).

The most simple and straightforward selection would be the p-OLS. This is a preferred solution for cases where group specific effect is observed or only contains constant term in which case it produces results that are both consistent and efficient. The specificity of p-OLS is that it does not take into account the panel structure of the data and evaluates each data entry independently. Generally, though, p-OLS can be suboptimal as the results tend to be biased due to unaccounted for heterogeneity across the entities.

Indeed, as we have noted earlier, Laeven and Levine (2009) show that bank specific factors such as ownership structure can be significant in predicting the riskiness of banks. The proposition is also backed by our preliminary analysis which shows notable differences in bank reaction based on their specialization (Table 2). This could indicate that our model of choice is FE which is equipped to account for effects on the level of entity that could influence the estimated parameters. It assumes that the individual effects are time-invariant and uncorrelated with individual characteristics of other groups. That also means that the error term and intercept should not be correlated with between entities. Omitted variable bias is therefore not

an issue for time-invariant variables. Also, time-invariant variables cannot be estimated by FE but this is not our concern since they are not the focus of this paper.

On the other hand, if the individual variations are random and they are not correlated with the independent variables, we can obtain more efficient estimates with the RE as it does not require estimating of so many parameters.

After evaluating the advantages and disadvantages of each of the options, we select FE. This claim is also substantiated by the Durbin-Wu-Hausman specification test which confirms the selection of FE. Consequently, our results should now be unbiased, consistent, and unthreatened by the fixed characteristics of the individual entities. Since our panel is fairly short, the contemporaneous correlation is not a threat and thus we need not to worry. On the other hand, we find that our data suffer from heteroskedasticity, which we solve by using robust estimation.

Finally, a common problem for FE models called 'Nickell bias' causes the estimates to be inconsistent with increasing number of cross-sectional units while keeping number of periods constant (Nickell, 1981). In our case, however, we will disregard this threat for two reasons. Firstly, with 10 periods and 65 cross-sectional units the threat is not so severe as it depends on infinite growth of the cross-sections and secondly, some recent research is showing that the remedies can sometimes be more harmful that the problem itself (N. L. Beck, Katz, & Mignozzetti, 2014).

Due to the similarity of the problems in question and most of the dataset that we use for investigating the different questions, the choice of FE is valid for all of our estimations. Therefore, the choice of FE estimation with robust standard errors to account for heteroskedasticity in our sample will be utilized to study all our hypotheses.

Table 2: Capitalization change by institution type (average, pp)

	Bank Holding & Holding Comp.	Commercial Banks	Cooperative Banks	Specialized Gvt. Credit Inst.	Savings Banks
2010	0.34	0.41	0.18	1.75	0.34
2011	-0.48	0.00	0.39	-1.07	1.03

Sources: 2011 EU-wide stress test (EBA, 2011d), 2010 EU-wide stress test (CEBS, 2010a), BankScope (Bureau van Dijk, 2015).

Note: The number of banks in each category is 10, 23, 6, 6, 2 and 10, 23, 6, 5, 2 for year 2010 and 2011 respectively. Bank specializations are assigned according to the BankScope database.

4 Empirical Analysis

4.1 Immediate Reaction to the Stress Tests

So far, academic literature did not provide much evidence of whether stress tests influence banks' capitalization and risk levels. Moreover, factors affecting and potentially altering this relationship are also unknown. Previously, we have established two hypothetical links connecting immediate changes in bank capitalization to stress tests, specifically focusing on the effect of results of each bank.

Firstly, through obtaining direct information about the banking sector and its competition the banks counterweigh the newly discovered vulnerabilities uncovered by scoring lower than their peers. They do so by decreasing their riskiness either through decrease of RWA or increase in their (Core) Tier 1 capital, thus increasing bank capitalization. Secondly, the less capitalized banks are being punished for their results by the authorities who either explicitly through public monitoring or implicitly through revealing the stress test thresholds force them to adjust their capitalization to meet some minimal requirements.

To test this link, in this chapter we analyze our first hypothesis:

> *H1: Stress tests force banks with worse results to increase their capitalization levels.*

A simple preliminary analysis of the data does provide some evidence regarding our hypothesis. Figure 6 and Figure 7 show the relationship between bank result and capitalization change within a five month period. After dividing the banks into three groups based on their results in the adverse scenario and plotting mean values of change in capitalization, we see linear relationships with varying implications for each exercise. In 2010, the banks with the worst results have seen stable capitalization levels, while the rest of the rest of the banks, including non-participants in the stress test, were increasing their capitalization levels at 0.62-0.72 pp over six months. In 2011, while the banks with the worst results were still stable, the capitalization decreased for banks with better results. Therefore, the 2011 case partially supports our hypothesis.

Figure 6: Average capital ratio adjustments by bank results, 2010

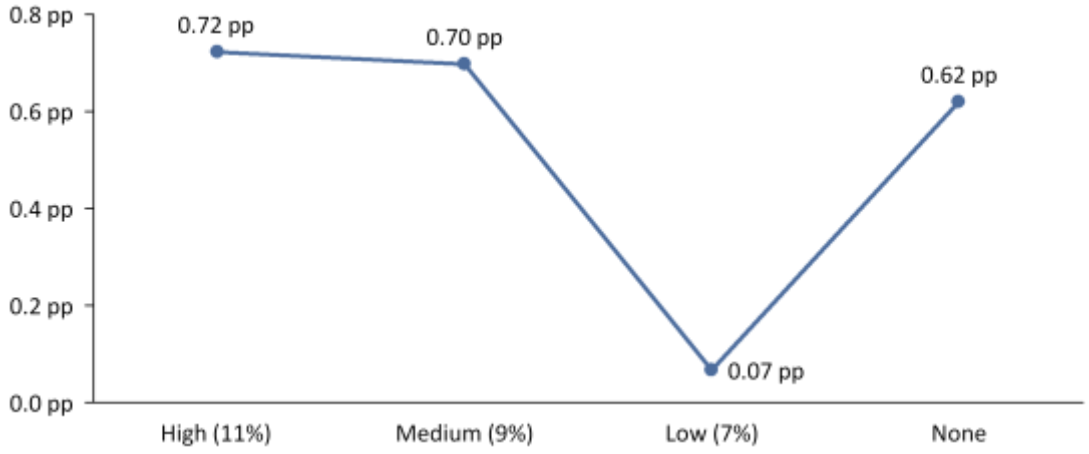
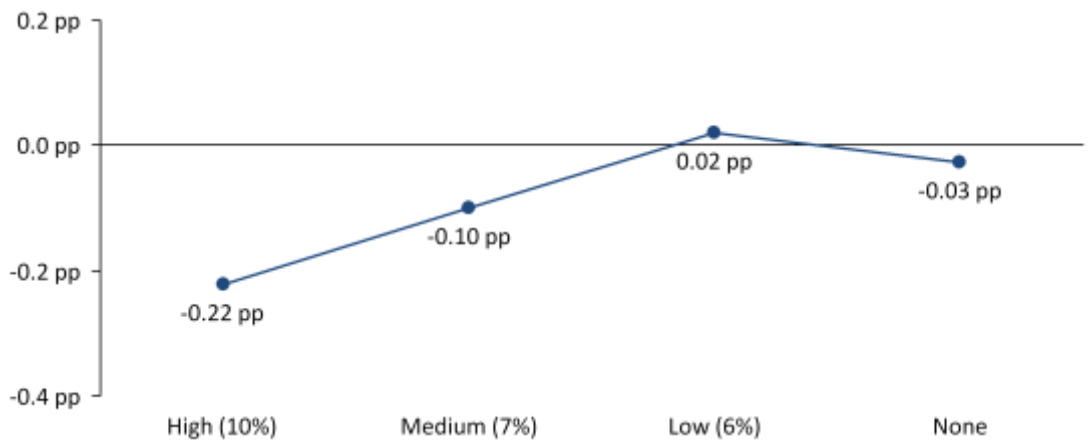


Figure 7: Average capital ratio adjustments by bank results, 2011



Sources:: 2010 EU-wide stress test (CEBS, 2010a), 2011 EU-wide stress test (EBA, 2011d), BankScope (Bureau van Dijk, 2015).

Note: The banks are divided into four groups. Three according to their capitalization levels under the stressed scenario with 33% banks with highest results in High, 33% with lowest capitalization in Low, and the remaining 33% in Medium. Fourth group represents banks that did not participate in the stress tests. Values in parentheses indicate group average capitalization under the stress test.

We can also draw some useful general insights that might help us understand the situation further. Firstly, within only one year we see a potential reversal of the relationship. This indicates either a severe change of market conditions or a potentially crucial impact of the several modifications in the stress test exercise. Secondly, while in 2010 the banks were improving their resilience (potentially still in reaction to the Great Recession), in 2011 we have seen declining on average (albeit slower than the previous increase). Thirdly, the one stable observed element is low or nil reactivity of banks with bad results.

Model

In order to determine the banks' reaction to the stress test results, as our dependent variable we choose the first difference of regulatory Tier 1 capital ratio (**ΔT1_ratio**) which is calculated as a change over the past 6 months in absolute terms. This selection was fairly straightforward, since it is widely used and the stress tests results are primarily presented and evaluated in terms of Tier 1 capital ratio[6]. Also, the measure is highly standardized among all institutions in the EU thanks to being the centrepiece of Basel regulations. To estimate impact of the stress tests, we use the following model:

$$\Delta T1\_ratio_{i,t} = \alpha + \beta_{2010}\mathbf{result\_2010}_i + \beta_{2011}\mathbf{result\_2011}_i + \gamma\mathbf{X}_{i,t} + \delta\mathbf{Y}_{i,t} + \varepsilon\mathbf{Z}_t + u_{i,t} \quad \textbf{(1)}$$

where *i* identifies the bank and *t* identifies time period with:

$$i = 1...65 \text{ and } t = 1...10.$$

In this model α, β_{2010}, β_{2011}, γ, δ, and ε are the estimated parameters and *u* is the error term. Our main focus lies with the first two vectors **result_2010** and **result_2011.** If we only used one variable denoting the result, however, a significant result might be caused by overall decrease of capitalization in banks that took part in the stress test, not by their good or bad results. Therefore, we split the two effects and include a separate variable for each of them. Firstly, we include dummy variables with value 1 for bank participating in the stress test in the given period and 0 otherwise (**part_2010** and **part_2011**). Secondly, we use variables indicating the relative positioning with respect to the median result (**result_2010_relative** and **result_2011_relative**). By definition, these variables will take on values from -0.5 for the bank with the worst score in the sample to 0.5 for bank with the best score in the sample. This will help us discern the two effects and provide deeper understanding of the impact. Furthermore, creation of separate variables for each stress test allows for the recognition of effects that only took place after one of the stress tests. It also enables us to seek causes for potential changes in these effects which we do in Hypothesis 4.

Based on our hypothesis, we expect **result_2010_relative** and **result_2011_relative** to be significant and negative, indicating that banks with better results did not

[6] The 2011 stress test was evaluated using a redefined measure Core Tier 1 ratio which is more restrictive but it constitutes 83% of Tier 1 capital. Therefore, any change in Core Tier 1 capital is transmitted to Tier 1 capital with minimal disturbance.

increase their capitalization as much as the banks with worse results. As our hypotheses only substantiate increase in capitalization by the low-scoring banks, we do expect the **part_2010** and **part_2011** variables to be significant and positive, representing the average shift.

X is a vector of bank specific variables. Owing to the fact that we are dealing with a FE model, the fixed bank specific characteristics are not included in the regression, which leaves us with only one variable. **Income** is defined as bank's net income over average total assets over the two quarters (in percentage). It is important we use the relative value since it helps us reveal the potential to replenish reserves. A bank with high ratio of income to assets can potentially retain earnings, does not need to rely on the capital markets, and thus enjoys higher flexibility and safety (does not need to hold so much capital).

Vector **Y** consist of country-level information on general macroeconomic conditions. The first included variable is GDP growth (**ΔGDP_home**) which represents the propensity of economic agents for intertemporal risk sharing. As Freixas and Rochet (1997) noted in their book, banks accumulate capital as a buffer for absorption of future shocks. In other words, we expect banks to 'save for the rainy days' when GDP is growing by increasing reserves and gradually dissolve the reserves when output is falling. The second variable is change in unemployment **ΔU_home** which can help the banks determine future of their portfolio before models such as VAR actually register any change in the default rates. We therefore expect that with growing unemployment the capitalization will be increasing, too.

Lastly, vector **Z** contains similar set of variables on the level of EU. Since European integration and market liberalization deepened the intra-EU relationships, we witness very high levels of interconnectedness with the share of internal trade reaching as high as 65% in 2010 (Eurostat, 2014). To grasp these relationships, we include two variables which generalize the national-level variables and indicate the macroeconomic conditions of the EU at any given period: **ΔGDP_EU** and **ΔU_EU.**

As a robustness check, in regression (3) we substitute our dependent variable for our own measure that is better equipped to deal with extreme values and outliers. This new variable is a discrete measure of change in Tier 1 capital ratio (**disc_ΔT1_ratio**) defined as presented in Table 3. By doing this, we decrease the influence of outliers that could have a significant impact in our sample where the variance is very limited (while normal business conditions lead to capitalization changes up to 2 pp, a change in bank strategy that our model does not account for could affect it by up to 10 pp). Also, this variable accounts for banks that might have disproportionately strong

reaction to some incentives to change capitalization. In this we follow Pasta (2009) who suggests that 'discretizing' a continuous variable can help discover non-linear relationships and provides a guide on how to proceed.

Table 3: discrete_ΔT1_ratio variable definition

Situation	ΔT1_ratio	disc_ΔT1_ratio	Obs. Total	2010	2011
Extreme increase	Higher than 2	3	49	4	2
Significant increase	1 to 2	2	105	10	4
Slight increase	0.5 to 1	1	151	21	12
Stable	-0.5 to 0.5	0	264	25	31
Slight decrease	-1 to -0.5	-1	45	2	8
Significant decrease	-2 to -1	-2	25	3	6
Extreme decrease	lower than -2	-3	11	0	2

Sources: 2011 EU-wide stress test (EBA, 2011d), 2010 EU-wide stress test (CEBS, 2010a), BankScope (Bureau van Dijk, 2015).

Note: 2010 and 2011 represent number of banks changing their Tier 1 capital in second periods of the respective years.

Results

First and foremost, using Model 1 we reveal that the banks that participated in the 2011 stress test did significantly decrease their capitalization levels within 6 months after the stress test publication (in comparison to other institutions that did not take part; reported in Table 4). Moreover, this finding is robust at a 1% significance level across multiple specifications using both the continuous and the discrete dependent variables. The same effect was not observed in the previous exercise where no significant difference between the participants and non-participants was discovered.

Our regressions did not reveal variations in reactions based on the relative performance of the participants. This result cannot be entirely generalized as we had to drop 17 out of 18 banks who failed the stress test due to data availability but it should hold for the remainder of the banks as it was robust across all specifications.

The findings produced by the regression therefore do not support our hypothesis and there is no evidence that the banks that scored low relative to their peers tried to 'catch up' or that they were forced to alter their risk profile by the authorities. While our hypothesis was not confirmed, there are three theories that are in line with the presented results. Firstly, as we argue in hypotheses 2 and 3, there are incentives for the banks to temporarily increase their capitalization for the stress testing period. The ensuing decrease then could manifest itself as an overall decrease in bank capitalization. This theory, however, will be tested more thoroughly in the next subchapter.

Table 4: Immediate reaction to the stress tests

	(1) ΔT1_ratio	(2) ΔT1_ratio	(3) disc_ΔT1_ratio
part_2010	0.08352	0.08352	0.08866
	(0.136)	(0.167)	(0.140)
result_2010_relative	0.52100	0.52100	0.23903
	(0.380)	(0.529)	(0.359)
part_2011	-0.67681***	-0.67681***	-0.79360***
	(0.205)	(0.170)	(0.239)
result_2011_relative	0.47872	0.47872	0.53237
	(0.810)	(0.551)	(0.806)
income	0.17273*	0.17273**	0.24476***
	(0.091)	(0.073)	(0.087)
ΔU_EU	-0.04488	-0.04488	1.33279
	(1.382)	(1.308)	(1.557)
ΔGDP_EU	2.28123	2.28123	3.50074
	(2.273)	(2.204)	(2.837)
ΔU_home	2.03168**	2.03168**	1.53322
	(0.874)	(0.899)	(1.056)
ΔGDP_home	-2.37454	-2.37454	-2.59228
	(2.030)	(1.954)	(2.425)
Observations	650	650	650
R-squared	0.039	0.059	0.055
Number of banks	65	65	65

Notes: Standard errors reported in parentheses. The model was estimated using fixed effects for each bank (within regression) with robust standard errors for regressions (1) and (3). Constants were included in the model but are not reported. Statistical significance at the 1%, 5%, and 10% level is indicated by ***, **, *, respectively.

Secondly, one of the channels of transmission that we have discussed is a signalling from the side of the authorities who inform the banks about their attitudes. When the stress test shows that the bank is not capitalized enough for the envisioned adverse scenario the authorities should take remedial steps to solve the problem and ascertain their authority. But as Ellahie (2013) noted, the actions of the EBA may have lacked decisiveness and thus revealed weakness of the authorities. The banks that participated in the stress test therefore experienced a situation when the regulators are not decisive enough to punish them for their mistakes. This would further promote risk-taking and enable the banks to decrease their capitalization.

Thirdly, suffering from the prolonged downturn after the Great Recession the markets had only little information about the banking sector. Unable to evaluate the quality of their counterparties' assets and their overall financial health, the stress test provided a benchmark and sufficient amount of data upon which the markets could build.

Thanks to the information disclosure, the exercise led to one of the first general reviews of the overall banking sector health. The counterparties, revealing that the exposures are more severe than previously expected (Ellahie, 2013), then punished the banks by a higher risk premium. As we have established earlier, this would lead to a shock followed by a decrease in profitability and capitalization. Even here, the discussed indecisiveness of the authorities could have affected the situation for the worse.

In the interpretation we gravitate mostly to the last theory. As is presented in our results the banks with higher income did not undergo such dramatic capitalization decrease. We see this as a sign that they had the means to partially or fully absorb an involuntary shock. If this argument holds, the two former theories are partially invalidated since they represent a deliberate decrease which the banks have no need to absorb. Also, the first two conclusions are contradictory to the findings of a survey performed by the PricewaterhouseCoopers (2014) where the banks themselves in 95% of cases report that the stress test results are never or very rarely used to change future strategy.

If this theory holds, the markets suffered to a large degree due to the regulators who put themselves into situation where they did not have enough decisiveness to carry out the implied obligations. Despite the negative impact our model discovered, however, there is a significant upside potential. The 2009 US SCAP exercise has proven that the markets can be stabilized by a stress test exercise if the scenario is relevant and the follow-up actions credible (Langley, 2013). Therefore, instead of producing more uncertainty, the stress test could potentially be a great tool to decrease it and fight situations such as credit crunch.

The authorities have means to prevent this situation in the future but they come at a cost. For example results could be presented on an aggregate level (or not at all) and not on a bank-by-bank basis. This would mitigate the adverse market reaction to the individual banks and decrease the negative impact. On the other hand, disclosure promotes discipline and monitoring by the public has been hailed on multiple occasions as very efficient (Barth, Caprio, & Levine, 2004, 2008; Beltratti & Stulz, 2012). This benefit would be lost.

4.2 Capitalization Adjustments in Anticipation of the Stress Tests and Their Reversal Afterwards

By focusing only on the reaction after the stress test, we risk missing some potentially significant relationships. There are indications that the banks could have learned about the tests in advance and adjust their capitalization *ex-ante* as discussed in the Hypotheses section. This would help them achieve better score through which the bank signals good health and stability. Especially at times of interbank uncertainty and lack of transparency due to large amounts of complex structured finance products in the banks' balance sheets this might be a valuable tool to calm the stakeholders. In turn, this action would help obtain cheaper liquidity due to decreased uncertainty of other banks and it would decrease the probability of market panic and bank runs.

The EU strives to mitigate such situations by providing safeguards, most notably the deposit insurance of 100 000 € per customer per bank. But with such a rapid growth of the banking sector as we have seen in the EU, it is not clear whether some countries would be able to fulfil this commitment (Pagano et al., 2014). Then the depositors would seek out and evaluate publicly available signals such as stress test results and the banks would be pushed to temporarily increase their capitalization. In the aftermath of the stress test this temporary elevation of the capitalization levels would become redundant because the short window of transparency would have expired. The banks would then return to their original equilibria with lower level of capitalization enabled by the lower transparency. To clarify the actual mechanisms we test the following hypotheses:

> *H2: Banks anticipate stress tests and adjust their risk profiles so that they achieve better result;*
>
> *H3: Banks reverse the adjustments afterwards.*

Brief look at the data offers some indication that the first of our two hypotheses might hold. When we divide banks according to their results into three groups, there is a weak distinctive pattern in 2010 to be recognized. We see that banks participating in the stress test increased their capitalization on average more than the non-participants. There is no stable relationship with regards to the future results of the banks. In 2010 we see that a group of banks that increased their capitalization the least is the one that eventually achieved the worst result. On the other hand, this relationship was entirely reversed in 2011. Similar instability can be observed for the group with medium results which saw the greatest capitalization increase in 2010 and

the lowest in 2011. The main finding that the participants have higher average increase in capitalization before the test, however, holds for the 2011 exercise, too.

Figure 8: Average *ex-ante* capital ratio adjustments by bank results, 2010

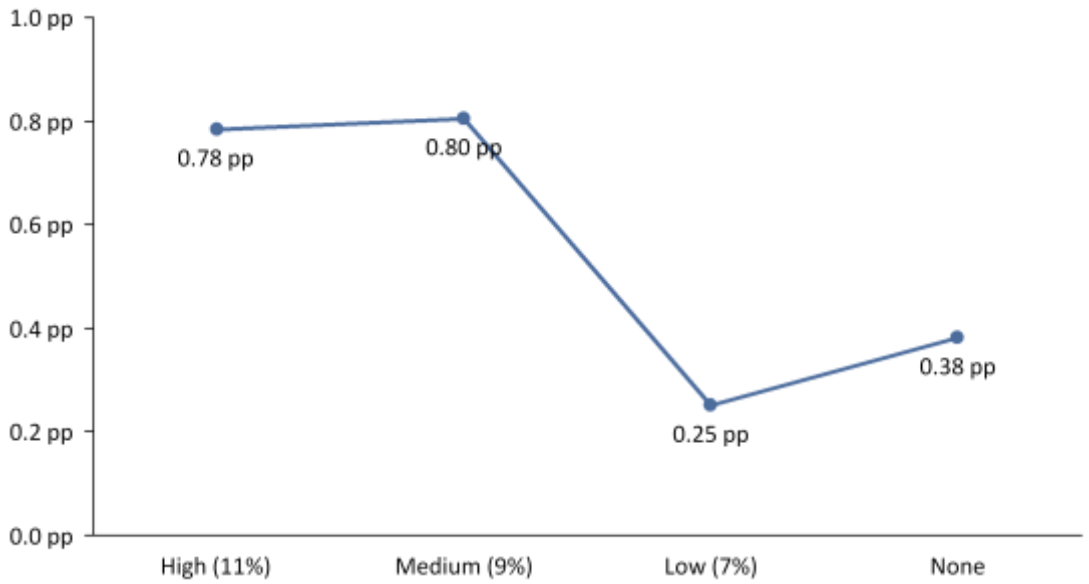
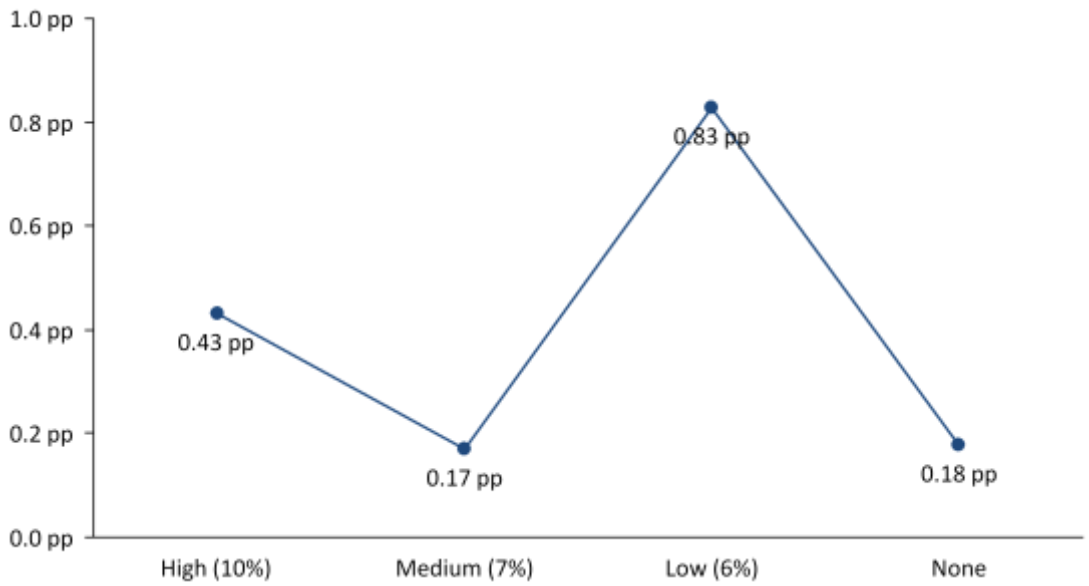


Figure 9: Average *ex-ante* capital ratio adjustments by bank results, 2011



Sources: 2010 EU-wide stress test (CEBS, 2010a), 2011 EU-wide stress test (EBA, 2011d), BankScope (Bureau van Dijk, 2015).

Note: Adjustments are over 6 month period between 1 Jul and 31 Dec prior to the balance sheet date. The banks are divided into four groups. Three according to their capitalization levels under the stressed scenario with 33% banks with highest results in High, 33% with lowest capitalization in Low, and the remaining 33% in Medium. Fourth group represents banks that did not participate in the stress tests. Values in parentheses indicate group average capitalization under the stress test.

Model

As our primary dependent variable we use change in regulatory Tier 1 capital ratio (**ΔT1_ratio**) due to its widespread use and codification. To check the robustness of our results in some of the regressions we substitute our dependent variable with a redefined discrete version (**disc_ΔT1_ratio**). Similarly to Model 1, the vectors **X**, **Y**, and **Z** containing the variables **Income**, **ΔGDP_home, ΔU_home, ΔGDP_EU,** and **ΔU_EU** are included in our model. With them, we are able to control for other effects potentially influencing the dependent variable such as the changes in home country/EU macroeconomic conditions and the ability of the bank to swiftly increase capitalization through retaining earnings. Notation also remains the same and α, β_{2010}, β_{2011}, γ, δ, and ε are the estimated parameters and u is the error term.

In Model 2 (reported in Table 5), we focus on H2 and include variables to determine how the banks' behaviour was affected by the future participation in the stress tests. In order to affect the results, the banks had to anticipate the stress test and make any changes in the second period of the previous year. Therefore we take two period leads of independent variables from Model 1, obtaining **part_2010_2lead** and **part_2011_2lead** (this variable is 1 for the to-be stress test participants in the period before balance sheet date and 0 otherwise). With these variables we will be able to determine, whether the expectation of participation in a stress test impacts the decisions about adjustments of Tier 1 capital ratio. Moreover, we will be able to differentiate between the two exercises thanks to including separate variable for each of them. Since the bank only knows whether it will participate but has no information about the future results, we do not include variables capturing its relative performance as opposed to Hypothesis 1. We obtain the following model:

$$\Delta T1\_ratio_{i,t} = \alpha + \beta_{2010}\, part\_2010\_2lead_i + \beta_{2011}\, part\_2011\_2lead_i + \\ + \gamma \mathbf{X}_{i,t} + \delta \mathbf{Y}_{i,t} + \varepsilon \mathbf{Z}_t + u_{i,t}. \qquad \textbf{(2)}$$

In Model 3 (reported in Table 6) we study whether any previous adjustments to the capitalization levels have been reversed after the short period of forced transparency passed (as the H3 proposes). To study this reversal, we use lags of variables denoting capitalization change in the periods prior to the balance sheet dates (**ΔT1_ratio_2010_lag**, **ΔT1_ratio_2011_lag**, **ΔT1_ratio_2010_2lag**, and **ΔT1_ratio_2011_2lag**). This variable is only defined for the stress test participants and is 0 otherwise. In other words, we try to reveal whether an *ex-ante* increase in capitalization was offset by an *ex-post* decrease in either of the two following periods:

$$\Delta T1\_ratio_{i,t} = \alpha + \beta_{2010}\mathbf{\Delta T1\_ratio\_lag}_i + \beta_{2011}\mathbf{\Delta T1\_ratio\_lag}_i + \\ + \gamma \mathbf{X}_{i,t} + \delta \mathbf{Y}_{i,t} + \varepsilon \mathbf{Z}_t + u_{i,t}. \quad \textbf{(3)}$$

With the current setup, however, in the second period of 2010 there are two effects at work: the reversal of the result from the 2010 exercise (**ΔT1_ratio_2010_2lag**) and the preparation for the 2011 exercise (**part_2011_2lead**). To verify our results and reconcile the two hypotheses we also provide Model 4 which contains both of them (reported in Table 7). This model will also serve as a robustness check for our results.

$$\Delta T1\_ratio_{i,t} = \alpha + \beta_{2010} part\_2010\_2lead_i + \beta_{2011} part\_2011\_2lead_i + \\ + \beta_{2010}\mathbf{\Delta T1\_ratio\_lag}_i + \beta_{2011}\mathbf{\Delta T1\_ratio\_lag}_i + \\ + \gamma \mathbf{X}_{i,t} + \delta \mathbf{Y}_{i,t} + \varepsilon \mathbf{Z}_t + u_{i,t}. \quad \textbf{(4)}$$

Results

Table 5 reports the estimates of our model focusing on bank *ex-ante* changes in capitalization. The results are not very surprising and provide some support for our hypothesis. We find that the coefficient for **part_2010_2lead** is positive which indicates that prior to the 2010 stress test the participating banks increased their capitalization on average by 0.36 pp more than the banks that did not participate. Multiple specifications of the model verify the robustness of this result (on 5%, 10%, and 5% significance levels). This observation has not re-emerged in a similar way in the 2011 exercise for which we do not find a significant difference between the capitalization change of the participating and non-participating banks.

This result shows that the motivation for banks to achieve good results in the stress tests even at the cost of producing inefficient portfolios is indeed an issue. If banks were to use this strategy consistently and extensively, this would be a serious threat to the stability of the banking sector since each stress test would induce capitalization swings translating to volatility in asset prices. Such conduct would also invalidate the stress test results and further harm the sector. This would be especially dangerous if the authorities were trying to use the stress test as a stabilization tool during turbulent times such as the 2009 US stress test which is commonly considered to be the benchmark for success (Candelon & Sy, 2015; Jobst et al., 2013).

Table 5: *Ex-ante* reaction to the stress tests

	(4) ΔT1_ratio	(5) ΔT1_ratio	(6) disc_ΔT1_ratio
part_2010_2lead	0.35922** (0.168)	0.35922* (0.187)	0.46050** (0.224)
part_2011_2lead	0.19430 (0.176)	0.19430 (0.172)	0.19163 (0.182)
income	0.18485* (0.093)	0.18485** (0.074)	0.25542*** (0.090)
ΔU_EU	-1.68793 (1.565)	-1.68793 (1.399)	-0.71843 (1.691)
ΔU_home	1.87168** (0.884)	1.87168** (0.904)	1.36736 (1.093)
ΔGDP_EU	-1.03405 (2.747)	-1.03405 (2.369)	-0.56739 (3.247)
ΔGDP_home	-2.30629 (2.147)	-2.30629 (1.977)	-2.45865 (2.549)
Observations	650	650	650
R-squared	0.036	0.036	0.035
Number of banks	65	65	65

Notes: Standard errors reported in parentheses. The model was estimated using fixed effects for each bank (within regression) with robust standard errors for regressions (4) and (6). Constants were included in the model but are not reported. Statistical significance at the 1%, 5%, and 10% level is indicated by ***, **, *, respectively.

Fortunately, the results show that this is not a persistent phenomenon and that did not repeat in 2011 where **part_2011_2lead** was positive but insignificant across all the specifications. That indicates that there are possibly efficient ways for the authorities to prevent this behaviour and prevent the unnecessary volatility. Since the hypotheses are not confirmed for the 2011 stress test, it is very unlikely that the underlying reason for the capitalization decline is caused by the banks artificially increasing and then lowering their riskiness.

Hypothesis 3 is tested by the regressions reported in Table 6 where the results again provide some support to this hypothesis. The theory that banks only increase their capitalization temporarily and reverse these adjustments after the stress test holds at 5% significance level for the 2010 stress test. This result is robust to changes of the dependent variable in regression (8) and (10) and inclusion of additional lags in the regressions (9) and (10).

Table 6: *Ex-post* reversal of the capitalization changes

	(7) ΔT1_ratio	(8) disc_ΔT1_ratio	(9) ΔT1_ratio	(10) disc_ΔT1_ratio
ΔT1_ratio_2010_lag	-0.39610**	-0.54189**	-0.43421**	-0.58940**
	(0.176)	(0.254)	(0.181)	(0.259)
ΔT1_ratio_2011_lag	0.09832	0.09320	0.01422	0.00906
	(0.189)	(0.232)	(0.187)	(0.239)
ΔT1_ratio_2010_2lag			0.05085	-0.03868
			(0.148)	(0.139)
ΔT1_ratio_2011_2lag			-0.88094***	-0.84282***
			(0.133)	(0.152)
income	0.21234**	0.28880***	0.20023**	0.28158***
	(0.102)	(0.099)	(0.096)	(0.095)
ΔU_EU	-0.86445	0.32153	-0.07860	1.05782
	(1.348)	(1.524)	(1.264)	(1.503)
ΔU_home	1.60568*	1.00763	1.35979*	0.75499
	(0.876)	(1.062)	(0.810)	(1.022)
ΔGDP_EU	0.76848	1.58058	1.65808	2.48443
	(2.105)	(2.660)	(2.026)	(2.571)
ΔGDP_home	-2.50074	-2.71901	-2.56393	-2.73974
	(2.147)	(2.559)	(2.108)	(2.508)
Observations	650	650	650	650
R-squared	0.041	0.052	0.043	0.054
Number of banks	65	65	65	65

Notes: Standard errors reported in parentheses. The model was estimated using fixed effects for each bank (within regression) with robust standard errors. Constants were included in the model but are not reported. Statistical significance at the 1%, 5%, and 10% level is indicated by ***, **, *, respectively.

We also find that the variable **ΔT1_ratio_2011_2lag** is significant at 1% level in regressions (9) and (10). Since there has not been a significant change specific to the tested banks prior to the 2011 exercise, we do not believe this is attributable to a reversal of a temporary change. Rather, it seems to signify a sector-wide decline in capitalization levels that previously increased significantly as seen in Figure 8. Therefore, we will not pay much attention to this result in the remainder of this paper.

Table 7 provides a robustness check for the previously presented results. We find that all variables except for one keep their significance levels. For **part_2010_2lead** the significance decreased to 20% after adding the second lag of capitalization change and remained at 5% without this change. Signs and magnitudes of the estimated coefficients remained mostly stable and no other major swings were observed.

Table 7: *Ex-ante* and e*x-post* changes in capitalization

	(11) ΔT1_ratio	(12) disc_ΔT1_ratio	(13) ΔT1_ratio	(14) disc_ΔT1_ratio
part_2010_2lead	0.33850**	0.43309**	0.16677	0.27063
	(0.163)	(0.216)	(0.150)	(0.209)
part_2011_2lead	0.16355	0.14720	0.01233	0.07543
	(0.181)	(0.183)	(0.139)	(0.198)
ΔT1_ratio_2010_lag	-0.37402**	-0.51930**	-0.42619**	-0.57614**
	(0.176)	(0.253)	(0.180)	(0.258)
ΔT1_ratio_2011_lag	0.09670	0.08859	0.01344	0.00856
	(0.194)	(0.236)	(0.188)	(0.240)
ΔT1_ratio_2010_2lag			0.06907	-0.04751
			(0.138)	(0.166)
ΔT1_ratio_2011_2lag			-0.86017***	-0.80784***
			(0.135)	(0.150)
Income	0.19785**	0.27220***	0.19454**	0.27254***
	(0.095)	(0.092)	(0.094)	(0.092)
ΔU_EU	-1.74442	-0.82867	-0.55399	0.30018
	(1.520)	(1.679)	(1.414)	(1.649)
ΔU_home	1.79148*	1.23613	1.45086*	0.90373
	(0.905)	(1.080)	(0.823)	(1.035)
ΔGDP_EU	-1.08789	-0.68047	0.83618	1.07074
	(2.670)	(3.210)	(2.418)	(3.010)
ΔGDP_home	-2.26499	-2.43739	-2.47712	-2.56349
	(2.217)	(2.609)	(2.150)	(2.547)
Observations	650	650	650	650
R-squared	0.044	0.047	0.099	0.081
Number of banks	65	65	65	65

Notes: Standard errors reported in parentheses. The model was estimated using fixed effects for each bank (within regression) with robust standard errors. Constants were included in the model but are not reported. Statistical significance at the 1%, 5%, and 10% level is indicated by ***, **, *, respectively.

4.3 Differences in Reaction to the 2010 and the 2011 Stress Tests

In the final part of our analysis, we scrutinize the differences in our results between the two stress tests. We identified two major factors that were altered within the year and that could impact the response of the markets. Firstly, the scenarios became more severe in the latter stress test while the passing mark remained effectively the same. Moreover, a zone where the banks are singled out and issued a warning has been put into place for banks that passed the test with a limited amount of capital above the

passing mark. At the same time, the literature also presents some doubts about the ability of the authorities to deal with the institutions that did not succeed and provide efficient solutions to the uncovered systemic issues (Candelon & Sy, 2015; Ellahie, 2013; Langley, 2013).

Secondly, information disclosure which was non-existent in the 2009 and only very limited in the 2010 stress tests became one of the most prominent aspects of the 2011 EBA exercise. This news revived a massive debate among the experts who try to assess whether the benefits of disclosure outweigh the costs in this case (Committee on the Global Financial System, 2000; Goldstein & Sapra, 2013; Goldstein, 2013).

> *H4: The results of H1, H2, and H3 will be the same for both the 2010 and the 2011 stress tests.*

Results

In our empirical analysis we have discovered two significant channels worth discussing. Each of them, however, only affected the banks in one of the stress tests. Firstly and uniquely to 2010, Models 2-4 revealed that the participating banks experienced an increase to their capitalization before the stress test and a reversal of this change just after the data were handed over to the authorities (results reported in Table 7). Secondly and uniquely to 2011, Model 1 shows that there was a significant decrease of capitalization for banks that participated in the stress test, regardless their results (reported in Table 4). But why did these results not emerge in both exercises?

In the first case, we suspect that the difference was caused by the fact that the banks were not able to duly and reliably determine whether the stress test will take place in 2011. That was caused by the fact that the balance sheets used were from the end of the year, while the exercise was announced one month later in January. On the other hand, one year earlier the 2010 exercise was already announced on the 3rd December.

Moreover, there are few pieces of information indicating that the banks did have a reason to expect them even earlier. Following the 2009 stress test results presentation to the Economic and Financial Affair Council of the EU in October, discussion on the EU level ensued and resulted in the Council calling upon CEBS for "[i]nformation, through stress testing, on the dependence of EU banks on public support and on the amount of capital available for further lending in the context of exit strategies (Council of the European Union, 2009a, p. 16)". We believe that this discussion could have served as a warning to the banks. On top of that, earlier in 2009 there were some signals that the first CEBS exercise might repeat very soon. The Council of the European Union (2009b) concluded that stress tests should be repeated

regularly and specifically envisioned one in 2010. Moreover, the success of the US SCAP revealed the potentially positive effect in case the results are published on a bank-by-bank basis.

For the 2011 stress test, on the other hand, we did not find similar early indicators. Despite a calming effect of the 2010 exercise on the markets (Candelon & Sy, 2015) it failed to repeat the US success and proved that stress testing is not a panacea. Further, we found no documents that would imply another stress testing exercise in the 2011 so strongly and early as it happened in the previous year. And finally, the official announcement took place later. The banks, therefore, did not have a reason to expect another round of testing.

In this regard, we evaluate the EBA's behaviour positively as we see a fast reaction (postponing the announcement) which prevented these temporary adjustments and unnecessary volatility. Moreover, this strategy was used again in 2014 with announcement of the stress test at the end of January. This indicates that the EBA, despite the large amount of criticism, is at least partially successful in their effort to systematically improve the exercises.

In the second case, we argue that there were two factors contributing to the negative market reaction and following capitalization levels demise in 2011 (Table 4). Firstly, Candelon and Sy (2015) note that despite the overall tightening of the conditions the adverse scenarios did not reflect the rapid worsening of the market conditions sufficiently (especially driven by the skyrocketing Greek bond yields). Similar concerns were raised by Jenkins and Murphy (2011), who consider the lack of the inclusion of Greek sovereign default to be a repeated error, and Alloway (2011), who points out that the adverse scenario was still much less strict that the one applied in the UK stress test.

The exercise was then further undermined by a massive bailout to Dexia which was at the brink of bankruptcy (Peston, 2011). Dexia came in joint 12^{th} place out of 91 participants with more than double the minimal required capital under the adverse scenario. The 90bn € capital injection only three months after the bank was labelled healthy by the results of the 2011 stress test was then the final blow to the credibility of the exercise.

Secondly, the exercise lacked an action plan on how to deal with the banks that fail or nearly fail the stress test. Contrary to the 2009 US stress test, apart from recommendations to the national authorities there was no specific commitment or recapitalization plan in place (Candelon & Sy, 2015; Ellahie, 2013). This was not

specific to the 2011 stress test only, but in combination with the aforementioned lack of credibility it further destabilized the banking sector.

The overall image was then that of an exercise which is very costly, too mild to uncover the issues that might realistically appear and lacking the decisiveness to deal with the problems that eventually might come up.

We derive several lessons from this result. The severity of the adverse scenario should be evaluated strictly on the future projections of the markets and taking into account all options, even if they are 'politically difficult'. Evaluating the severity in comparison to the previous exercise is therefore not sufficient to capture the real market conditions.

The authorities should have a credible, well-defined back-up plan. In case any serious problems are discovered, the authorities should have a strategy and sufficient resources to solve them efficiently and ensure the markets that they have the situation under control. In 2011, we have seen neither of these. Specification of reaction to the results was vague (a 'recommendation to the national authorities') and the individual countries were supposed to discipline banks that were in some cases simply too large and important for them.

If we go back to one of the definitions of macroprudential stress testing, the objective specified by CEBS is to "assess the overall resilience of the EU banking sector and the banks' ability to further absorb possible shocks ... (CEBS, 2010e, p. 1)". In the light of our results, we agree with the definition but it seems that CEBS/EBA did not fully recognize one simple fact. The authorities are an integral part of the banking sector. If the authorities outline simple and efficient rules, the sector benefits from higher stability and less uncertainty. If the rules are confusing and the markets are not certain that they will be enforced, uncertainty grows and stability declines.

Stress tests do not simply reveal fragility in the banks' balance sheets – they also reveal the quality of the regulation on the market. It is not only about the quantitative and technical parameters of the exercise but also about the overall strength and commitment of the authorities. Consequently, if a stress test is to be performed successfully, the authorities must also be prepared to bear significant costs.

The most fitting theoretical foundation explaining the importance of this phenomenon is probably presented by the institutional economics. As Buchanan (1987) noted in his speech: "[c]learly, the differing institutional structures may, themselves, affect choice behavior." Therefore, the market outcome is not only determined by the

conditions and choices of the individual banks. It is also heavily influenced by the rules within which the banks operate and the institutions that govern them.

Finally, decreasing the information disclosure level would not necessarily eliminate this threat. If the authorities conduct a stress test without publishing any results, the markets still expect them to remedy any problems. If no action is undertaken and some of the banks fail just few months later, this is again a signal (albeit weaker) that the banking sector is not regulated efficiently.

With the presented evidence we reject our fourth hypothesis. Despite only a very short time period between the both tests and no dramatic changes to the methodology, we find that the reactions differed substantially. We believe the change was based on the fact that the EBA strives to derive valuable lessons and improve the methodology, but the fast moving market conditions present it with ever new challenges.

5 Conclusion

In this thesis, we examine whether macro stress tests conducted by national and international authorities impact risk profiles of the tested banks. Specifically, we focus on the 2010 and 2011 exercises performed in the EU by the CEBS/EBA and test how they impacted the banks' capitalization levels. Our results suggest a significant impact on capitalization dependent on the stress test execution.

Firstly, we find that in 2010 the banks tried to decrease their risk levels just before the stress tests and reverse these adjustments afterwards to present themselves as safer institutions to their stakeholders. In this, we empirically substantiate some previously raised theoretical concerns.

This behaviour is a token of competitive behaviour and could help decrease the probability of a run for the individual bank. On the other hand, we believe that the symmetricity of the situation resulted in a state of artificial volatility where everyone is worse off. Fortunately, we registered an improvement in 2011, where this effect disappeared. We attribute this change to the fact that the stress test announcement was postponed and there was no timely and reliable enough indication that the 2011 exercise will take place.

Secondly, we find a significantly negative impact of the 2011 stress test on the capitalization levels of the participating banks compared to the non-participants. We believe that the decrease was caused by the inability of the regulators to present a relevant scenario and credible commitment to solving the issues that could arise from the exercise. By performing the exercise, rather than injecting the markets with confidence like the US 2009 SCAP exercise did, the EBA destabilized them. This increased the cost of funding which further translated to losses and decreased capitalization of the banks.

In view of this information, we conclude that stress tests do not simply test the resilience of the banks' balance sheets but also the ability and capacity of the authorities to act when needed. The authorities should therefore recognize this responsibility and only perform stress tests when their financial and political capacity allows it.

Finally, a comparison of the two exercises shows that despite their quick succession and methodological similarity the impact on capitalization levels of the participating banks was vastly different. Therefore, we argue that even minor changes in execution – both qualitative and quantitative – can be crucial to the overall success of the exercise.

Since this is the first paper empirically analyzing the link of stress testing and bank riskiness, we offer two ways to extend it. The first and the more straightforward one is inclusion of other stress tests from around the world to verify the robustness of our results. The second one is a case study focusing on the differences between stress tests which would help determine more accurately the triggers of the individual channels.

Bibliography

Admati, A. R., Demarzo, P. M., Hellwig, M. F., Pfleiderer, P., Acharya, V., Adrian, T., … Vermaelen, T. (2010). *Fallacies, Irrelevant Facts, and Myths in the Discussion of Capital Regulation: Why Bank Equity is Not Expensive* (No. 86).

Agoraki, M.-E. K., Delis, M. D., & Pasiouras, F. (2011). Regulations, competition and bank risk-taking in transition countries. *Journal of Financial Stability*, *7*(1), 38–48.

Alloway, T. (2011). Standard & Poor's speak the truth on Europe's stress tests. *Financial Times*, *May*(18).

Altman, E. I., & Saunders, A. (2001). An analysis and critique of the BIS proposal on capital adequacy and ratings. *Journal of Banking & Finance*, *25*(1), 25–46.

Baradaran, M. (2014). Regulation by hypothetical. *Vanderbilt Law Review*, *67*(5), 1247–1326.

Barth, J. R., Caprio, G., & Levine, R. (2004). Bank regulation and supervision: what works best? *Journal of Financial Intermediation*, *13*(2), 205–248.

Barth, J. R., Caprio, G., & Levine, R. (2006). *Rethinking Bank Regulation: Till Angels Govern*. New York, NY: Cambridge University Press.

Barth, J. R., Caprio, G., & Levine, R. (2008). Bank Regulations are Changing: For Better or Worse? *Comparative Economic Studies*, *50*(4), 537–563.

Barth, J. R., Caprio, G., & Levine, R. (2012). *The evolution and impact of bank regulations* (No. 6288).

Barth, J. R., Caprio, G., & Levine, R. (2013). *Bank Regulation and Supervision in 180 Countries from 1999 to 2011* (No. 18733).

BCBS. (2002). *Quantitative impact study 3. Technical Quidance* (Vol. 44). Basel.

BCBS. (2004). *International Convergence of Capital Measurement and Capital Standards: A Revised Framework*. Basel.

BCBS. (2005). *Amendment to the Capital Accord to incorporate market risks*. Basel.

BCBS. (2009). *Principles for Sound Stress Testing Practices and Supervision*. Basel.

BCBS. (2011). *Basel III: A global regulatory framework for more resilient banks and banking systems*. Basel.

BCBS. (2014). *Basel III: Monitoring Report*. Basel.

Bebchuk, L. A., & Spamann, H. (2010). Regulating bankers' pay. *Georgetown Law Journal*, *98*(2), 247–287.

Beck, N. L., Katz, J. N., & Mignozzetti, U. G. (2014). Of Nickell Bias and its Cures: Comment on Gaibulloev, Sandler, and Sul. *Political Analysis*, *22*(2), 274–278.

Beck, T., Demirguc-Kunt, A., & Levine, R. (2006). Bank supervision and corruption in lending. *Journal of Monetary Economics*, *53*(2006), 2131–2163.

Beltratti, A., & Stulz, R. M. (2012). The credit crisis around the globe: Why did some banks perform better? *Journal of Financial Economics*, *105*(1), 1–17.

Berger, A. N., Klapper, L. F., & Turk-Ariss, R. (2008). Bank Competition and Financial Stability. *Journal of Financial Services Research*, *35*(2), 99–118.

Bischof, J., & Daske, H. (2012). *Mandatory supervisory disclosure, voluntary disclosure, and risk-taking of financial institutions: Evidence from the EU-wide stress-testing exercises*.

Bloomberg. (2015). Greece government bond 10-year yields.

Blum, J. (1999). Do capital adequacy requirements reduce risks in banking? *Journal of Banking & Finance*, *23*(5), 755–771.

Blum, J. M. (2002). Subordinated debt, market discipline, and banks' risk taking. *Journal of Banking & Finance*, *26*(7), 1427–1441.

Blum, J. M. (2008). Why "Basel II" may need a leverage ratio restriction. *Journal of Banking & Finance*, *32*(8), 1699–1707.

Bodoni, S. (2012). Dexia Sale of Luxembourg BIL Unit Approved by EU Regulators. Retrieved April 1, 2015, from http://www.bloomberg.com/news/articles/2012-07-25/dexia-sa-sale-of-luxembourg-unit-approved-by-eu-regulators

Brennan, J. (2011). Bank of Ireland Agrees to Sell Burdale Division to Wells Fargo. Retrieved April 1, 2015, from http://www.bloomberg.com/news/articles/2011-12-19/bank-of-ireland-agrees-to-sell-burdale-division-to-wells-fargo

Buder, M., Lienemeyer, M., Magnus, M., Smits, B., & Soukup, K. (2011). The Rescue and Restructuring of Hypo Real Estate. *Competition Policy Newsletter*, (3), 41–44.

Buch, C. M., & DeLong, G. (2008). Do weak supervisory systems encourage bank risk-taking? *Journal of Financial Stability*, *4*(1), 23–39.

Buchanan, J. M. (1987). The Constitution of Economic Policy. *American Economic Review*, *77*(3), 243–250.

Bulsara, H. P., Desai, H. A., & Miniaoui, H. (2015). An exploratory study of consumer demeanor towards financial investment. *Investment Management and Financial Innovations*, *12*(1), 124–133.

Burakov, D. V. (2014). Limited liability problem, bank capital and credit cycles: A behavioral economic approach. *Middle - East Journal of Scientific Research*, *21*(1), 28–32.

Bureau van Dijk. (2015). Bankscope.

Candelon, B., & Sy, A. N. R. (2015). *How Did Markets React to Stress Tests?* (No. WP/15/75).

Carosio, G. (2009). Introduction. In M. Quagliariello (Ed.), *Stress-testing the Banking System: Methodologies and Applications* (pp. xxi–xxii). New York, NY: Cambridge University Press.

CEBS. (2010a). 2010 EU-wide stress test results. Retrieved December 12, 2014, from https://www.eba.europa.eu/risk-analysis-and-data/eu-wide-stress-testing/2010/results

CEBS. (2010b). *Aggregate outcome of the 2010 EU wide stress test exercise coordinated by CEBS in cooperation with the ECB.*

CEBS. (2010c). *CEBS'S Press release on state of play with the 2010 EU-wide stress testing exercise*.

CEBS. (2010d). *CEBS's Press release on the results of the 2010 EU-wide stress testing exercise*.

CEBS. (2010e). *CEBS's Statement on key features of the extended EU-wide stress test*.

Cerutti, E., & Schmieder, C. (2014). Ring fencing and consolidated banks' stress tests. *Journal of Financial Stability*, *11*, 1–12.

Cihak, M., Demirguc-Kunt, A., Peria, M., & Mohseni-Cheraghlou, A. (2012). *Bank regulation and supervision around the world: a crisis update* (No. 6286).

Cirasino, M., & Garcia, J. A. (2008). *Measuring Payment System Development*. Washington, DC.

Committee on the Global Financial System. (2000). *Stress testing by large financial institutions: Current practice and aggregation issues*. Basel.

Council of the European Union. (2009a). 2981st Council meeting press release. Brussels.

Council of the European Union. (2009b). Council conclusions on strengthening EU financial stability arrangements press release. Luxembourg.

Crockett, A. (2011). What financial system for the 21st century? Basel.

Demirgüç-Kunt, A., & Detragiache, E. (2002). Does deposit insurance increase banking system stability? An empirical investigation. *Journal of Monetary Economics*, *49*, 1373–1406.

Diamond, D. W., & Rajan, R. G. (2000). A theory of bank capital. *Journal of Finance*, *55*(6), 2431–2465.

Dick, A. A. (2006). Nationwide Branching and Its Impact on Market Structure, Quality, and Bank Performance. *The Journal of Business*, *79*(2), 567–592.

EBA. (n.d.). EBA's role in stress testing. Retrieved May 1, 2015, from http://www.eba.europa.eu/risk-analysis-and-data/eu-wide-stress-testing

EBA. (2011a). *2011 EU-wide Stress Test Aggregate Report*.

EBA. (2011b). *2011 EU-wide Stress Test Methodological Note*.

EBA. (2011c). *Overview of the EBA 2011 banking EU-wide stress test*.

EBA. (2011d). *Results of the 2011 EU-wide stress test*.

EBA. (2011e). The EBA publishes details of its stress test scenarios and methodology. Retrieved April 4, 2015, from https://www.eba.europa.eu/-/the-eba-publishes-details-of-its-stress-test-scenarios-and-methodology

EBA. (2012). *Report on the fulfilment of the EBA recommendation following the 2011 EU-wide stress test*.

EBA. (2014a). Results of 2014 EU-wide stress test.

EBA. (2014b). The 2014 European Banking Authority EU-wide Stress Test. Retrieved May 1, 2015, from https://www.youtube.com/watch?v=bCBnr6Z3DXQ

Ellahie, A. (2013). Capital Market Consequences of EU Bank Stress Tests.

Enria, A. (2011). *Opening Statement - Publication of the 2011 EU-wide Stress Test Results*. London.

Enrich, D. (2011). Ireland's Banks Get Failing Grades. Retrieved April 17, 2015, from http://www.wsj.com/articles/SB10001424052748703806304576234180828120692

Etzioni, A. (2009). The Capture Theory of Regulations - Revisited. *Society*, *46*(4), 319–323.

European Commission. (2010). *Commission proposes package to boost consumer protection and confidence in financial services*. Brussels.

Eurostat. (2014). Eurostat Statistics.

Evans-Pritchard, A. (2009). Let banks fail, says Nobel economist Joseph Stiglitz. Retrieved April 1, 2015, from http://www.telegraph.co.uk/finance/newsbysector/banksandfinance/4424418/Let-banks-fail-says-Nobel-economist-Joseph-Stiglitz.html

Fama, E. (2014). American Enterprise Institute Annual Dinner 2014. Washington, DC: American Enterprise Institute.

Flannery, M. J., Kwan, S. H., & Nimalendran, M. (2013). The 2007–2009 financial crisis and bank opaqueness. *Journal of Financial Intermediation*, *22*(1), 55–84.

Forssbaeck, J., & Oxelheim, L. (2014). *The Oxford Handbook of Economic and Institutional Transparency*. Oxford: Oxford University Press.

Frandsen, A.-C., Hiller, T. B., Traflet, J., & McGoun, E. G. (2013). From money storage to money store: Openness and transparency in bank architecture. *Business History*, *55*(5), 695–720.

Freixas, X., & Rochet, J. C. (1997). *Microeconomics of banking* (2. ed.). Cambridge, MA: MIT Press Ltd.

French, K. R., Baily, M. N., Campbell, J. Y., Cochrane, J. H., Diamond, D. W., Duffie, D., … Stulz, R. M. (2010). *The Squam Lake report: Fixing the financial system*. *The Squam Lake Report: Fixing the Financial System*. Princeton University Press.

Furlong, F. T., & Keeley, M. C. (1989). Capital regulation and bank risk-taking: A note. *Journal of Banking and Finance*, *13*(6), 883–891.

García-Marco, T., & Robles-Fernández, M. D. (2008). Risk-taking behaviour and ownership in the banking industry: The Spanish evidence. *Journal of Economics and Business*, *60*(4), 332–354.

Gick, W., & Pausch, T. (2012). *Optimal Disclosure of Supervisory Information in the Banking Sector Optimal Disclosure of Supervisory Information in the Banking Sector*.

Goldstein, I. (2013). Disclosure of Banks' Stress-Test Results. *Public Policy Initiative*, *1*(6).

Goldstein, I., & Sapra, H. (2013). Should Banks' Stress Test Results be Disclosed? An Analysis of the Costs and Benefits. *Foundations and Trends in Finance*, *8*(1), 1–54.

Goodhart, C. a. E. (2006). A framework for assessing financial stability? *Journal of Banking & Finance*, *30*(12), 3415–3422.

Greenspan, A. (2010). The Crisis. *Brookings Papers on Economic Activity*, *2010*(1), 201–246.

Groenwegen, J., Spithooven, A., & van den Berg, A. (2010). *Institutional Economics: An Introduction*. New York, NY: Palgrave Macmillan.

Grossman, R. S. (2001). Double liability and bank risk taking. *Journal of Money, Credit and Banking*, *33*(2).

Guay, W. R. (1999). The sensitivity of CEO wealth to equity risk: An analysis of the magnitude and determinants. *Journal of Financial Economics*, *53*(1), 43–71.

Hakenes, H., & Schnabel, I. (2011). Bank size and risk-taking under Basel II. *Journal of Banking & Finance*, *35*(6), 1436–1449.

Heid, F. (2007). The cyclical effects of the Basel II capital requirements. *Journal of Banking & Finance*, *31*(12), 3885–3900.

Hellwig, M. (1995). Systemic Aspects of Risk Management in Banking and Finance. *Swiss Journal of Economics and Statistics*, *131*(4), 723–737.

Hoggarth, G., Reis, R., & Saporta, V. (2002). Costs of banking system instability: Some empirical evidence. *Journal of Banking & Finance*, *26*(5), 825–855.

Chen, C. R., Steiner, T. L., & Whyte, A. M. (2006). Does stock option-based executive compensation induce risk-taking? An analysis of the banking industry. *Journal of Banking & Finance*, *30*(3), 915–945.

Chortareas, G. E., Girardone, C., & Ventouri, A. (2012). Bank supervision, regulation, and efficiency: Evidence from the European Union. *Journal of Financial Stability*, *8*(4), 292–302.

Jenkins, P., & Murphy, M. (2011). Quality of Stress Test Disclosures a Mixed Bag.

Jobst, A. a., Ong, L. L., & Schmieder, C. (2013). *A Framework for Macroprudential Bank Solvency Stress Testing: Application to S-25 and Other G-20 Country FSAPs* (No. 13|68). *IMF Working Papers* (Vol. 13).

Jussim, L. (2012). *Social Perception and Social Reality*. *Social Perception and Social Reality: Why Accuracy Dominates Bias and Self-Fulfilling Prophecy*. Oxford University Press.

Laeven, L., & Levine, R. (2009). Bank governance, regulation and risk taking. *Journal of Financial Economics*, *93*(2), 259–275.

Laeven, L., & Valencia, F. V. (2012). *Systemic Banking Crises Database: An Update* (No. 12/163). *SSRN Electronic Journal*.

Langley, P. (2013). Anticipating uncertainty, reviving risk? On the stress testing of finance in crisis. *Economy and Society*, *42*(1), 51–73.

Lindquist, K.-G. (2004). Banks' buffer capital: how important is risk. *Journal of International Money and Finance*, *23*(3), 493–513.

Milne, A. (2002). Bank capital regulation as an incentive mechanism: Implications for portfolio choice. *Journal of Banking & Finance*, *26*(2002), 1–23.

Morris, S., & Shin, H. S. (2008). Financial regulation in a system context. *Brookings Papers on Economic Activity*, *2008*(2), 229–261.

Morrison, A. D., White, L., We, S., Diamond, D., Gianetti, M., & Marriotti, T. (2005). Crises and Capital Requirements in Banking. *American Economic Review*, *95*(5), 1548–1572.

Nickell, S. (1981). Biases in Dynamic Models with Fixed Effects. *Economica*, *49*(6), 1417–1426.

Pagano, M., Langfield, S., Acharya, V., Boot, A., Brunnermeier, M., Buch, C., … van den Burg, I. (2014). *Is Europe Overbanked?*

Pasiouras, F., Tanna, S., & Zopounidis, C. (2009). The impact of banking regulations on banks' cost and profit efficiency: Cross-country evidence. *International Review of Financial Analysis*, *18*(5), 294–302.

Pasta, D. J. (2009). *Learning When to Be Discrete : Continuous vs. Categorical Predictors* (No. 248-2009). *SAS Global Forum*. San Francisco, CA.

Peston, R. (2011). Dexia bank gets massive bailout. Retrieved May 1, 2015, from http://www.bbc.com/news/business-15235915

Petrella, G., & Resti, A. (2013). Supervisors as information producers: Do stress tests reduce bank opaqueness? *Journal of Banking & Finance*, *37*(12), 5406–5420.

PricewaterhouseCoopers. (2014). *Passing the stress test PwC survey on regulatory stress testing in banks*.

Quagliariello, M. (Ed.). (2009). *Stress-testing the Banking System: Methodologies and Applications*. New York, NY: Cambridge University Press.

Rakoff, J. S. (2014). The Financial Crisis: Why Have No High-Level Executives Been Prosecuted? *The New York Review of Books*, *January*(9).

Schaeck, K., Cihak, M., & Wolfe, S. (2009). Are competitive banking systems more stable? *Journal of Money, Credit and Banking*, *41*(4), 719–734.

Schuermann, T. (2014). Stress testing banks. *International Journal of Forecasting*, *30*(3), 717–728.

Spong, K. (2000). *Banking Regulation: Its Purposes, Implementation, and Effects* (5th ed.). Kansas City: Federal Reserve Bank of Kansas City, Division of Bank Supervision and Structure.

Steinhauser, G. (2014). European Banking Authority Releases 2014 Bank Stress-Test Scenarios. Retrieved April 1, 2015, from http://www.wsj.com/articles/SB10001424052702303939404579531160493328286

Taleb, N. (2007). *The Black Swan: The Impact of the Highly Improbable Fragility*. Random House Publishing Group.

Uhde, A., & Heimeshoff, U. (2009). Consolidation in banking and financial stability in Europe: Empirical evidence. *Journal of Banking & Finance*, *33*(7), 1299–1311.

Van den Heuvel, S. J. (2008). The welfare cost of bank capital requirements. *Journal of Monetary Economics*, *55*(2), 298–320.

Van Gaal, M., & Van Der Starre, M. (2013). SNS Nationalized in Netherlands After Real Estate Losses. Retrieved April 14, 2015, from http://www.bloomberg.com/news/articles/2013-02-01/sns-will-be-nationalized-after-losses-on-real-estate-loans

Wolff, G. B. (2011). *Is recent bank stress really driven by the sovereign debt crisis?* (No. 2011/12). Brussels.

Wolff, G. B., & Angeloni, C. (2012). *Are banks affected by their holdings of government debt?* (No. 2012/07). Brussels.

Yang, J., & Tsatsaronis, K. (2012). Bank stock returns , leverage and the business. *BIS Quarterly Review*, (March), 45–59.