Correlation between the 2014 EU-Wide Stress test and market based measures of systemic risk

Sonia Dissem*
Université de Lille - Skema Business School

Fréderic Lobez
Université de Lille

In this paper, we compare the EBA stress test results done in 2014 to market based measures of capital losses which are the Marginal Expected Shortfall (MES), the Systemic Risk Measure ($SRISK$) and the Delta Conditional Value-at-Risk ($\Delta CoVaR$). These measures allow us to estimate the expected capital shortfall in case of a crisis. Our sample uses 57 European banks over 22 countries. We find that $SRISK$ is the best predictor of systemic risk among the three systemic risk measures since it is the most correlated with stress test results. Furthermore, we focused on the realized outcomes (realized loss, realized return and realized volatility) and compared them to the 2014 EU stress test results.

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* Corresponding author: Mrs. Sonia Dissem, Univ. Lille - EA 4112 - LSMRC, F-59000 Lille, France
Email: sonia.dissem@univ-lille2.fr

1. Introduction

The 2007-2009 financial crisis has highlighted that legal frameworks vary considerably across countries. This lack of consistency, and in some cases total absence of legal framework for bank failure, has created big problems especially for banks that are systemic. The immediate result was a messy intervention by financial authorities in many countries, which caused an increase in public debt, leading to serious consequences for taxpayers. Therefore, stress tests are available to better regulate the banking system and to prevent the costs of the financial sector's distress (Hirtle et al., 2009; Acharya et al., 2010; Hanson et al., 2011). Authorities have always been conscious of the need to stress test banks. Indeed, since the financial crisis of 2007-2009, stress tests are considered as a standard tool implemented around the globe by regulators. Moreover, stress tests ensure the alertness of taxpayers; allow to restore market confidence and to have transparent assessments of banks' risks. Nowadays, it is necessary to ensure that the financial sector is sufficiently capitalized, even in a severe economic distress, in order to be able to intermediate firms' functions. In this paper, we consider stress tests done in the European Union in 2014. These stress tests are built by defining a hypothetical stress scenario by referring to shocks to financial and macroeconomic variables. The losses to assets on the balance sheet of banks that come from the translation of the adverse scenario are borne by equity capital. The capital ratios are used to evaluate the required capitalization of a bank. Indeed, capital ratios are necessary to determine which banks failed the stress test.

In order to estimate the expected capital shortfall, we don't only have regulatory stress tests of financial institutions, we also have market-based measures of capital losses of financial firms which are the Marginal Expected Shortfall (MES) constructed by Acharya et al. (2010), the Delta Conditional Value-at-Risk ($\Delta CoVaR$) of Adrian and Brunnermeier (2016) and the Systemic Risk Measure ($SRISK$) of Acharya et al. (2012) and Brownlees and Engle (2016).

The question that we explore here is the effectiveness and the efficiency of the 2014 EU wide stress test. From this main question, we can derive three underlying questions that we have studied in depth in the results section. The three underlying questions are the following: Do the required capital shortfalls of stress tests correspond to market implied capital Shortfall ($SRISK$)? Do the stress test projected losses correspond to market implied losses ($MV\ Loss$, MES and $\Delta CoVaR$)? Do the 2014 EU stress test results correspond to the realized outcomes (realized return, loss and volatility)?

Our motivations are related to the construction of the European banking regulation system. In addition, the emergence of systemic risk occurs at a time of low capitalization of the financial

sector. We focused on stress tests because stress tests do not serve the goal of macro prudential regulation as they should according to Acharya et al. (2014). For the same authors, there is a lack of robustness, severity and transparency. In addition, stress tests relying on Basel risk regulation are not sufficient. We also know that stress tests are periodic and limited by the applicability of the stress scenarios. Another important point is that the denominator of capital ratios (the risk-weighted assets) is an inconsistent measurement across banks because banks can manipulate this value. We should not also forget for the regulation issue the complexity of the economic regulation. The main technical issue is that the EBA bases its potential intervention by the stress tests results while there are other market measures that could be realized more frequently.

In order to achieve our objectives we have compared the 2014 EU-wide stress tests estimates with *V-Lab* estimates ($MV\ Loss$, $SRISK$ and$Vlab\ M_{LVGRs}$). The *Volatility Laboratory* (*V-Lab*) is a website[1] which gives real time measurement, forecasting and modeling of financial volatility and correlations for a wide range of assets. We will focus on the section of systemic risk analysis of world financials. We have compared the same stress tests estimates with other systemic risk measures (MES and $\Delta CoVaR$). For these comparisons, we have used the Spearman Rank Correlation between the 2014 EU stress tests projected losses and the $MV\ Loss$, MES and $\Delta CoVaR$, between the 2014 EU stress tests capital shortfalls and the $SRISK$ and between the 2014 EU stress tests projected ratios and the *V-Lab* ratio: $Vlab\ M_{LVGRs}$. Finally, we have used the Spearman Rank Correlation between the 2014 EU-wide stress tests and *V-Lab* outcomes with the realized outcomes of banks.

Our research is related to the paper of Acharya et al. (2014). They have compared the capital shortfall measured by regulatory stress tests to a benchmark methodology (the "V-Lab stress test"). Their main finding is that the ranking of financial institutions is not well correlated to the ranking of the "V-Lab stress test" when capital shortfalls are measured relative to RWA. The opposite is true when capital shortfall is a function of total assets. The limitations of this paper are related to the comparison's limitation to $SRISK$ and to the end of the stress scenario. So, our contribution is based on the focus on other market systemic risk measures which are MES and $\Delta CoVaR$. We believe that it is also interesting to focus on the baseline scenario to note if there is a financial stress. We believe that it is important to know if one of the market systemic measures or two of them or the three are correlated with stress test results. If a correlation exists, this means that we can avoid the costs of

[1] http://V-Lab.stern.nyu.edu/
Created by Robert Engle, Rob Capellini, Michael Robles and Hseu-Ming Chen

the construction of stress tests each two or three years and focus on and use more frequently the market systemic risk measures.

Our results show that stress tests are not efficient and their effectiveness is not well proved. Indeed, we find that when capital requirements are based on the size and leverage of banks, using the market capital shortfall ($SRISK$) is better than relying on capital shortfalls of stress tests. Moreover, we believe that using directly the market implied losses ($MV\ Loss$, MES and $\Delta CoVaR$) is better than using the stress projected losses since we have found that the correlation between both is high. In addition, we find that the estimated market returns ($LRMES$ and $Vlab\ M_{LVGRs}$) downloaded on 09/30/2014 are better predictors than the regulatory stress test estimated returns ($T1C\ return$, $T1CR$ and $T1LVGRs$) during the three years (2014, 2015 and 2016) of the six months realized returns computed between 09/30/2014 and 03/31/2015. It is the same when we compare the estimated market risk measure ($Vlab\ Risk\ Weight$) downloaded on 09/30/2014 and the regulatory stress test estimated risk measure ($EBA\ risk\ Weight$) for the six-month realized volatility computed between 09/30/2014 and 03/31/2015. Thus, we believe that using market measures of risk is essential. We also believe that market measures complement the arsenal of stress tests, making the use of the latter potentially less frequent and limited to banks that market measures would have been identified as sensitive.

The rest of the paper is structured as follows. In Section 2, we present macro prudential stress tests literature review. A critical analysis of these tools is presented in the same section. The data used are presented in Section 3. We compare the outcomes of stress tests and the systemic risk measures in Section 4 .We also compare stress test and *V-Lab* outcomes with the realized outcomes in Section 5. We make a robustness check in Section 6. We conclude in Section 7.

2. Stress tests literature review

In these recent years, many studies were related to stress tests and their market impact. Some of them are related to the information quality of stress tests. Morgan et al. (2010) found that the disclosure of US stress tests results under the Supervisory Capital Assessment Program (SCAP) in 2009 produced significant market reaction of stock prices.

They have also found that the market only reacted to stress tests clarifications and to the publications of stress test results. Another study by Quijano (2014) confirms that the US stress test SCAP 2009 results conveyed new information to market participants and thus reduced information asymmetries vis-à-vis US banks. A qualitative assessment, conducted by Hirtle et al. (2009),

concluded that the SCAP 2009 stress test process was seen as transparent and rigorous. Petrella and Resti (2013) found that the 2011 European stress test results significantly affected the market and are considered as a credible assessment tool which allows reducing bank opaqueness. Elhalie (2012) found that the disclosure of 2011 EU stress test results reduced information asymmetry. Borio et al (2013) criticized the state of art in macro stress testing by evaluating its strengths and weaknesses. They made five propositions two of them are that "*macro stress testing is a toolbox, not a single box*" and "*macro stress tests can greatly help in crisis management/ resolution...*"

Stress tests are considered as a modern tool to measure the deficiencies of bank's capital. So, they have a disciplinary virtue. As mentioned before, it is clearly a tool that allows a bank to detect early important changes in the risk structure, evaluate the stability of a bank during crises, and take preventive actions to ensure bank's viability and the whole economy sustainability during periods of crisis. In order to protect the solvency of a bank, it is important that bank's supervisory board and executive board make the right decisions to construct the best countermeasures.

From a macroeconomic point of view, the methodology used for the 2014 EU-wide stress test is tougher than the 2011 version. In addition, banks need to take into account losses on some government bonds in their banking books. So, this new version has clearly positive spots in comparison to the previous one.

Kapinos et al. (2015) have summarized the key benefits of stress tests into four points. First, it captures systemic risk; so it complements Basel capital regulation. Second, it may decrease asymmetric information between market participants and opacity of the banking industry. Third, it allows participants to stay aware of different adverse shocks. Fourth, it is a way to encourage banks to gather better data and participate in more robust risk management practices.

In the sense of Guttentag and Herring (1986), stress testing allowed risk managers and regulators to reduce disaster myopia. A lot of researchers agree that stress tests allowed improving governance within banks. Indeed, the quality of the data at the bank level is better than before the 2008-2009 crisis. Thus, bank executives have the ability to forward-looking risk management problems.

The main negative criticism that we can make concerning stress tests is the unrealistic scenarios (baseline and adverse) that could put the EU banks in unreality. We can compare these scenarios either when we take into account historical rates or when we take into account rates of US stress tests. In the first case, we can compare the projected unemployment rate of 12.2% in 2016 for the adverse scenario with the real unemployment rate in 2014 of 10.2%. We know that 12.2% is less

than the actual unemployment rate in Croatia, Spain and Greece[2]. So, the projected unemployment rates could be unrealistic. In the second case, for the Comprehensive Capital Analysis and Review (CCAR), in the US stress test, the equity prices are expected to decline by 50 percent whereas for the 2014 EU-wide stress test they are expected to decline only by 19 percent relative to the baseline scenario. The same for the commercial property prices which are expected to decline by 35 percent for the US CCAR and only by 15 percent for the EBA 2014 stress test. An interesting study done by the German institute ZEW[3] in 2014 reveals that when financial markets decline by 10%, EU banks are expected to generate 154 billion Euros of capital to meet a solvency ratio of 8%. So, in this case the ZEW institute was interested on focusing on other hypotheses not made by the ECB. We can conclude that risks can be underestimated. According to Breuer et al. (2012), the stress scenarios should be well designed and have three main characteristics: severity, plausibility and suggestiveness of risk-reducing action. But, there is a trade-off between severity and plausibility. Indeed, Drehmann (2009) found that in two-thirds of cases, the real crises were stricter than their projections.

Another important criticism is the static balance sheet assumption where the EBA didn't take into account the bank's ability to react to an adverse situation. We know that in US and UK, the dynamic balance sheets hypothesis was applied. Some analysts also criticized the fact that the EBA stress test exercise is mainly focusing on history rather than future.

Many researchers have argued that for stress test results; the total assets should be taken into account to compute the leverage ratio and not to the risk weighted assets. If we focus on the Supervisory Capital Assessment Program (SCAP), which are the US stress tests of the 19 largest US bank companies, we discover that many authors reviewed the key characteristics in order to ameliorate bank control in the future.

Hirtle et al. (2009) are one of these authors. They have noticed that some risks were omitted like the liquidity, operational and funding risk. According to them, these risks should be included in the future in order to calculate net interest margins. Indeed, we know that these risks are difficult to quantify and hard to compare to the loss projections of the SCAP.

Indeed, stress tests don't focus how the failure of a bank can affect the other banks. The macroeconomic scenario should be worsened. In addition, for the EU-wide tests, one of the drawn assumptions is the zero asset growth. This measure is important for defining capital ratios but it is

[2]Unemployment rates available in April 2016 are: Croatia (14.6%), Spain (20.1%) and Greece (24.2%). http://ec.europa.eu/eurostat/

[3] http://www.lesechos.fr/16/10/2014/LesEchos/21794-105-ECH_tests-de-resistance

also hard to model explicitly. According to Kapinos et al. (2015), there are some technical issues related to stress testing. According to Kolm (2015), increasing regulations on the banking sector may raise the systemic risk in the shadow banking industry which provides credit intermediation through securitization. The same authors believe that to prevent excessive risk taking, it is important to include shadow banks to optimize capital regulations. It is necessary to ensure that banks' equity per unit of investment remains the same for all securitization strategies. Thus, it should be interesting to focus on the other sectors related to banking such as shadow banking.

The strongest criticisms concern the existence of stress tests. Indeed, some authors argue that stress tests should not be conducted. According to Kapinos et al. (2015), stress testing can be an opportunity for the regulators to not focus anymore on banks that have succeeded on previous stress tests. In fact the success may be a sign, for market participants, of bank's health. But, if the bank is in reality unhealthy, the regulatory authorities must take responsibility. Another point is that financial institutions can manipulate the system by creating new financial products that may reduce their stress-tested losses. The same authors think that stress testing should help banks to identify the risk related to their management strategy. So, according to them, stress testing is an opportunity to decrease bank bankruptcy. Moreover, for them, stress testing is a big charge for small and non-complex financial institutions. Indeed, the benefits of stress testing for these institutions do not correspond to the costs taken by regulators and banks. In addition, many midsize and smaller banks are less sensitive to the macroeconomic environment that was described by regulators to build their scenarios. So, for Tarullo (2014b) it is important to have a threshold for the banks that are involved in the stress testing procedure. According to him, higher asset threshold should be used.

For Hirtle and Lehnert (2014), stress testing can compromise the reputation of regulators especially if a bank resists stress testing and goes bankrupt soon thereafter. Indeed, it was the case for some banks in Spain and Ireland after the EU-wide stress testing in 2011.

Some researchers argue that historical data will not be informative in predicting the next crisis. Moreover, according to Bookstaber et al. (2014) and Jacobidies et al. (2014), crisis are infrequent. Thus, stress test results may provide false interpretations. So, maintaining up-to-date stressful scenarios is essential.

We believe that stress tests should be well-structured, with a clear methodology, and well-established in order to avoid spending a huge amount of money to construct them each two or three years. They should be efficient which means that the benefit cost ratio should be interesting. We believe that the results should be given automatically without wasting a huge amount of resources. It should be part of the bank's strategy. We also believe that scenarios and assumptions should be

well constructed in order to obtain the right capital shortfall during crises. The process of stress tests should be industrialized and formalized in order to reduce the time allocated to the construction of scenarios. It is important to avoid re-computation. The data should also be easily and publicly available. We don't have, for instance, the number of employees participating in the implementation of stress tests. But, we know from a qualitative survey published by PwC[4] that almost 90% of the respondents of their survey have less than 20 employees devoted to stress tests. So, people resources should be allocated more adequately, like in US where banks use a high staff dedicated to stress tests. So, the quality of the data should be well-established. It should be centralized for analysis and planning.

3. Data

The information about market systemic risk measures of financial institutions is publicly available. We took the data from the *Volatility Laboratory* (*V-Lab*) website. The data concerns the whole world for which financial data is publicly available. In order to be able to compare with stress test results, we need to take exactly the same banks. We know that there are 123 European banks for which the stress test exercise was done. We have the possibility to select 57 banks from the *V-Lab* website. The main reason for which we have this difference is because banks in the stress tests exercises, which we don't have in the V-Lab website, are not publicly traded. We show in table 1 (Panel A and B) the aggregate results of common banks between V-Lab and stress tests. From this table, we can notice the big difference between the "Loss" and "Net Loss" of stress tests for both scenarios.

If we compare the *V-Lab* methodology with the regulatory stress tests, we can conclude that the *V-Lab* scenario is much easier than the complex multi-factor scenarios of stress tests. We know that the methodology used of stress test is hard to understand. Thus, *V-Lab* results are robust to any economic environment. We also know on the one hand that stress tests are constructed thanks to the detail in information given to supervisors. On the other hand *V-Lab* outcomes are based on publicly available market data that allow forecasting. Thus *V-Lab* is considered as a benchmark that regulators should use to evaluate their own stress tests results.

The only results taken from the *V-Lab* website are $SRISK$ and MES. $\Delta CoVaR$ was constructed by us using the software STATA and following Adrian & Brunnermeier (2016) methodology. To that end, we have selected from COMPUSTAT the following variables in order to compute daily stock

[4]Passing the stress test PwC survey on regulatory stress testing in banks, Financial Services and Risk regulation January 2014

returns: Global Company Key, Issue ID, Data Date, Company Name, Currency Code, Share Outstanding, Closing Price, International Security Identification Number (ISIN), ISO Code Country (fic) and Standard Industry Classification Code (sic). We have selected the companies which have a SIC code between 6000 and 6999. This corresponds to the business list: Finance, Insurance and Real Estate. We have selected these SIC codes in order to compute the whole business list index. Then, we have selected the EU countries plus Norway. We have dropped companies which do not have an ISIN. We have also dropped companies for which the ISIN and the date are duplicated. We have selected the absolute value of prices to compute daily returns.

We have dropped the returns that are equal to the blank.

Our index return (R_t) is equal to the following formula:

$$R_t = \frac{\sum(mv\ it * r\ it)}{\sum(mv\ it)} \qquad (1)$$

Where mv is the market value of the bank i at time t and r it is the daily stock return of bank i at time t. Finally we have used a quantile regression estimation to compute $\Delta CoVaR$.

4. Stress test outcomes versus market results

To estimate a bank performance on a specific bad scenario like a financial crisis, we need to take into account the stress tests outcomes. The objective of a stress test is to allow banks to be more robust to the adverse macroeconomic scenario. Thus, stress test results help us to determine banks that are susceptible to risk during stress conditions. In this section, we will focus on stress test outcomes versus market results. The market results are related to $MV\ Loss$, MES and $\Delta CoVaR$ that we compare to stress test projected losses. We also compare $SRISK$ to stress test capital shortfall. We end this section with a comparison between the stress test projected ratios and a market leverage ratio.

4.1. Stress tests projected losses vs. $MV\ Loss$, MES and $\Delta CoVaR$

As specified earlier, we need to use the Spearman ranking correlation methodology to test the 2014 EU stress tests projected losses, stress tests capital shortfall and stress tests projected ratios ($T1R, T1CR\ and\ T1LVGR$).

We take the projected losses of stress tests because we know that the direct impact of the stress scenario should be visible on them. We will show that stress test losses and market losses correlate well.

For the comparison between stress tests projected losses and the *V-Lab* market capitalization loss ($\text{MV Loss} = \text{MV} * \text{LRMES}$), we followed Acharya et al. (2014). In figure 1, we notice that HSBC Holdings plc has the highest MV Loss. Because of the impact of projected revenues under the stress scenario, we notice in table 1 (Panel A and B) the large difference between the "Net Loss"= max(0,-Net profit after tax) and "Loss"= (Impairment losses + Trading losses) of stress tests. The main reason for which we have this gap is that stress tests losses are projected over three years whereas the *V-Lab* loss is a six-month loss. Thus, we can conclude that the order of amplitude of *V-Lab* losses (MV Loss) is similar to the amplitude of the "Loss" of stress tests.

The rank correlations of the *V-Lab* loss with the stress tests projected losses (total loss, trading losses and impairment losses) are very high and significant for both scenarios (baseline and adverse) and for the three years (table 2, panel A). This makes *V-Lab*'s ranking and the ranking of losses under supervisory stress scenarios very consistent. However, the correlations of the *V-Lab* loss with the total net loss are negative or almost equal to zero for both scenarios and during the three years. This means that banks with higher profits under EBA stress scenarios are predicted to have higher losses in *V-Lab* and this arises because we have found in our databases that some banks still report positive profits under the baseline and adverse scenario where stressed revenues cover stressed losses.

For the comparison between stress tests projected losses and MES and $\Delta CoVaR$, we followed Huang et al. (2012). These authors found that the SCAP (US stress test) stress test losses are well correlated to different market-based measures of systemic risk. Thus, we have used the MES of Acharya et al. (2010) instead of the $LR\text{MES}$, and the MES is multiplied by Tier 1 capital instead of the market capitalization. In figure 2, we can notice that the R square is high and equal to 0.76 for the correlation between the MES weighted by bank's Tier 1 capital and the EBA stress test total losses in 2016 for the baseline scenario. The $\Delta CoVaR$ of Adrian and Brunnermeier (2016) is expressed in amount (billions of Euros). In figure 3, the R square is also high and equal to 0.63 for the correlation between $\Delta CoVaR$ in euro term and the EBA stress test total losses in 2016 for the baseline scenario. According to Huang et al. (2012), the main advantage of MES and $\Delta CoVaR$ is that both take into account the size, probability of default and correlation of each bank. We can notice from table 2, panel B and panel C that MES and $\Delta CoVaR$ are well correlated with the total losses of stress tests since the results are very high and significant. It is the same for the trading losses and impairment losses. However, for the net loss, as it was the case for the *V-Lab* loss, the correlations of MES and $\Delta CoVaR$ with the total net loss are negative or almost equal to zero for

both scenarios and during the three years. We can conclude that MES, $\Delta CoVaR$ and $MV\ Loss$ are good predictors of the stress tests projected losses. In the robustness check section, we will determine the best predictor among the three measures.

4.2. Stress tests capital shortfalls vs. $SRISK$

The equivalent of stress tests capital shortfalls in *V-Lab* is the market based estimate $SRISK$. We can notice from table 1 (Panel A and B) the differences in amount between *V-Lab* $SRISK$ and the estimated capital shortfall of stress tests. The severity of $SRISK$ is completely contradictory to stress tests estimates for both scenarios and during the two years (2014 and 2015) since the information for $SRISK$ in 2016 is not still available. Indeed, for the adverse scenario, we notice that the capital shortfall estimates (4.2 EUR bn in 2014 and 10.1 EUR bn in 2015) appear very low compared to the corresponding $SRISK$ (702 EUR bn and 665 EUR bn, respectively). This is coherent with the result of Hanson et al. (2011) that market ratios in general are an obligatory constraint for banks whereas regulatory ratios are not. More details about stress test capital shortfall are available in table 3. Indeed, this table reports the capital gap for each of the fifty seven banks for the 2016 baseline and adverse scenario. Fifteen banks were estimated to have gaps and forty two were deemed adequately capitalized. The estimated capital gap ranged from about € 0.13 million to €4.63 million. Measured per bank assets, the estimated capital gap ranged from approximately 0.2 percent to 5.08 percent.

Table 4 represents the ranking correlation between the *V-Lab* $SRISK$ and the EBA estimated capital shortfall on 12/31/2013. The stress capital shortfalls are expressed into three formulas. The first formula is what the EBA stress test discloses as a capital shortfall estimate, defined by:

$$Dicslosed\ Capital\ Shortfall = \max(0, [k * RWA - T1C]), \quad (2)$$

where k is the prudential capital ratio threshold used in the stress test (8% for the baseline scenario and 5.5% for the adverse scenario), RWA is the bank's risk weighted assets and $T1C$ is the capital level of a bank. We observe that most banks have a zero capital shortfall for the EBA stress test reflecting the lack of severity of stress tests (figure 4).

The second formula is computed when we remove the zero bound and derive the 'absolute' capital shortfall

$$Capital\ Shortfall\ (RWA) = k * RWA - T1C, \quad (3)$$

We can have an overall idea about the result of this equation which is the capital shortfall in terms of *RWA* by analyzing figure 5. Indeed, we can notice that the minimum amount (capital excess) is

higher in the adverse scenario than in the baseline scenario during the three years. It is the same for the maximum amount (capital shortfall). The median corresponds to a capital shortfall and is almost the same for both scenarios and during the three years. The mean of the medians is equal to -2040 EUR millions.

We observe that most banks end up with a capital excess at the end of the stress scenario (figure 6). The rank correlation with $SRISK$ (reported in Table 4) is highly negative, significant, and is almost the same for both scenarios and during the three years (-0.688 in 2014, -0.693 in 2015 and -0.684 in 2016 for the baseline scenario). Banks with the highest estimated capital shortfall in *V-Lab* $SRISK$ are considered to be the less risky in EBA stress tests. Indeed, most of systemically important institutions according to $SRISK$ finish with large capital excesses at the end of the stress scenario. Our results are in line with Acharya et al. (2014) findings.

The third formula is based on total assets. Indeed, we can compute the stress test capital shortfall as a function of total assets instead of risk weighted assets.

$$Capital\ Shortfall\ (TA) = k * TA - T1C, \quad (4)$$

Where k is the same prudential ratio and TA is the total assets of the bank at the end of the stress scenario. The result of this equation is an opportunity to know what the EBA stress test would have produced if capital adequacy was measured by a simple leverage ratio. Table 5 shows how the rank correlation between $SRISK$ and the capital shortfall of the 2014 EBA stress test fluctuates from highly negative (-0.684 and -0.526 in 2016 for the baseline and adverse scenario respectively) to highly positive (0.925 and 0.844 in 2016 for the baseline and adverse scenario respectively) when the EBA shortfall is written as a function of total assets (figure 7) instead of risk-weighted assets (figure 6). With this definition, the required capitalization of 57 EU banks would have increased from €20.2 billion to €364.6 billion for 2016 adverse scenario (figure 8).

4.3. Stress tests projected ratios vs. *V-Lab* ratio

The purpose of this part is to compare stress test ratios to a *V-Lab* ratio. In order to do so, we need to follow the *V-Lab* ratio defined by Acharya et al. (2014). Indeed, they have defined a *V-Lab* market leverage ratio as the ratio of market cap to quasi-market assets under the *V-Lab* stress scenario.

$$Vlab\ M_{LVGRs} = \frac{MV(1-LRMES)}{MV(1-LRMES)+Debt}, \quad (5)$$

The results of this equation are available in table 1 (Panel A and B) for both scenarios and for the following years: 2013, 2014 and 2015. The rank correlations between the EBA stress test projected ratios and *V-Lab* ratio ($Vlab\ M_{LVGRs}$) are reported in table 5. The main conclusion of this table is that, as in the previous section, rank correlations increase when risk-weighted assets are replaced by total assets in stress tests measures. We can notice in the same table that the two first measures of stress test projected ratios are based on RWA and the last one is based on total assets. Indeed, the last measure (T1 LVGR) is defined as a Tier 1 leverage ratio which allows the evaluation of bank leverage. Basel III recommended this measure and defined it as the ratio of Tier 1 capital to total assets (T1/Total assets). According to Haldane (2012), the T1 LVGR ratio is a better predictor of the failure of financial institutions than the Core Tier 1 Capital ratio (T1CR). We find that Lloyds Banking Group plc and Allied Irish Banks plc would have failed the stress test if the Basel III 3% leverage requirement had existed.

In figure 9, the correlation between the stressed Tier 1 leverage ratios and the market leverage ratio ($Vlab\ M_{LVGRs}$) appears to be strong. Indeed even in table 5, we can notice than the ranking correlation with $Vlab\ M_{LVGRs}$ ratio increases from 0.43 to 0.59, for the 2016 adverse scenario, when risk-weighted assets are replaced by total assets.

5. Stress tests and market outcomes versus realized outcomes

Realized outcomes are related to the realized returns, loss and volatility. Realized outcomes allow us to determine whether the stress test outcomes and scenario were credible. Realized outcomes that we compare to stress test outcomes allow also us to identify other deficiencies of EBA 2014 wide stress test that would prevent it from identifying the vulnerabilities of banks. *V-Lab* output was downloaded before the disclosure date of the EBA stress test: 09/30/2014. We would specify that our calculations either for six months or one year concerning the realized outcomes provided us same conclusions. In this section, we have taken into account the heterogeneity in size in the European banks. Indeed, we know that size can distort the final results by amplifying correlations. Thus, to mitigate size effect we created two subsamples: one for the 15 large banks (with core Tier 1capital over € 20 billion) and the other one for the remaining 42 small banks. The 15 large banks include HSBC, Barclays, Lloyds, BNP Paribas, Crédit Agricole, Deutsche Bank, etc. The tables in this section show the performance of the EBA and *V-Lab* in forecasting the actual ranking of banks' realized outcomes. A last point concerning this section is that we have only take into account the baseline scenario for stress test results since there is no crisis between September 30th 2014 and March 31st 2015.

5.1. Stress tests and *V-Lab* estimated losses vs. realized loss

Table 6 shows the capacity of *V-Lab* and the EBA in forecasting the actual ranking of banks' realized loss which is defined by

$$Realized\ loss = -MVit * \sum_{t+1}^{t+131} \ln\left(\frac{Pit}{pit-1}\right), \quad (6)$$

Where $MVit$ is the market-value of equity of bank i (all converted in Euros), with t=09/30/2014 and W=130 (six months).

From table 6 and for the large banks, we can notice that ranking correlations between the EBA total net loss and the 6 month realized loss are negative. This means that these large banks which have positive projected profits in the EBA stress test sustained the highest losses. These results are confirmed when we focus on the ranking correlations of the EBA total loss and the 6 month realized loss. If we compare for the same category of large banks with the market results ($MV\ Loss$, MES and $\Delta CoVaR$), we can notice that EBA projected total losses are a better predictor of the ranking of realized losses than these market systemic risk measures. Indeed, the ranking correlation of EBA total loss and the 6-month realized loss is equal to 0.59 and is significant in 2014 for the large banks whereas for the same category the ranking correlation with *V-Lab* $MV\ Loss$ is equal to 0.16 and is not significant.

5.2. Stress tests and *V-Lab* estimated returns vs. realized return

In table 7, we have compared different capital ratios in predicting the ranking of European banks by their realized stock returns during the six months following the disclosure of the 2014 EBA stress test. The realized stock return of bank i at time t is defined by

$$Realized\ return = -\sum_{t+1}^{t+131} \ln\left(\frac{Pit}{pit-1}\right), \quad (7)$$

Where, pit is the stock price of the bank.

We can notice that the correlations are not high. The rank correlation for large banks, for the *V-Lab* ratio is 0.54, for the Tier leverage ratio, it is 0.66 and for the Core Tier 1 capital ratio it is -0.13. Thus, we can conclude that the EBA T1LVGRs and the *V-Lab* ratio are better predictors of the ranking of the realized six months returns than the EBA T1CR. These results confirm the previous results where the weakness of financial institutions is better predicted when using the capital ratio relative to risk-weighted assets instead of total assets.

5.3 Stress tests and *V-Lab* estimated risk measure vs. realized volatility

In this section, we would like to determine if the risk measures of stress tests and *V-Lab* are considered as measures of bank risk during a crisis. So, we have compared the performance of these risk measures to a realized measure which is the six-month realized volatility defined by

$$Realized\ volatility = \sqrt{\frac{1}{130}\sum_{t+1}^{t+131}(rit - \bar{r}\,\mathrm{it}, 130)^2}, \quad (8)$$

where $\bar{r}\mathrm{it}, 130$ is the six months forward average return of bank i at date t. In our case, t is equal to 09/30/2014. In this section, we need to define the risk measures of stress tests and *V-Lab*. For the latter, Acharya et al.(2012) defined the effective market risk weight to quasi-market assets corresponding to a $SRISK$of zero. To that end, the current market capitalization should be above a fraction k of some "market risk weighted" assets:

$$MV \geq \frac{k}{1-(1-k)LRMES}(MV + Debt), \quad (9)$$

Therefore, the $\mathrm{V-Lab\ risk\ weight}$ of the bank is

$$\mathrm{V-Lab\ risk\ weight} = (1-(1-\mathrm{k})\mathrm{LRMES})^{-1}, \quad (10)$$

The $\mathrm{V-Lab\ risk\ weight}$ is comparable to the $\mathrm{EBA\ risk\ weight}$ (risk measure of stress test) of a bank defined by the ratio of its RWA to total assets. The risk weight could be read as a measure of risk per unit of asset; the higher the risk weight, the riskier the asset holdings of a bank. Figure 10 compares the $\mathrm{V-Lab\ risk\ weight}$ to the projected risk weight at the end of the EBA stress scenario. These measures have nothing in common since the R square is very low. Aareal Bank AG, BancoPopolare - SC, ING Bank N.V. and KBC Group NV are among the riskiest banks according to the $\mathrm{V-Lab\ risk\ weight}$ and the safest with the EBA risk weight; these banks have values above the 75% quantile of the $\mathrm{V-Lab\ risk\ weight}$ distribution and appear below 25% quantile of the EBA risk weight distribution. In addition, in figure 11 we show that there is a correlation between stressed Tier 1 leverage ratios (the ratio of Tier 1 to total assets) and stressed risk weights in the 2014 European stress test. Thus, banks with low risk weights have the highest leverage. This shows the bad incentives created by stressed risk weights. Acharya and Steffen (2013) show that this type of behavior was intrusive among euro-zone banks. Therefore, the use of Basel static risk weights appears to have misguided the recapitalization of the financial sector.

We would like to remember that the main objective of this section is to compare the six-months realized volatility to the $\mathrm{EBA\ risk\ weight}$ and $\mathrm{V-Lab\ risk\ weight}$. Table 8 shows that only the $\mathrm{V-Lab\ risk\ weight}$ predicts the ranking of banks' realized risk. The rank correlation between the

six-months realized volatility of European banks' stock returns and the ranking of EBA risk weight is positive but not significant, whereas the correlation with the $\text{V} - \text{Lab risk weight}$ (0.45) is positive and significant at the 1% level for the fifteen largest banks. Das and Sy (2012) find that risk-weighted assets cannot be used to predict market measures of risk. All these results show that Basel risk weights were misleading in the 2014 EBA stress test since there is no correlation between the stressed regulatory risk weights and the realized risk of banks.

6. Robustness check

The objective of this section is to confirm that SRISK is the best explanatory variable of the EBA capital shortfall and $\text{MES} * \text{T1}$ of Huang et al. (2012) is the best predictor of the EBA total losses. To that end, we have run some regressions. In table 9, we have defined the EBA 2014 capital shortfall as the dependent variable and the main measures of systemic risk (SRISK, MV loss, $\text{MES} * \text{T1}$ and $\Delta\text{CoVaR} * \text{mv}$) as the independent variables. We have constructed this table by taking into account the baseline and adverse scenario to identify if there is a difference between both scenarios. We have found that both scenarios give similar results. The main deduction of this is that SRISK is the best predictor of capital shortfall. Indeed, during the three years and for both scenarios, SRISK is the most significant variable among the systemic risk measures. Its coefficient is high for the EBA capital shortfall that was projected in 2016 for the adverse scenario. We can notice that the coefficient of MV loss is also high and significant but it was not stable during the three years and for both scenarios. Even for ΔCoVaR in amount, which was defined by Adrian and Brunnermeier (2016), we can notice that the coefficients are high and significant but not stable.

In order to better confirm these results, we have focused on the EBA 2011 outcomes. Indeed, we have run the same regressions for the previous stress test. We have found in table 10 the same results. SRISK is also the best explanatory variable of the EBA 2011 capital shortfall. The coefficients are very high and significant for both scenarios and during the two years.

We need also to identify the best predictor of the EBA total losses among the systemic risk measures. We have used the same independent variables to determine the one that fits the most the EBA total losses. In table 11, we can identify the $\text{MES} * \text{T1}$ as the best predictor of the EBA 2014 total losses. Indeed, all the coefficients are positive and significant during the three years and for both scenarios. For instance, the coefficient of the $\text{MES} * \text{T1}$ is equal to 6.98 for the EBA projected losses in 2014 and for the adverse scenario. To confirm these results, we have again focused on the results of the EBA 2011 total losses and found the same conclusions (table 12). Indeed, the

coefficient of $MES * T1$ is positive and significant during the two years and for both scenarios. For instance, the coefficient is equal to 4.5 for the EBA 2011 total losses for the adverse scenario.

We wanted also to confirm that even if stress tests continue to be done in the future, it is important to compute in terms of total assets and not in terms of risk weighted assets. Indeed, table 13 summarizes the results of regression EBA shortfall in terms of RWA with the zero bound on SRISK. To that end, we have used an OLS and probit regression. For the latter regression, we have converted the dependent variable (EBA capital shortfall) into a binary variable by considering higher than zero and less than zero. We can notice that all the coefficients of the independent variables are negative for both regressions. We can conclude that when the EBA capital shortfall is constructed in terms of RWA, the results are not significant. To better confirm these results, we have run OLS and probit regressions of the EBA shortfall in terms of total assets on SRISK (Table 14). The coefficients of the explanatory variables are positive and significant mainly for the OLS regression. Thus, total assets should be taken into account for the calculation of the EBA capital shortfall.

7. Conclusion

This article gives an evaluation of the results of the 2014 EU-wide stress test. Criticisms about stress tests have been raised by many researches. In this paper, we compare these stress test outcomes to market based systemic risk measures.

We find that capital requirements should be based on the market capital shortfall ($SRISK$) rather than based on capital shortfalls of stress tests. Moreover, *V-Lab* outcomes and the projected losses of stress tests correlate well. In addition, the estimated market returns and market volatility are good predictors of the realized performance of banks. Thus, we have shown that market based systemic measures ($SRISK$, MES and $\Delta CoVaR$) can be explicative of the capital shortfall and the total losses of the EBA since these two latter measures are very important in evaluating the health of any bank all over the world.

This article recommends, as suggested by Acharya et al. (2014), to complete the evaluation of stress tests by taking into account these market based measures of risk. We also recommend that to provide more robust estimates of the bank risk, the capital requirements should be based on the size and leverage of banks. Thus, what has left financial sectors undercapitalized is the use of regulatory risk weights in stress tests. Basel risk standards based on RWA gave incentives to construct exposures to low risk-weighted assets and resulted in under-diversification.

References

Acharya, V., R. Engle and D. Pierret (2014): "Testing macroprudential stress tests: The risk of regulatory risk weights", Journal of Monetary Economics 65, 36-53.

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

Acharya, V., L. H. Pedersen, T. Philippon and M. Richardson (2010): "Measuring systemic risk", Working paper. Available at http://ssrn.com/abstract=1595075.

Acharya, V. and S. Steffen (2013): "The "Greatest" Carry Trade Ever?: Understanding Eurozone Bank Risks", Journal of Financial Economics 115(2), 215-236.

Adrian, T. and M. K. Brunnermeier (2016): "CoVaR", American Economic Review, forthcoming.

Bookstaber, R., J. Cetina, G. Feldberg, M. Flood and P. Glasserman (2014): "Stress tests to promote financial stability: assessing progress and looking to the future", Journal of Risk Management in Financial Institutions, 7(1), 16-25.

Borio, C., M. Drehmann and K. Tsatsaronis (2013): "Stress-testing macro stress testing: does it live up to expectations?", Journal of Financial Stability, 12(C), 3-15.

Breuer, T., M. Jandacka, K. Rheinberger and M. Summer (2012): "How to find plausible, severe and useful stress scenarios? ", International Journal of Central Banking, 5(3), 205-224.

Brownlees, C. and R. Engle (2016): "SRISK: A conditional capital shortfall measure of systemic risk", Working paper. Available at http://ssrn.com/abstract= 1611229.

Das, S. and A. N. Racine Sy (2012): "How Risky are Banks' Risk-Weighted Assets? Evidence from the Financial Crisis", Working Paper. Available at http://ssrn.com/abstract=1997749.

Drehmann, M. (2009): "Macroeconomic Stress-testing Banks: a survey of methodologies in stress-testing the banking system", Cambridge University Press.

Guttentag, J. and R. Herring (1986): "Disaster Myopia in international banking", Essays in International Finance, No. 164, Princeton University.

Haldane, A. (2012): "The Dog and the Frisbee", Bank of England speech, Available at http://www.bankofengland.co.uk/publications/documents/speeches/ 2012/speech596.pdf.

Hanson, S., A. Kashyap and J. Stein (2011): "A macroprudential approach to financial regulation", Journal Economic Perspectives, 25(1),3-28.

Hirtle, B. and A. Lehnert (2014): "Supervisory stress tests", Federal Reserve Bank of New York Staff Report, No. 696.

Hirtle, B., T. Shuermann and K. Strioh (2009): "Macroprudential supervision of financial institutions: lessons from the SCAP", Federal Reserve Bank of New York Staff Reports, No.409.

Huang, X., H. Zhou and Z. Haibin (2012): "Systemic risk contributions", Journal of Financial Services Research 42(1), 55-83.

Jacobidies, M., M. Drexler and J. Rico (2014): "Rethinking the future of financial services: A structural and evolutionary perspective on regulation", Journal of Financial Perspectives, 2(1), 1-26.

Kapinos, P., C. Martin and O. Mitnik (2015): "Stress testing banks: Whence and whither?", Federal Deposit Insurance Corporation Center for Financial Research, Working paper. Available at https://www.fdic.gov/bank/analytical/CFR/2015/WP_2015/WP2015_07.pdf.

Kolm, J. (2015): "Securitization, shadow banking and bank regulation", Working paper. Available at http://ssrn.com/abstract=2521390.

Morgan, D.P., S. Peristiani and V. Savino (2010): "The information value of the stress test and bank opacity", Federal Reserve Bank of New York Staff Reports, No. 460.

Petrella, G. and A. Resti (2013): "Supervisors as information producers: do stress tests reduce bank opaqueness?", Journal of Banking and Finance, 37(12), 5406-5420.

Quijano, M. (2014): "Information Asymmetry in US banks and the 2009 bank stress test", Economics Letters, 123(2), 203-205.

Tarullo, D. (2014): "Rethinking the aims of prudential regulation", Remarks at the Federal Reserve Bank of Chicago Bank Structure Conference, May 8.

Table 1. Stress tests vs. *V-Lab* estimates

These tables present the aggregate outcome of the 57 common banks between *V-Lab* and regulatory stress tests. *V-Lab* output, which was converted in Euros, is downloaded for the following dates: 12/31/2013, 12/31/2014 and 12/31/2015. $SRISK$ is the *V-Lab*'s capital shortfall estimate, $Vlab\ M_{LVGRs}$ is the ratio of market cap to quasi-market assets under *V-Lab* stress scenario (Eq.(5)), $\text{MV Loss} = \text{MV} * \text{LRMES}$. Stress tests ratios are cross-sectional averages. Stress tests losses are the sum of projected losses over the stress scenario and across banks. "Loss"= Impairment losses + Trading losses. "Net Loss"=max(0,-Net profit after tax). In parentheses: number of banks failing the systemic risk criterion.

Panel A: **Baseline scenario k=8%**

K=8%	Stress tests estimates				*V-Lab* estimates		
	Shortfall	**Ratio**	**Loss**	**Net loss**	**SRISK**	**M-LVGRs**	**MV loss**
2013		10.72% (9)			1 180 € bn (53)	3.78%	478 € bn
2014	4.4 € bn	10.84% (9)	114.9 € bn	6.44 € bn	1 285 € bn (52)	3.56%	489 € bn
2015	6.3 € bn	11.15% (9)	79.1 € bn	4.62 € bn	1 254 € bn (52)	3.81%	404 € bn
2016	7.8 € bn	11.37% (9)	67.6 € bn	1.81 € bn			

Panel B: Adverse Scenario K=5.5%

K=5.5%	Stress tests estimates				*V-Lab* estimates		
	Shortfall	**Ratio**	**Loss**	**Net loss**	**SRISK**	**M-LVGRs**	**MV loss**
2013		10.72% (2)			632 € bn (49)	3.79%	478 € bn
2014	4.2 € bn	9.39% (5)	197.7 € bn	50.63 € bn	702 € bn (50)	3.56%	489 € bn
2015*	10.1 € bn	8.60% (10)	155.8 € bn	40.13 € bn	665 € bn (44)	3.81%	404€ bn
2016	20.2€ bn	8.10% (15)	126.6€ bn	23.43€ bn			

Table 2. Rank correlations: Stress tests projected losses vs. *V-Lab*.

These tables present the rank correlations of stress tests and *V-Lab* outcomes. Panel A: rank correlations with *V-Lab*'s $\text{MV loss} = \text{LRMES} * \text{MV}$. Panel B: rank correlations with ΔCoVaR. Panel C: rank correlations with MES. Stress tests "Total Net Loss" and "Total Loss" are defined in table 1, without a zero bound on net losses. *V-Lab* download date: 12/31/2013. ***, ** and* indicate significance at 0.01, 0.05 and 0.10 levels, respectively.

Panel A: Rank correlations with *V-Lab* MV loss 12/31/2013

Stress tests projected losses	2014 Baseline Scenario	2014 Adverse Scenario	2015 Baseline Scenario	2015 Adverse Scenario	2016 Baseline Scenario	2016 Adverse Scenario
Total Net Loss	-0.6595***	0.1429	-0.7492***	0.0356	-0.8102***	-0.0594
Total Loss	0.7665***	0.8075***	0.7610***	0.8437***	0.7631***	0.8153***
Trading losses	0.7833***	0.7912***	0.7833***	0.7912***	0.7833***	0.7912***
Impairment losses	0.7295***	0.7915***	0.7257***	0.8193***	0.7284***	0.8000***

Panel B: Rank correlations with Δ CoVaR 12/31/2013

Stress tests projected losses	2014 Baseline Scenario	2014 Adverse Scenario	2015 Baseline Scenario	2015 Adverse Scenario	2016 Baseline Scenario	2016 Adverse Scenario
Total Net Loss	-0.6696***	0.0482	-0.7058***	-0.0515	-0.7560***	-0.0907
Total Loss	0.6602***	0.6854***	0.6641***	0.7335***	0.6822***	0.7100***
Trading losses	0.6869***	0.7056***	0.6869***	0.7056***	0.6869***	0.7056***
Impairment losses	0.6229***	0.6810***	0.6354***	0.7080***	0.6500***	0.7069***

Panel C: Rank correlations with MES 12/31/2013

Stress tests projected losses	2014 Baseline Scenario	2014 Adverse Scenario	2015 Baseline Scenario	2015 Adverse Scenario	2016 Baseline Scenario	2016 Adverse Scenario
Total Net Loss	-0.6213***	0.2958	-0.7273***	0.1320	-0.8243***	0.0181
Total Loss	0.8484***	0.8737***	0.8458***	0.9013***	0.8463***	0.8853***
Trading losses	0.8669***	0.8695***	0.8669***	0.8695	0.8669***	0.8695***
Impairment losses	0.8033***	0.8501***	0.8066***	0.8754***	0.8063***	0.8674***

Table 3. Sample used

This table presents the stress test capital shortfall, the total assets and the capital Gap/assets of the 57 EU banks. It shows the EBA results for the year 2016 and during the baseline and adverse scenario.

2016_Adverse Sceanrio	Capital Gap (Millions of Euros)	Assets (Millions of Euros)	Capital Gap/ Assets %
Banks Needing Capital (Gap Banks)			
Eurobank Ergasias	4.63	91.27	5.07
Banca Monte dei Paschi di Siena S.p.A.	4.25	197.24	2.15
National Bank of Greece	3.43	114.04	3.01
Banca Carige S.P.A.	1.83	36.15	5.08
Banco Comercial Português	1.14	90.34	1.26
Österreichische Volksbanken	0.86	42.20	2.05
Permanent tsb plc.	0.85	55.02	1.55
Banca Popolare Di Milano	0.68	54.02	1.27
Piraeus Bank	0.66	90.73	0.73
Banco Popolare - Società Cooperativa	0.43	124.12	0.34
Banca Piccolo Credito Valtellinese	0.38	27.75	1.36
Dexia NV*	0.34	224.16	0.15
Banca Popolare di Sondrio	0.32	33.49	0.95
Hellenic Bank Public Company Ltd	0.28	6.64	4.17
Banca Popolare Dell'Emilia Romagna	0.13	64.46	0.20
Banks with adequate Capital (No Gap Banks)			
Aareal Bank AG	0	62.82	0
Allied Irish Banks plc	0	163.48	0
Alpha Bank	0	75.47	0
Banco Bilbao Vizcaya Argentaria	0	660.39	0
Banco BPI	0	39.27	0
Banco de Sabadell	0	161.81	0
Banco Popular Español	0	145.76	0
Banco Santander	0	1072.87	0
BANK BPH SA	0	8.16	0
BANK HANDLOWY W WARSZAWIE SA	0	12.79	0
Bank of Valletta plc	0	8.00	0
Bankinter	0	49.55	0
Barclays plc	0	1296.44	0
BNP Paribas	0	1385.46	0
Commerzbank AG	0	563.54	0
Credito Emiliano S.p.A.	0	30.70	0
Danske Bank	0	397.96	0
Deutsche Bank AG	0	1322.88	0
DNB Bank Group	0	279.21	0
Erste Group Bank AG	0	239.08	0
GETIN NOBLE BANK SA	0	16.23	0
Groupe Crédit Agricole	0	1546.98	0
HSBC Holdings plc	0	2205.66	0
IKB Deutsche Industriebank AG	0	24.46	0
ING Bank N.V.	0	909.79	0
Intesa Sanpaolo S.p.A.	0	616.54	0
Jyske Bank	0	35.44	0
KBC Group NV	0	250.26	0
Lloyds Banking Group plc	0	1009.42	0
Mediobanca	0	73.73	0
Nordea Bank AB (publ)	0	499.45	0
OTP Bank Ltd	0	36.54	0
PKO BANK POLSKI	0	48.68	0
Royal Bank of Scotland Group plc	0	857.85	0
Skandinaviska Enskilda Banken	0	264.18	0
Société Générale	0	762.00	0
Svenska Handelsbanken AB (publ)	0	349.87	0
Swedbank AB (publ)	0	218.81	0
Sydbank	0	15.27	0
The Governor and Company of the Bank of Irelanc	0	119.79	0
UniCredit S.p.A.	0	874.18	0
Unione Di Banche Italiane	0	127.79	0

2016_Baseline Sceanrio	Capital Gap (Millions of Euros)	Assets (Millions of Euros)	Capital Gap/ Assets %
Banks Needing Capital (Gap Banks)			
Eurobank Ergasias	2.282	90.832	2.512
Banca Carige S.P.A.	1.321	36.163	3.653
National Bank of Greece	1.278	112.869	1.132
Banca Monte dei Paschi di Siena S.p.A.	1.215	190.421	0.638
Banco Popolare - Società Cooperativa	0.693	117.873	0.588
Banca Popolare Di Milano	0.495	54.063	0.916
Österreichische Volksbanken	0.191	41.325	0.463
Banca Piccolo Credito Valtellinese	0.174	27.616	0.631
Banca Popolare di Sondrio	0.145	33.739	0.429
Banks with adequate Capital (No Gap Banks)			
Banco Comercial Português	0	90.364	0
Permanent tsb plc.	0	51.608	0
Piraeus Bank	0	90.730	0
Dexia NV*	0	183.662	0
Hellenic Bank Public Company Ltd	0	6.788	0
Banca Popolare Dell'Emilia Romagna	0	63.792	0
Aareal Bank AG	0	47.766	0
Allied Irish Banks plc	0	150.196	0
Alpha Bank	0	76.267	0
Banco Bilbao Vizcaya Argentaria	0	621.535	0
Banco BPI	0	38.846	0
Banco de Sabadell	0	166.463	0
Banco Popular Español	0	145.036	0
Banco Santander	0	1060.532	0
BANK BPH SA	0	8.162	0
BANK HANDLOWY W WARSZAWIE SA	0	12.355	0
Bank of Valletta plc	0	7.921	0
Bankinter	0	49.700	0
Barclays plc	0	1116.715	0
BNP Paribas	0	1332.431	0
Commerzbank AG	0	491.298	0
Credito Emiliano S.p.A.	0	29.566	0
Danske Bank	0	390.005	0
Deutsche Bank AG	0	1031.961	0
DNB Bank Group	0	262.099	0
Erste Group Bank AG	0	227.062	0
GETIN NOBLE BANK SA	0	16.232	0
Groupe Crédit Agricole	0	1418.509	0
HSBC Holdings plc	0	1872.754	0
IKB Deutsche Industriebank AG	0	24.247	0
ING Bank N.V.	0	855.641	0
Intesa Sanpaolo S.p.A.	0	594.651	0
Jyske Bank	0	30.830	0
KBC Group NV	0	223.412	0
Lloyds Banking Group plc	0	923.788	0
Mediobanca - Banca di Credito Finanziario S.p.A.	0	73.297	0
Nordea Bank AB (publ)	0	480.988	0
OTP Bank Ltd	0	36.201	0
PKO BANK POLSKI	0	50.880	0
Royal Bank of Scotland Group plc	0	833.307	0
Skandinaviska Enskilda Banken AB (publ) (SEB)	0	232.727	0
Société Générale	0	732.343	0
Svenska Handelsbanken AB (publ)	0	299.528	0
Swedbank AB (publ)	0	201.319	0
Sydbank	0	13.810	0
The Governor and Company of the Bank of Irelar	0	118.113	0
UniCredit S.p.A.	0	846.656	0
Unione Di Banche Italiane	0	126.869	0

Table 4. Rank correlations: Stress tests capital shortfalls vs. *V-Lab*

This table presents the rank correlations of stress tests and *V-Lab*'s capital shortfall SRISK . *V-Lab* download date: 12/31/2013.
***, ** and* indicate significance at 0.01, 0.05 and 0.10 levels, respectively.

Rank correlations with *V-Lab* $SRISK$ 12/31/2013

Stress tests capital shortfalls	2014 Baseline Scenario	2014 Adverse Scenario	2015 Baseline Scenario	2015 Adverse Scenario	2016 Baseline Scenario	2016 Adverse Scenario
max(0,Shortfall(RWA))	-0.1461	-0.0872	-0.1378	-0.1380	-0.1271	-0.1109
Shortfall (RWA)	-0.6877***	-0.6573***	-0.6925***	-0.5905***	-0.6837***	-0.5252***
Shortfall (TA)	0.9328***	0.8008***	0.9295***	0.8404***	0.9250***	0.8442***

Table 5. Rank correlations: Stress tests projected ratios vs. *V-Lab*

This table presents the rank correlations of stress tests projected ratios and $Vlab\ M_{LVGRs}$ (eq.(5)). "min" stands for the minimum ratio over the three years of the EBA 2014 stress scenario. *V-Lab* download date: 12/31/2013.
***, ** and* indicate significance at 0.01, 0.05 and 0.10 levels, respectively.

Rank correlations with $Vlab\ M_{LVGR}$, 12/31/2013

Stress tests projected ratios	2014 Baseline Scenario	2014 Adverse Scenario	2015 Baseline Scenario	2015 Adverse Scenario	2016 Baseline Scenario	2016 Adverse Scenario	Minimum value of the 3 years Baseline Scenario	Minimum value of the 3 years Adverse Scenario
T1R	0.3938***	0.4124***	0.4384***	0.4485***	0.4833***	0.4285***	0.4566***	0.4201***
T1CR	0.4666***	0.4890***	0.5178***	0.5392***	0.5566***	0.5113***	0.5196***	0.5057***
T1 LVGR	0.5471***	0.5715***	0.6020***	0.6184***	0.6254***	0.5929***	0.5905***	0.5934***

Table 6. Rank correlations: Realized EUR loss vs. EBA and *V-Lab* outcomes

This table presents the rank correlations of the EBA and *V-Lab* outcomes with the realized outcomes of banks after the disclosure of the EBA stress test in October 2014. Panel A: rank correlations of the EBA outcomes with the 6-month realized loss (eq.(6)). Panel B: rank correlations of the *V-Lab* outcomes with the 6-month realized loss (eq.(6)). *V-Lab* output was downloaded before the disclosure date of the EBA stress test: 09/30/2014. Sample size: 15(large), 42 (small), 57 (all). (p-values in parentheses).

Panel A: Rank correlations with the 6-month realized EUR loss 09/30/2014

Estimated Losses	All 2014	All 2015	All 2016	Large 2014	Large 2015	Large 2016	Small 2014	Small 2015	Small 2016
EBA Total Net loss	0.2130	0.3473	0.3669	-0.1821	-0.5179	-0.4536	0.4203	0.3411	0.3059
	(0.1117)	(0.0081)	(0.0050)	(0.5159)	(0.048)	(0.0895)	(0.0056)	(0.0271)	(0.0488)
EBA Total loss	-0.2293	-0.2385	-0.2610	0.5964	0.3286	0.2429	-0.069	-0.0365	-0.0656
	(0.0862)	(0.074)	(0.0499)	(0.0189)	(0.2318)	(0.3831)	(0.6643)	(0.8183)	(0.68)

Panel B: Rank correlations with the 6-month realized EUR loss 09/30/2014

Estimated losses	All	Large	Small
V-Lab MV loss	-0.3235 (0.0141)	0.1571 (0.5760)	-0.2100 (0.1820)
ΔCoVaR	-0.4133 (0.0014)	0.1893 (0.4993)	-0.3307 (0.0324)
MES	-0.0615 (0.6494)	-0.2714 (0.3278)	0.1184 (0.4552)

Table 7. Rank correlations: Realized EUR return vs. EBA and *V-Lab* outcomes

This table presents the rank correlations of the EBA and *V-Lab* outcomes with the realized outcomes of banks after the disclosure of the EBA stress test in October 2014. Panel A: rank correlations of the EBA outcomes with the 6-month realized return (eq.(7)). Panel B: rank correlations of the *V-Lab* outcomes with the 6-month realized return (eq.(7)). *V-Lab* output was downloaded before the disclosure date of the EBA stress test: 09/30/2014. Sample size: 15(large), 42 (small), 57 (all). (p-values in parentheses)

Panel A: Rank correlations with the 6-month realized return 09/30/2014

Estimated returns	All 2014	All 2015	All 2016	Large 2014	Large 2015	Large 2016	Small 2014	Small 2015	Small 2016
EBA T1C return	0.2606	0.2946	0.2810	-0.0393	-0.1036	-0.2500	0.3133	0.3769	0.3717
	(0.0502)	(0.0261)	(0.0342)	(0.8894)	(0.7134)	(0.3688)	(0.0433)	(0.0139)	(0.0154)
EBA T1CR	-0.0690	-0.0844	-0.0954	**-0.4500**	-0.2250	-0.1286	-0.0437	-0.0762	-0.1155
	(0.6099)	(0.5325)	(0.4802)	(0.0924)	(0.4201)	(0.6479)	(0.7836)	(0.6313)	(0.4665)
EBA T1LVGRs	0.0314	0.0394	-0.0032	0.2679	**0.5179**	**0.6643**	-0.0239	-0.0570	-0.1087
	(0.8168)	(0.7710)	(0.9809)	(0.3344)	(0.048)	(0.0069)	(0.8806)	(0.7201)	(0.4933)

Panel B: Rank correlations with the 6-month realized return 09/30/2014

Estimated returns	All	Large	Small
V-Lab LRMES	-0.1527 (0.2568)	**-0.7607** (0.0010)	-0.0231 (0.8846)
*V-Lab*M_LVGRs	0.2553 (0.0553)	**0.5429** (0.0365)	0.2249 (0.1522)

Table 8. Rank correlations: Realized EUR volatility vs. EBA and *V-Lab* outcomes

This table presents the rank correlations of the EBA and *V-Lab* outcomes with the realized outcomes of banks after the disclosure of the EBA stress test in October 2014. Panel A: rank correlations of the EBA outcomes with the 6-month realized volatility (eq.(8)); EBA risk weight=RWA/TA. Panel B: rank correlations of the *V-Lab* outcomes with the 6-month realized volatility (eq.(8)); *V-Lab* risk weight (eq.(10). *V-Lab* output was downloaded before the disclosure date of the EBA stress test: 09/30/2014.

Sample size: 15(large), 42 (small), 57 (all). (p-values in parentheses).

Panel A: Rank correlations with the 6-month realized volatility 09/30/2014

Estimated Risk measure	**All 2014**	**All 2015**	**All 2016**	**Large 2014**	**Large 2015**	**Large 2016**	**Small 2014**	**Small 2015**	**Small 2016**
EBA Risk Weight	0.3316 (0.0117)	0.3294 (0.0123)	0.3162 (0.0166)	0.0393 (0.8894)	0.1000 (0.7229)	0.1250 (0.6571)	0.2326 (0.1382)	0.2244 (0.1531)	0.2122 (0.1773)

Panel B: Rank correlations with the 6-month realized volatility 09/30/2014

Estimated risk measure	**All**	**Large**	**Small**
V-Lab RiskWeight	0.1803 (0.1795)	**0.4500 (**0.0924)	0.2212 (0.1591)

Table 9. Market based measures vs. EBA 2014 capital shortfall

This table summarizes the results of regression the EBA 2014 capital shortfall in terms of total assets on market systemic risk measures (SRISK, MV Loss, MES * T1 and ΔCoVaR * mv). Results are presented for the three years and for the baseline and adverse scenario.

The market systemic risk measures are dowloaded:12/31/2013. The reported R^2 is then the Pseudo R^2.

***, ** and* indicate significance at 0.01, 0.05 and 0.10 levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	ShortfallTA_2014_B	**ShortfallTA_2015_B**	**ShortfallTA_2016_B**	**ShortfallTA_2014_A**	**ShortfallTA_2015_A**	**ShortfallTA_2016_A**
SRISK	273.673***	300.980***	313.661***	291.147***	396.504***	443.427***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
MV- Loss	197.000	286.811**	305.526**	155.969	328.608*	539.924***
	(0.241)	(0.048)	(0.023)	(0.297)	(0.062)	(0.002)
MES*T1	677.620	-1680.700	-2337.711	-4579.098	-6359.373*	-7451.522**
	(0.848)	(0.577)	(0.400)	(0.147)	(0.085)	(0.038)
ΔCoVaR*mv	5130.846**	3511.672	2374.733	5570.489**	4646.528*	990.444
	(0.049)	(0.112)	(0.240)	(0.020)	(0.091)	(0.705)
_cons	738.893	805.566	825.081	682.842	924.375	1091.802
	(0.333)	(0.218)	(0.171)	(0.299)	(0.228)	(0.142)
R2_a	0.905	0.921	0.928	0.701	0.752	0.791
Obs.	57	57	57	57	57	57

Table 10. Market based measures vs. EBA 2011 capital shortfall

This table summarizes the results of regression the EBA 2011 capital shortfall in terms of total assets on market systemic risk measures (SRISK, MV Loss, MES * T1 and ΔCoVaR * mv). Results are presented for the three years and for the baseline and adverse scenario. The market systemic risk measures are dowloaded:12/31/2010. The reported R^2 is then the Pseudo R^2.

***, ** and* indicate significance at 0.01, 0.05 and 0.10 levels, respectively.

	(1)	(2)	(3)	(4)
	ShortfallTA_2011B	**ShortfallTA_2012B**	**ShortfallTA_2011A**	**ShortfallTA_2012A**
SRISK	1010.999***	986.418***	1020.631***	969.764***
	(0.000)	(0.000)	(0.000)	(0.000)
MV_LOSS	995.550	510.880	813.335**	418.024
	(0.148)	(0.445)	(0.047)	(0.275)
MES*T1	-28217.953***	-26206.991***	-22800.392***	-19199.743***
	(0.000)	(0.000)	(0.000)	(0.000)
ΔCoVaR*mv	3826.304	6619.173	2997.900	4586.279
	(0.534)	(0.274)	(0.411)	(0.188)
_cons	-538.225	-444.908	-632.626	-245.152
	(0.768)	(0.804)	(0.557)	(0.810)
R2_a	0.864	0.853	0.852	0.854
Observation	53	53	53	53

Table 11. Market based measures vs. EBA 2014 total losses

This table summarizes the results of regression the EBA 2014 stress test projected total losses on market systemic risk measures (SRISK, MV Loss, MES * T1 and ΔCoVaR * mv). Results are presented for the three years and for the baseline and adverse scenario. The market systemic risk measures are dowloaded:12/31/2013. The reported R^2 is then the Pseudo R^2.

***, ** and* indicate significance at 0.01, 0.05 and 0.10 levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	T.LossB14	**T.lossB15**	**T.lossB16**	**T.lossA14**	**T.lossA15**	**T.lossA16**
SRISK	-0.050***	-0.023**	-0.013	-0.074***	-0.042	-0.026
	(0.000)	(0.027)	(0.169)	(0.001)	(0.101)	(0.239)
MVLOSS	-0.148***	-0.075**	-0.052*	-0.242***	-0.069	-0.025
	(0.000)	(0.014)	(0.070)	(0.000)	(0.194)	(0.581)
MES*T1	5.265***	3.163***	2.280***	6.979***	5.186***	3.719***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ΔCoVaR*mv	3.223***	1.449***	1.321***	5.040***	1.600*	0.967
	(0.000)	(0.002)	(0.004)	(0.000)	(0.057)	(0.177)
_cons	0.268*	0.197	0.177	0.758***	0.259	0.243
	(0.052)	(0.145)	(0.174)	(0.000)	(0.267)	(0.227)
R2_a	0.929	0.843	0.806	0.939	0.873	0.850
Observation	57	57	57	57	57	57

Table 12. Market based measures vs. EBA 2011 total losses

This table summarizes the results of regression the EBA 2011 stress test projected total losses on market systemic risk measures (SRISK, MV Loss, MES * T1 and ΔCoVaR * mv). Results are presented for the three years and for the baseline and adverse scenario. The market systemic risk measures are dowloaded:12/31/2010. The reported R^2 is then the Pseudo R^2.

***, ** and* indicate significance at 0.01, 0.05 and 0.10 levels, respectively.

	(1)	(2)	(3)	(4)
	T.Loss2011BS	**T.Loss2012BS**	**T.Loss2011AS**	**T.Loss2012AS**
SRISK	-0.024**	-0.018**	-0.061*	-0.019
	(0.040)	(0.030)	(0.061)	(0.293)
MV_LOSS	0.181**	0.043	0.393**	0.287***
	(0.024)	(0.450)	(0.014)	(0.002)
MES*T1	2.288***	2.170***	4.503***	2.503***
	(0.001)	(0.000)	(0.001)	(0.001)
ΔCoVaR*mv	-0.770	0.544	-3.240**	-1.374*
	(0.278)	(0.295)	(0.025)	(0.085)
_cons	0.106	0.107	0.132	0.487**
	(0.615)	(0.489)	(0.752)	(0.040)
R2_a	0.817	0.861	0.781	0.890
Observation	53	53	53	53

Table 13. SRISK vs. EBA 2014 capital shortfall in terms of RWA

This table summarizes the results of regression EBA shortfall in terms of RWA with the zero bound on SRISK. Results are presented separately for the 2 years, for which the data is available, and for the baseline and adverse scenario: 2014_B 2015_B 2014_A 2015_A. For each regression SRISK is calculated at the end of the period over which the dependent variable is measured. In the Probit regression the dependent variable is converted into a binary variable by only considering higher than zero and less than zero. The reported R^2 is then the Pseudo R^2.
***, ** and* indicate significance at 0.01, 0.05 and 0.10 levels, respectively.

	OLS (1)	**OLS (2)**	**OLS (3)**	**OLS (4)**	**PROBIT (5)**	**PROBIT (6)**	**PROBIT (7)**	**PROBIT (8)**
	Shortfall 14_B	**Shortfall 15_B**	**Shortfall 14_A**	**Shortfall 15_A**	**Shortfall 14_B**	**Shortfall 15_B**	**Shortfall 14_A**	**Shortfall 15_A**
SRISK_B_2014	-0.002***				-0.029**			
	(0.004)				(0.010)			
SRISK_B_2015		-0.002***				-0.034**		
		(0.003)				(0.017)		
SRISK_A_2014			-0.002**				-0.023**	
			(0.040)				(0.038)	
SRISK_A_2015				-0.004***				-0.047**
				(0.002)				(0.013)
_cons	0.209***	0.206***	0.108**	0.217***	-0.691***	-0.676***	-1.193***	-0.689***
	(0.002)	(0.002)	(0.025)	(0.001)	(0.004)	(0.005)	(0.000)	(0.002)
R2_a	4.82%	4.63%	1.58%	4.22%	9.95%	10.29%	4.33%	8.59%
Observation	57	57	57	57	57	57	57	57

Table 14. SRISK vs. EBA 2014 capital shortfall in terms of total assets

This table summarizes the results of regression EBA shortfall in terms of total assets on SRISK. Results are presented separately for the 2 years, for which the data is available, and for the baseline and adverse scenario: 2014_B 2015_B 2014_A 2015_A. For each regression SRISK is calculated at the end of the period over which the dependent variable is measured. In the Probit regression the dependent variable is converted into a binary variable by only considering higher than zero and less than zero. The reported R^2 is then the Pseudo R^2.***, ** and* indicate significance at 0.01, 0.05 and 0.10 levels, respectively.

	OLS (1)	**OLS (2)**	**OLS (3)**	**OLS (4)**	**PROBIT (5)**	**PROBIT (6)**	**PROBIT (7)**	**PROBIT (8)**
	Shortfall_14_B	**Shortfall_15_B**	**Shortfall_14_A**	**Shortfall_15_A**	**Shortfall 14_B**	**Shortfall 15_B**	**Shortfall 14_A**	**Shortfall15_A**
SRISK _B_2014	347.490***				0.117*			
	(0.000)				(0.088)			
SRISK_B_2015		319.217***				0.244**		
		(0.000)				(0.020)		
SRISK_A_2014			228.956***				0.065*	
			(0.000)				(0.057)	
SRISK_A_2015				298.158***				0.237**
				(0.000)				(0.027)
_cons	2070.900***	2410.286***	1253.719***	2134.001***	0.634*	0.291	0.483**	0.517**
	(0.000)	(0.000)	(0.008)	(0.000)	(0.052)	(0.355)	(0.041)	(0.038)
R2_a	82.9%	83.5%	58.6%	61.6%	23.5%	28.7%	13.9%	23.8%
Observation	57	57	57	57	57	57	57	57

Figure 1. *V-Lab* market cap loss (EUR millions)
Banks are ranked according to their MV loss. *V-Lab* download date: 12/31/2013

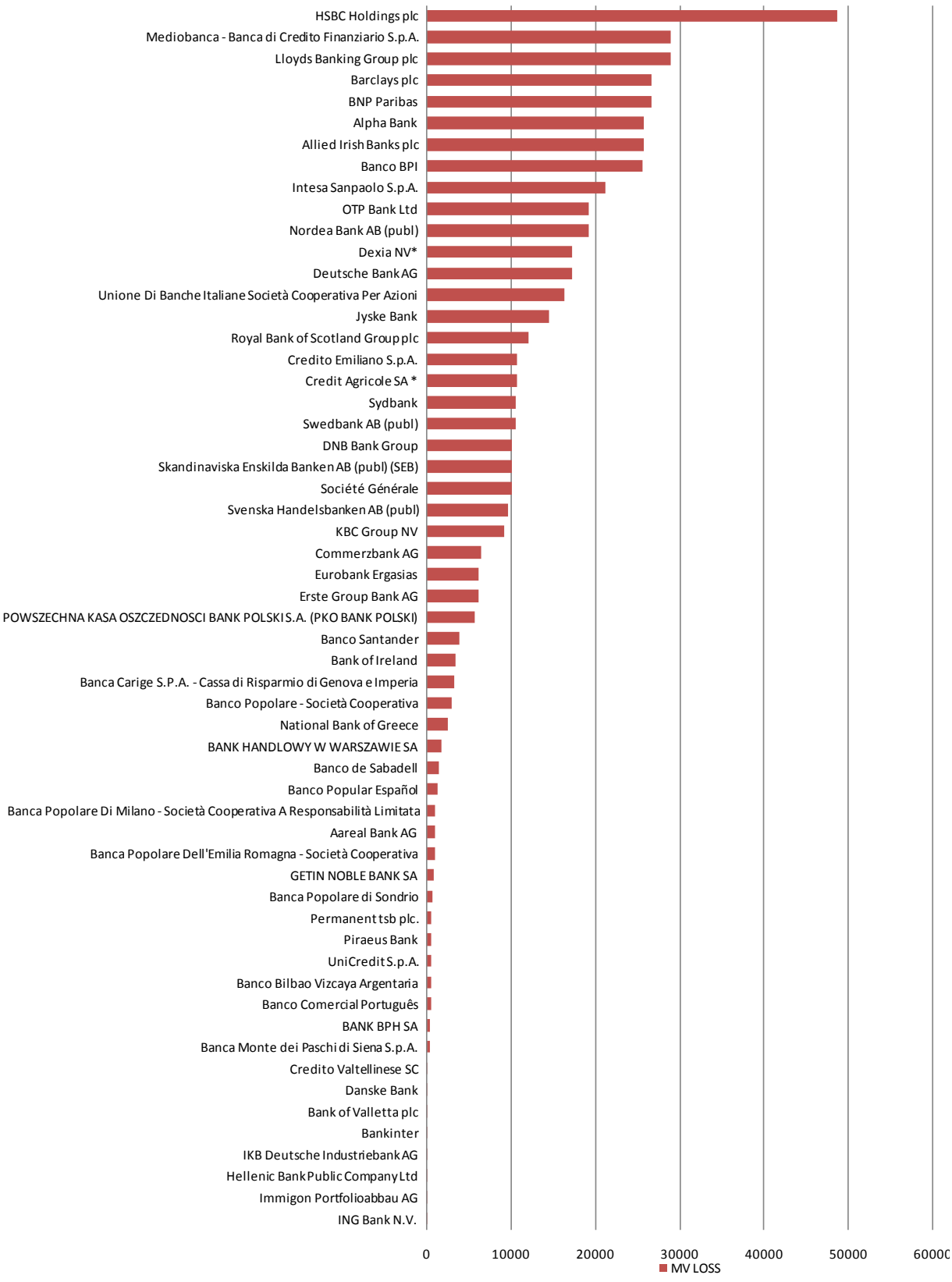

Figure 2 . EBA-Total loss vs. MES

This graph compares the systemic risk measure: marginal expected shortfall (MES) weighted by bank's tier-1 capital to the EBA stress test result for the year 2016 during the baseline scenario

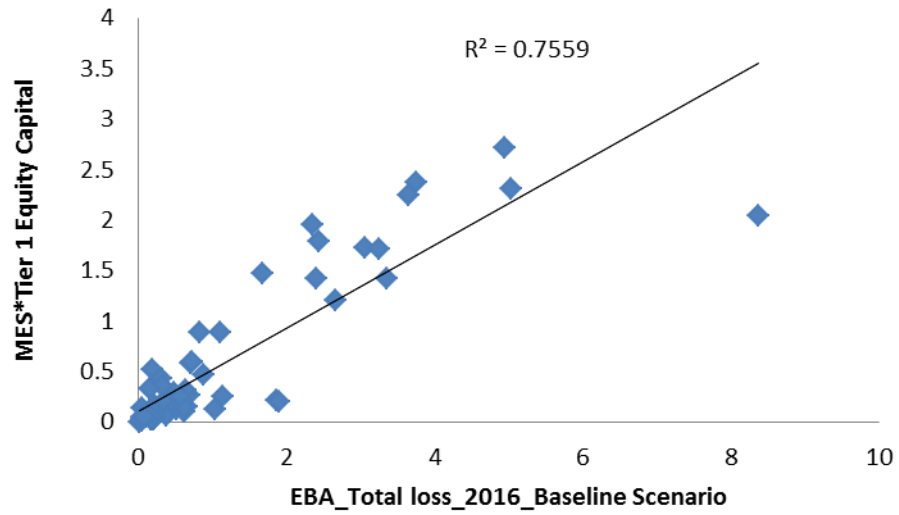

Figure 3. EBA-Total loss vs. ΔCoVaR

This graph compares the systemic risk measure: conditional value at risk (ΔCoVaR) in euro term to the EBA stress test result for the year 2016 during the baseline scenario.

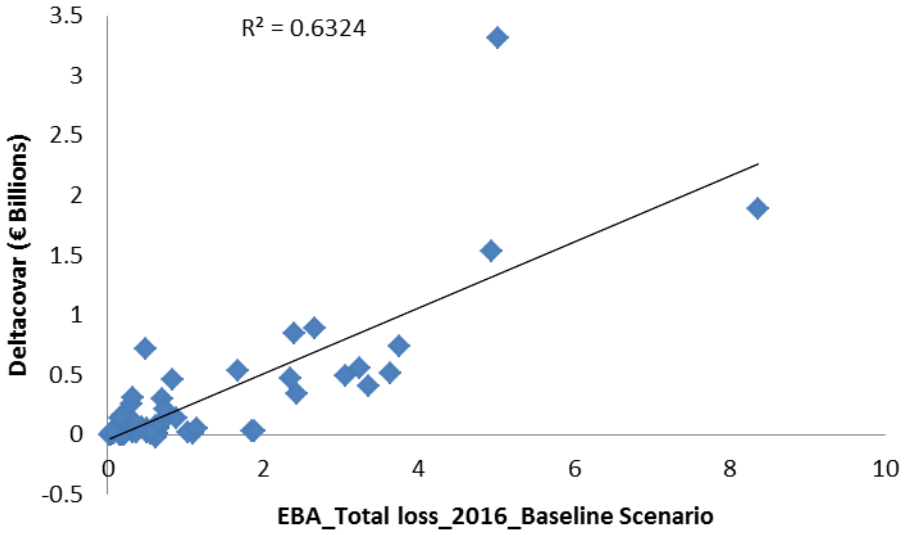

Figure 4. EBA Disclosed Capital Shortfall vs. SRISK
Disclosed capital shortfall in the EBA 2014 stress test (eq. (2)) vs. SRISK (EUR Billions).
V-Lab download date: 12/31/2013.

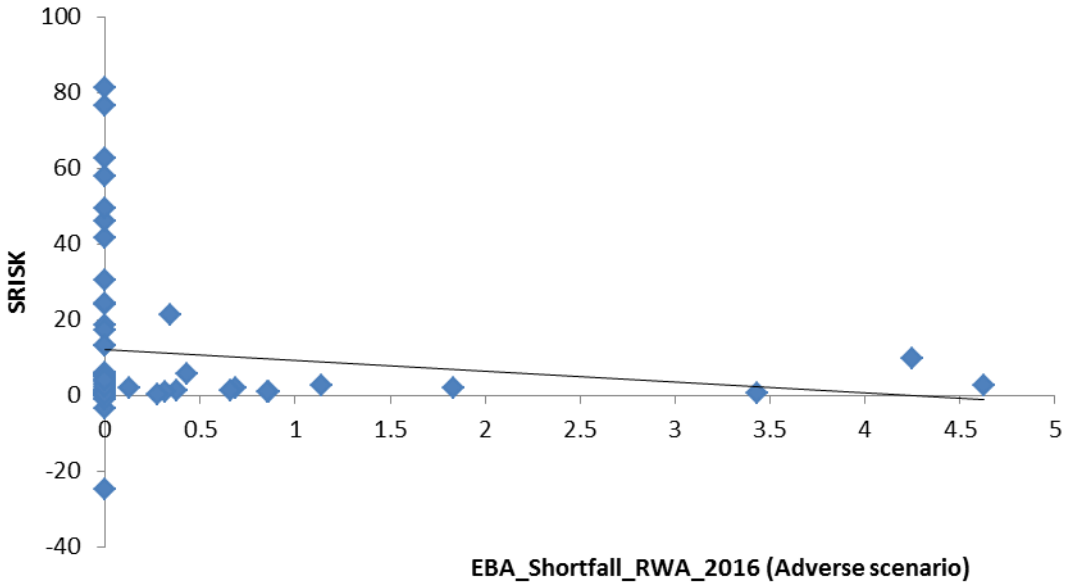

Figure 5. EBA 2014 stress test 'absolute' risk capital/excess (EUR millions)
B stands for baseline scenario and A stands for adverse scenario

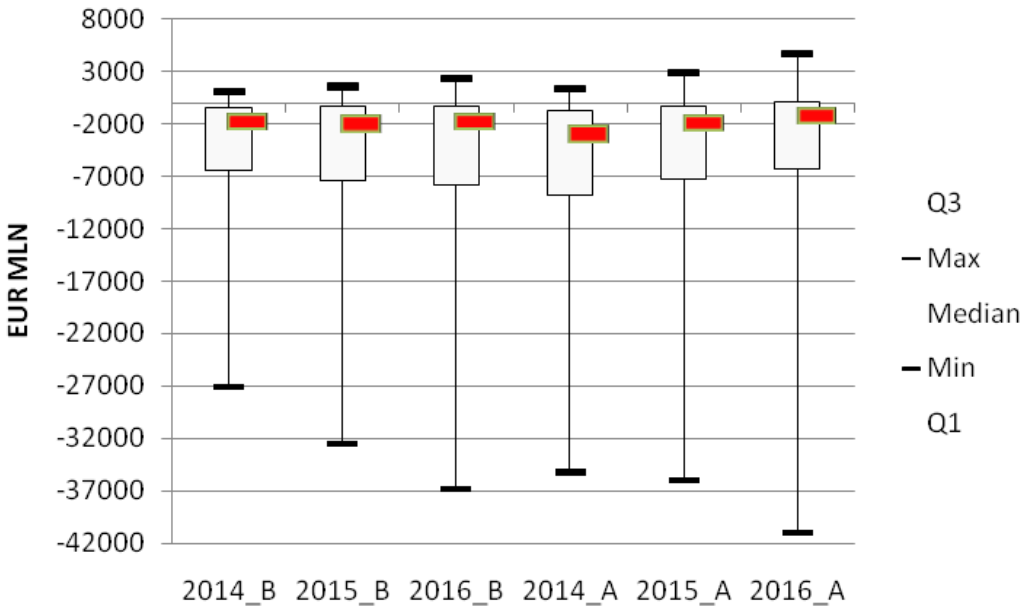

Figure 6. EBA 'Absolute' Capital Shortfall/excess vs. SRISK
EBA 2014 stress test 'absolute' risk-based capital shortfall/excess (eq. (3)) vs. SRISK (EUR billions).
V-Lab download date: 12/31/2013

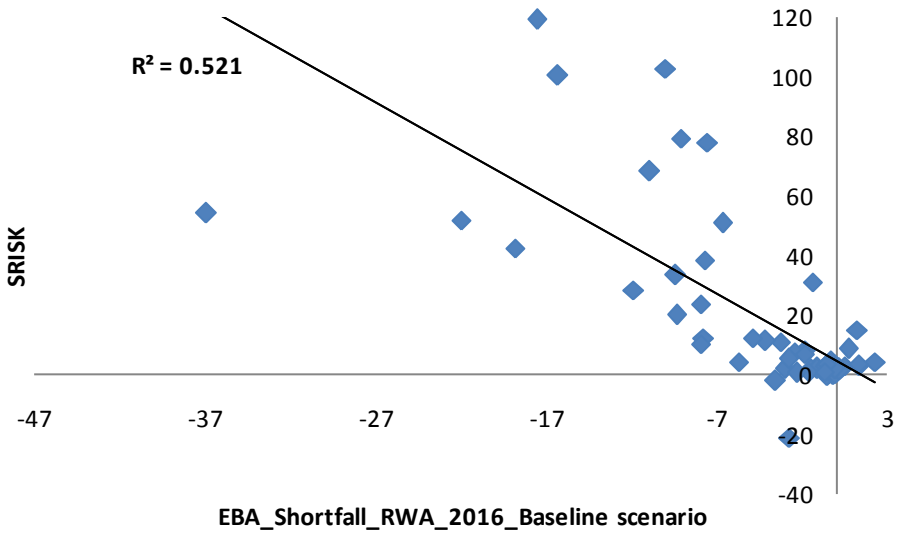

Figure 7. EBA Capital Shortfall in terms of total assets vs. SRISK
EBA 2014 stress test leverage-based (eq.(4)) vs. SRISK (EUR billions).
V-Lab download date: 12/31/2013

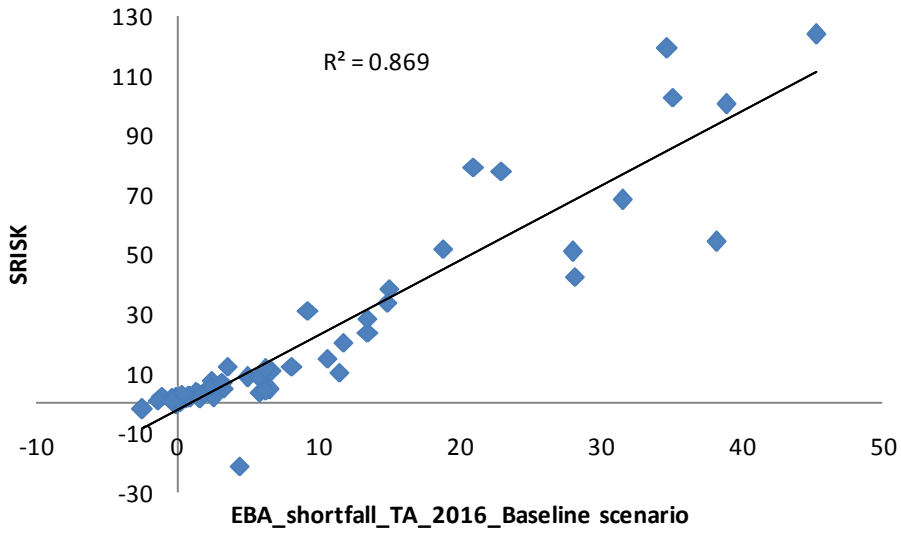

Figure 8: **EBA Capital Shortfalls**

The required capitalization (in total) of the 57 EU banks.EBA represents the Disclosed capital shortfall in the EBA 2014 stress test (eq. (2)),TA represents EBA 2014 stress test leverage-based (eq.(4)) and RWA represents EBA 2014 stress test 'absolute' risk-based capital excess (eq. (3)). B stands for the baseline scenario and A stands for the adverse scenario

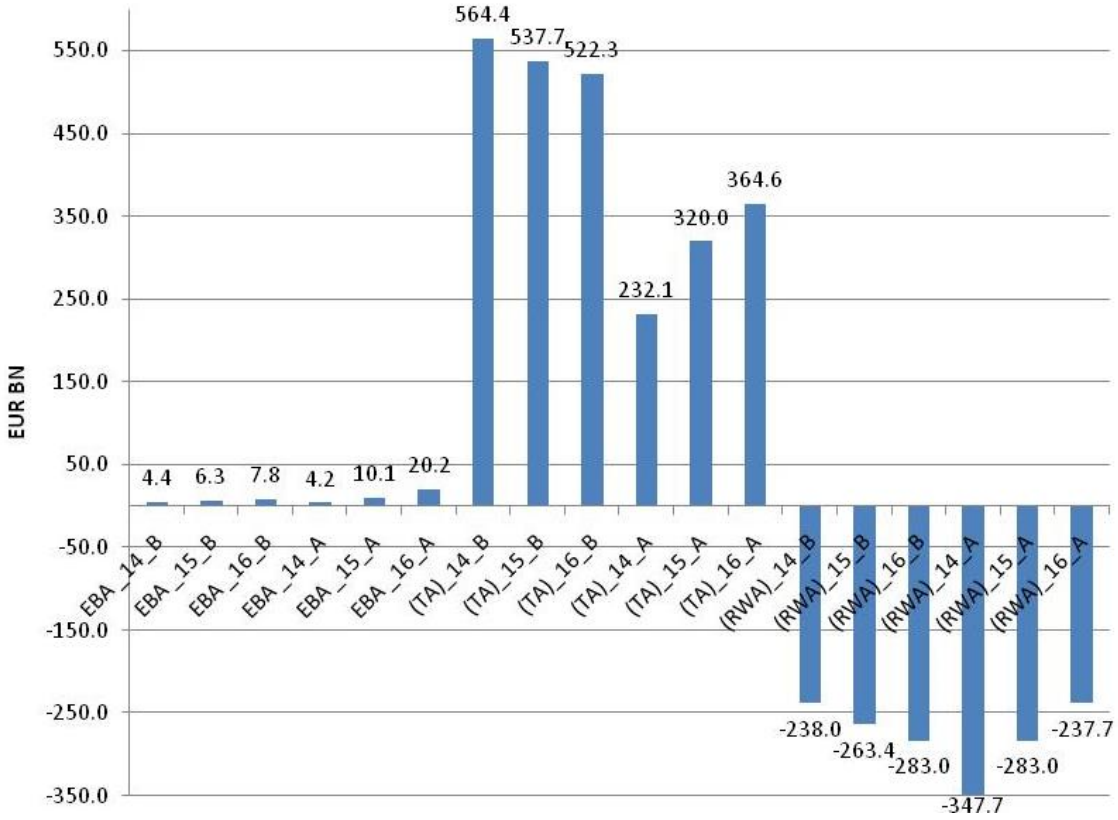

Figure 9. Stress tests Tier 1 leverage ratios vs. *V-Lab* market leverage ratio

EBA 2014 stressed T1 Leverage ratio vs. *V-Lab* market leverage ratio. *V-Lab* download date: 12/31/2013. EBA 2014 ratios are the projected ratios at the end of the stress scenario.

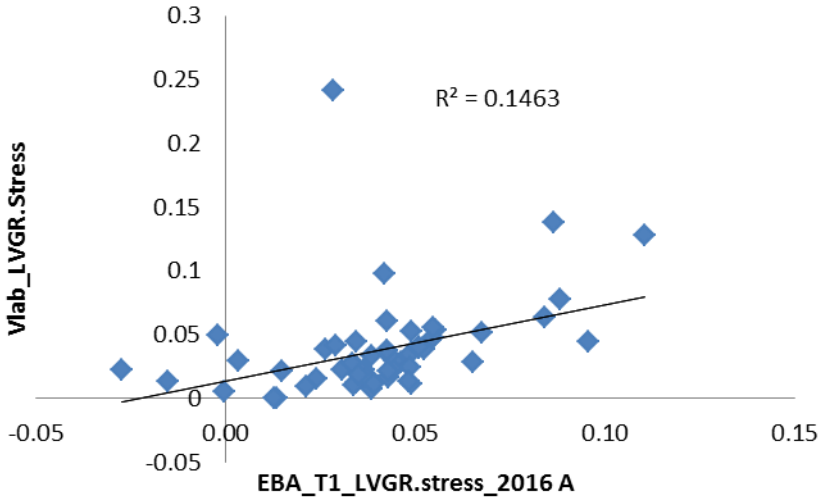

Figure 10. Stress test risk weight vs. *V-Lab* risk weight
Stress test risk weight vs. *V-Lab* risk weight. Projected regulatory risk weight at the end of the EBA 2014 stress scenario (RWA/TA) against *V-Lab* risk weight (eq.(10)).
V-Lab download date: 12/31/2013.

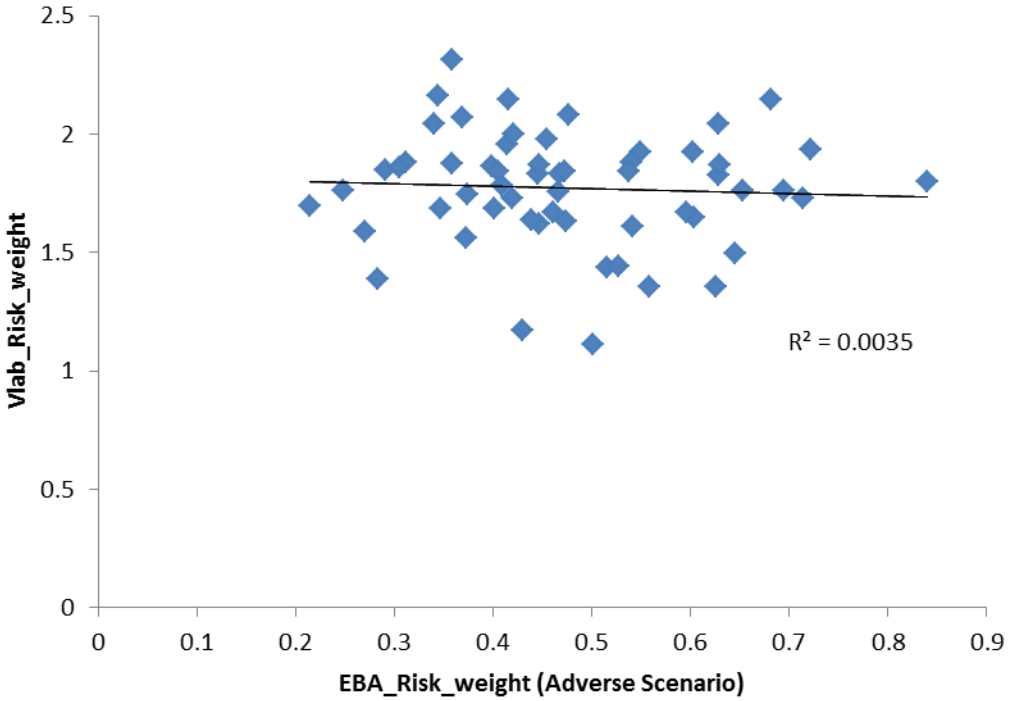

Figure 11. Stress test risk weight vs. T1 leverage ratio
Stress test risk weight vs. T1 leverage ratio. Projected regulatory risk weight at the end of the EBA 2014 stress scenario (RWA/TA) against the projected Tier 1 Leverage ratio at the end of the EBA 2014 stress scenario.
V-Lab download date: 12/31/2013