Assessing Banking Risk in Europe: Replication of and Extension of "Testing macroprudential stress tests: The risk of regulatory risk weights" by Acharya, Engle, and Pierret (2014)

Comparative Macroprudential Stress Testing: Assessing European Banks in 2016

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Abstract

This report analyzes the findings of the article *"Testing Macroprudential Stress Tests: The Risk of Regulatory Risk Weights"* by Acharya, Engle, and Pierret (2014), which concludes that regulatory stress tests often underestimate capital shortfalls compared to V-Lab, especially during times of economic stress, giving an overly optimistic view of banks' stability. To evaluate this claim, the same comparative analysis from the article for the 2011 EBA stress tests and the V-Lab stress test was replicated and extended to 2016. The final results indeed corroborate the article's conclusion that risk-based regulatory capital shortfalls are underestimated, with asset-based capital shortfalls yielding more favorable outcomes.

Key Words: V-Lab Stress Test; EBA Stress Test; Risk-weighted-based Capital Requirements; Asset-based Capital Requirements; Capital Shortfalls.

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1. Introduction

The 2008 financial crisis had profound and far-reaching effects on the global economy, particularly within the baking sector. Numerous financial institutions faced severe liquidity shortages and solvency crises, resulting in government bailouts and substantial monetary interventions. In this manner, as stated by Buch and Dages (2018) "the global crisis exposed a pattern of excessive risk-taking and inadequate capital and liquidity buffers within the industry, together with shortcomings in the prudential framework".

In order to prevent the recurrence of the crises and to address the new challenges and uncertainties of the post-crisis economy, a series of initiatives and new regulations were implemented with the aim of improving the resilience of the banking industry and restoring public confidence. Particular emphasis was given to the implementation of macroprudential stress tests in order to evaluate the resilience of financial institutions, ensuring that banks could survive adverse economic conditions.

Nevertheless, criticism has emerged on the accuracy and efficiency of the traditional regulatory stress test. The article *"Testing Macroprudential Stress Tests: The Risk of Regulatory Risk Weights"* by Acharya, Engle, and Pierret (2014), critically evaluated the limitations of traditional stress tests by comparing its results with a market-based alternative, the V-Lab stress test. This comparison exposed notable differences between the capital shortfall estimated by the regulatory stress tests and those derived from real-time market data, thereby undermining the accuracy of regulatory risk-weight based stress tests.

This report aims to assess prevailing doubts regarding the effectiveness of the traditional regulatory stress test. To critically evaluate the conclusions presented in the article *"Testing Macroprudential Stress Tests: The Risk of Regulatory Risk Weights"* by Acharya, Engle, and Pierret (2014), will be conducted a replication of Figure 3 a) – EBA Capital Shortfall vs SRISK,

Figure 3 b) EBA Overall Shortfall vs SRISK, Figure 4 a) EBA “absolute” risk-based Capital Shortfall vs SRISK and Figure 4 b) – EBA leveraged based capital shortfall vs SRISK, as well as Table 3 – Realized volatility regressions, for the year 2011 of the referred article.

Furthermore, by extending the recreation and analysis of the mentioned figures and table to 2016, this paper aims to contribute to the ongoing discussion about the adequacy of macroprudential stress tests and assess whether the discrepancies between regulatory and marked-based stress tests have persisted or widened in recent years. The ultimate goal is to offer insights into how regulatory frameworks can be enhanced to better capture emerging risk and safeguard financial stability in an increasingly complex and interconnected global economy.

2. SRISK and V-Lab Data

In order to obtain a deeper understanding of the methodology employed by the Volatility Laboratory (V-Lab) in its systemic risk analysis, an analysis of V-Lab and the range of data it offers was conducted. The key concepts from this examination are outlined below according to the information presented on the V-Lab website.

The **Crisis Threshold** represents the market index decline percentage over six months that triggers a systemic crisis, the default threshold is 40%, mirroring the 2007-2009 financial crisis. (Volatility Laboratory n.d.).

Prudential Capital Requirement (k) is the capital ratio an institution needs to withstand a crisis. According to the Volatility Laboratory (n.d.), the default prudential capital requirement is defined as 8% for firms in Africa, Asia, and America and 5.5% for Europe, which will be the focus of this report.

As quoted by the Volatility Laboratory (n.d.), **SRISK** accounts for "the expected capital shortfall of a financial firm in a systemic crisis where the broad market index falls by more than 40% in a six-month period". SRISK is calculated as

$$SRISK = k * Debt - (1 - k) * (1 - LRMES) * MV \quad (1)$$

LRMES represents the expected percentage loss in a firm's equity when the MSCI All-Country World Index falls by the crisis threshold in a six-month period (Volatility Laboratory n.d.). It is computed according to the formula below, where **d** is the six-month crisis threshold for the market index decline and **beta** is the firm's Dynamic Conditional Beta (Volatility Laboratory n.d.).

$$LRMES = 1 - \exp(\log(1 - d) * beta) \quad (2)$$

According to the same source, **Marginal SRISK** is defined as the difference between SRISK at the currently selected market decline and SRISK at a 0% market decline.

Cor is defined by Volatility Laboratory (n.d.) as “the dynamic conditional correlation between the equity return on a stock and the return on the MSCI All-Country World Index”.

Vol is the annualized volatility of the equity of the company, estimated with a GJR-GARCH model and updated daily (Volatility Laboratory n.d.).

Lastly, **Lvg** is the Quasi Leverage of a company, calculated as 1 plus its book value of liabilities divided by its market value of equity (Volatility Laboratory n.d.). In the case of firms with separate accounts, liabilities should be reduced by the proportion of separate accounts to include in the SRISK calculation.

3. Literature and Previous Research

"Testing Macroprudential Stress Tests: The Risk of Regulatory Risk Weights"

The global financial crisis of 2008 underscored the need for robust mechanisms to assess the resilience of financial institutions. One key tool developed in the aftermath was the macroprudential stress test, which became integral to financial regulation. Stress tests are designed to evaluate how well a bank can withstand adverse economic scenarios and ensure that it holds sufficient capital to absorb potential losses. In the context of the paper "*Testing Macroprudential Stress Tests: The Risk of Regulatory Risk Weights"* by Acharya, Engle, and Pierret (2014), plays a crucial role by critiquing traditional regulatory stress tests and proposing an alternative market-based approach.

Regulatory stress tests, as conducted by bodies like the Federal Reserve and the European Central Bank, rely on regulatory risk weights to assess risk. These weights are predefined metrics that assign the level of risk to different assets held by banks, for instance, government bonds may receive a lower risk weight, while loans to small businesses might be classified as riskier. However, multiple studies have criticized the static and rule-based approach. Risk weight is often based on regulatory assumptions rather than real-time data, which can misrepresent actual market conditions. The paper argues that the risk weight failed to capture evolving market risks, such as those seen during the financial crisis, where ostensibly safe assets like mortgage-backed securities turned out to be highly volatile. Similarly, Demirgüç-Kunt and Detragiache (2010) contend that regulatory stress tests provide a snapshot of bank stability based on historical data, which may not reflect certain markets shift or contagion effects. Acharya, Engle, and Pierret (2014) build upon this criticism, demonstrating how regulatory risk weights can underestimate systemic risk, particularly in times of financial distress. The paper compares the capital shortfall predicted by regulatory stress tests to those estimated using a market-based alternative the V-lab stress test developed at NYU. The V-lab

test uses real-time market data making it more responsive to changes in market conditions and systemic risk factors

This test offers a distinct approach to evaluating systemic risk instead of relying on fixed risk weights. It uses statistical models to assess value at risk and expected shortfall, key measures that reflect an institution's risk exposure based on current market data. Value at risk, for instance, meets the maximum potential loss over a specific period with a certain confidence level, while the expected shortfall calculates the expected loss if that threshold is exceeded. These techniques provide a dynamic view of risk, taking into account market volatility asset correlation, and systemic shocks. Multiple studies have emphasized the value of market-based measures and assessing financial stability. Adrian and Brunnermeier (2016) proposed a "CoVar", a model similar to the V-lab that captures the spillover risk from one financial institution to another. They argue that market-based stress tests can more accurately capture interconnectedness and contagion risk factors that regulatory tests often overlook. The V-lab model like the CoVar model adapts to market conditions, offering a more forward-looking perspective on the risk. In this paper, I also found that the V-Lab stress test consistently predicts larger capital shortfalls compared to regulatory tests, particularly during periods of financial instability. This suggests that regulatory tests may give a false sense of security by underestimating the true risk exposure of banks especially those "too big to fail"

The core debate surrounding stress testing frameworks is whether to rely on regulatory or market-based approaches to measure risk. Advocates of regulatory stress tests argued that they are almost standardized and transparent, making it easier for regulators to compare banks across the sector. Regulatory stress tests also ensure consistency, as banks are evaluated under the same hypothetical scenarios. However, their reliance on fixed risk weights can overlook important dynamics of financial markets. Market-based stress tests, like V-Lab, provide more flexibility and can quickly incorporate changes in market volatility and systematic risk. Studies

like Huang, Zhou, and Zhu (2012) have shown that market-based measures, such as credit default swap (CDS) spreads, can offer early warnings of financial stress well before regulatory tests reflect this risk. Acharya, Engle, and Pierret (2014) reinforce this argument by showing that V-lab tests, which incorporate market data, highlight larger capital shortfalls and better reflect real-time risk. However, critics of the market-based approach caution that these models can be highly sensitive to short-term market fluctuations, which may lead to overestimation of this during periods of temporary market stress. This could force banks to hold excessive capital buffers, potentially stifling lending and economic growth oh this "procyclical" nature of market-based stress tests could exacerbate economic downturns by concerning banks' lending capacity during times of market volatility

Since the publication of Acharya, Engle, and Pierret (2014), new risks have emerged in the financial sector, particularly in the fields of climate risk and digital assets, which introduce further complexity into the stress testing debate. Recent studies have highlighted the growing importance of integrating climate-related financial risk into stress-testing frameworks. The Network for Greening the Financial System (NGFS) has called for stress tests that incorporate scenarios related to climate change, such as the transition to a low-carbon economy or physical risk from extreme weather events. The market-based model could be more adaptable to this risk as they integrate environmental data into their stressed scenarios. Secondly, the digital assets and cryptocurrencies. The rise of digital currencies and decentralized finance has introduced new sources of systematic risk. Stress testing frameworks must now account for the volatility and potential contagion effect of digital assets. Some studies argue that the regulatory stress test, as currently structured does not adequately capture the risk posed by cryptocurrency and their interconnectedness with traditional financial institutions. Market-based stress tests could offer a better approach to integrating these new financial products into systematic risk evaluations.

In conclusion, the literature highlights a persistent tension between regulatory and market-based approaches to stress testing. While regulatory stress tests offer standardization and transparency, they often fail to capture the real-time dynamics of the systemic risk. Market-based models, like most of the ones used until V-Lab, failed to capture the real-time dynamics of systematic risk. On the other hand, a market-based model like the V-Lab one provides a more adaptable framework, incorporating current market conditions into risk assessment. However, concerns about the procyclical tendency as sensitivity to short-term volatility remain. They also argue that integrating market-based measures into macroprudential stress tests with the financial landscape evolving rapidly, particularly with new risks like climate change in digital assets, this integration will likely be crucial for improving the effectiveness of stress tests. Future research should explore how this emerging risk can be systematically incorporated into both regulatory and market-based stress tests to ensure financial stability and an increasingly complex global economy.

In order to compare this initial study with an updated global economy and financial markets, it was necessary to compare the results presented in 2011 with further years. A year that would preferably incorporate new regulations implemented in the banking system or relevant external events happening. To see if the conclusions from 2011 will still be the same. The selection process involved the review of multiple articles and research studies, with particular emphasis placed on the insights provided by the following key source.

"The Decade of Financial Regulatory Reform: 2009 to 2019"

This paper offers a comprehensive review of financial reforms following the global financial crisis in 2008. After the global financial crisis, several financial reforms were implemented to address systematic risk, particularly within asset management and banking. Amendments and new regulations emerged worldwide, especially in the United States and the European Union,

impacting banks, asset managers, insurers, and other financial entities. The report "*The Decade of Financial Regulatory Reform: 2009 to 2019"* by Novick et al. (2020) emphasizes that reforms aimed to enhance transparency bluster capital requirements and improve liquidity and risk management. First of all, it would look at the US financial regulatory reforms the Dodd-Frank Act (DFA) in the United States was a pivotal point in restructuring financial oversights it mandated stricter regulation on OTC derivatives, establishing the financial stability oversight consent (FSOC) and improve reporting for hedge funds and private equities. The term Dodd-Frank refers to a comprehensive and complicated piece of financial regulation born out of the Great Recession of 2008. The full name of the act is the Dodd-Frank Wall Street Reform and Consumer Protection Act but it is better known and most often referred to as the Dodd-Frank in simple terms. It contains laws that place major regulations on the financial industry. It grew out of the Great Recession with the intention of preventing another collapse of the major financial institutions like Lehman Brothers. Dodd-Frank is also geared toward protecting consumers with rules like keeping borrowers from abusive lending and mortgage practices by banks. The document contains 16 major areas of reform. Some of the most important are the following. Consumer protection to oversee financial products like credit cards, loans, and mortgages, which is one of the main reforms to ensure transparency and prevent abusive practices by financial institutions. They also created, like previously referred, the FSOC to identify risk in financial institutions and market practices. The Volcker rule, restricted prior proprietary trading by banks and limited their investment in hedge funds and private equity to reduce risky activities. They also increased oversight of credit rating agencies, holding them accountable for the accuracy of their ratings. They impose stricter standards for mortgage lending to ensure borrowers can repair loans, aiming to prevent subprime lending abuses. In the end, they also established the Federal Insurance Office FIO to monitor the insurance industry, especially concerning systemic risk and international agreements. The US regulators.

Also implemented reforms to improve the quality and frequency of different data. Focusing on mutual fund reporting, liquidity risk, and stress testing.

Some European Financial regulatory reforms were also analyzed, such as the Alternative Investment Fund Managers Directive (AIFMD). “The Alternative Investment Fund Managers Directive (AIFMD) is a European Union (EU) regulation that applies to alternative investments, many of which were left largely unchecked prior to the 2008-09 global financial crisis. The directive sets standards for marketing around raising private capital, remuneration policies, risk monitoring, and reporting, as well as overall accountability. The primary goal of the AIFMD is to protect investors as well as reduce some of the systemic risks that alternative investment funds can pose to the EU and its economy.” Says A. Hayes (2021) in “Alternative Investment Fund Managers Directive (AIFMD)”

New regulations such as the Markets in Financial Instruments Directive (MiFID II) and European Market Infrastructure Regulation (EMIR) also appeared after the crisis to increase the transparency and accountability of the different markets and to reduce the risk associated with derivative trading. Finally, the paper focuses on the possible future areas of financial regulations. The different examples given are, firstly the LIBOR transition. Which is a benchmark interest rate that is used globally in financial contracts of any type. However, some concerns about manipulation and reliability have risen in the past years. And so, regulators initiated its phase-out. In 2021 the Secured Overnight Financing Rate (SOFR) has emerged as its replacement. This transition includes multiple risks, with contract changing, managing financial reports, etc. A second example included in this paper is the issue of cybersecurity. Financial markets are becoming more and more digital. With it, the protection of financial infrastructure has become one of the top priorities. It is not impossible to see the trading platforms, financial data, etc. being attacked causes large-scale market instability. Financial institutions are investing in advanced security measures such as real-time monitoring, incident

response protocols, and regulatory compliance frameworks like the EU's General Data Protection Regulation (GDPR). With these two being the main preoccupation right now, the paper still talks about the pension fund underfunding and when the promised future payments exceed their assets. Or as the Central Clearing Counterparties and the market fragmentation and equity market resiliency that is happening in the financial world nowadays. To conclude, the paper *"The Decade of Financial Regulatory Reform: 2009 to 2019"* by Novick et al. (2020) shows us that the evolution of financial regulation after the Great Financial Crisis of 2008 has transformed the market in terms of risk and transparency. The regulatory framework remains a work in progress. And regulations are added every year to adapt to the emerging markets and the shifts in the actual ones.

4. Methodology

Figure 3 a): EBA Disclosed Capital Shortfall vs SRISK 2011

In order to recreate Figure 3 a) from Acharya, Engle, and Pierret (2014), the capital shortfall estimate presented in the EBA stress test published in July 2011 (EBA_Shortfall.RWA) was regressed on the capital shortfall estimates SRISK under V-Lab stress scenario, in € millions. The disclosed capital shortfall estimates in the 2011 EBA stress test are given by

$$Disclosed\ Capital\ Shortfall\ =\ \max(0, [k' * RWA_S - Capital_S]) \qquad (3)$$

Where k' is the 5% prudential capital ratio used in the 2011 EBA stress test (Acharya, Engle, and Pierret 2014). RWAs are the risk-weighted assets of each bank at the end of the adverse stress test scenario (Acharya, Engle, and Pierret 2014), on 31/12/2012, given by item 30025 "Capital adequacy – Risk-weighted assets after the effects of mandatory restructuring plans publicly announced and fully committed before 30 April 2011". Capitals refers to the capital level of each bank also at the end of the adverse stress test scenario (Acharya, Engle, and Pierret 2014), on 31/12/2012, given by item 30035 "Capital adequacy - Core Tier 1 capital after government support, capital raisings and effects of restructuring plans fully committed by 30 April 2011". Python was used for the correct cleaning and treatment of the EBA data to achieve the desired Disclosed Capital Shortfall.

The SRISK capital shortfall estimates were obtained by collecting the SRISK value provided on the V-Lab database for each bank on 31/12/2010 and converting these values to EUR using the relevant historical USD/EUR exchange rate of 0.7518 obtained through Yahoo! Finance (2010).

When cross-referencing the already clean and treated data from EBA and V-Lab it was only possible to identify 26 matching banks out of the 90 banks participating in the 2011 EBA stress test. Since the V-Lab database and SRISK estimations are based on public market-based

information, most of the banks not identified on the V-Lab database were non-public traded banks.

Figure 3 b): EBA Overall Capital Shortfall vs SRISK 2011

To recreate Figure 3 b) from Acharya, Engle, and Pierret (2014), the Overall Shortfall estimates disclosed in the EBA Capital exercise in December 2011 (EBA_Overall_Shortfall) were regressed on the capital shortfall estimates SRISK under V-Lab stress scenario, in € millions.

The overall capital shortfall estimate in the EBA Capital Exercise is given by

$$EBA\ Overall\ Shortfall\ =\ \max(0, [0.09 * RWA - TIC]) + BuffSOV \qquad (4)$$

Where 9% is the target Core Tier 1 capital ratio, RWA_s are the risk-weighted assets of each bank and BuffSOV represents the capital buffer resulting from eurozone sovereign debt exposures (Acharya, Engle, and Pierret 2014).

However, due unavailability of the BuffSOV variable, the overall shortfall was obtained by using item 101300 "Overall Shortfall (+) / Surplus (-) after including sovereign capital buffer and additional impairments on sovereign exposures" on 30/09/2011, from the Capital Composition Data file of the data disclosed regarding the Capital Exercise.

The SRISK capital shortfall estimates were obtained by collecting the SRISK value provided by V-Lab for each bank on 30/09/2011 and converting these values to EUR by using the relevant historical USD/EUR exchange rate of 0.7361 obtained through Yahoo! Finance (2011).

Due to the same restrictions on the availability of SRISK estimates mentioned above, it was only possible to identify 40 banks out of the 90 banks participating in the 2011 EBA stress test.

Figure 4 a): EBA Absolute Risk-based Capital Shortfall vs SRISK 2011

On the recreation of Figure 4 a) from Acharya, Engle, and Pierret (2014), it was regressed the "absolute" risk-based capital shortfall/excess in the EBA stress test disclosed in July 2011

(EBA_Shortfall.RWA (absolute)) on the capital shortfall estimates SRISK under V-Lab stress scenario, in € millions.

The absolute capital shortfall estimates in the 2011 EBA stress test are given by

$$Absolute\ Disclosed\ Capital\ Shortfall\ =\ k' * RWA_S - Capital_S \quad (5)$$

Where k' is the 5% prudential capital ratio used in the 2011 EBA stress test (Acharya, Engle, and Pierret 2014), RWA_s are the risk-weighted assets of each bank at the end of the stress test scenario (Acharya, Engle, and Pierret 2014), 31/12/2012, given by item 30025 "Capital adequacy - Risk-weighted assets after the effects of mandatory restructuring plans publicly announced and fully committed before 30 April 2011"; $Capital_s$ refers to the capital level each bank at the end of the stress test scenario (Acharya, Engle, and Pierret 2014), 31/12/2012, given by item 30035 "Capital adequacy - Core Tier 1 capital after government support, capital raisings and effects of restructuring plans fully committed by 30 April 2011"

The SRISK capital shortfall estimates were obtained by collecting the SRISK value provided by V-Lab for each bank on 31/12/2010 and converting these values to EUR by using the relevant historical USD/EUR exchange rate of 0.7518 obtained through Yahoo! Finance (2010).

Due to the same restrictions earlier mentioned, it was only possible to cross-reference 26 banks from the 90 banks included in the 2011 EBA stress test.

Figure 4 b): EBA Leverage-based Capital Shortfall vs SRISK 2011

To recreate Figure 4 b) from Acharya, Engle, and Pierret (2014), the "absolute" risk-based capital shortfall/excess in the EBA stress test disclosed in July 2011 (EBA_Shortfall.RWA (absolute)) was regressed on the capital shortfall estimates SRISK under V-Lab stress scenario, in € millions.

The leverage-based capital shortfall estimates in the 2011 EBA stress test are given by

$$Capital\ Shortfall\ (TA)\ =\ k * TA_S - Capital_S \quad (6)$$

Where k is the 5,5% prudential capital ratio used in the 2011 EBA stress test (Acharya, Engle, and Pierret 2014), TA_s are the total assets of each bank at the end of the stress test scenario, 31/12/2012, given by item 30029 "Capital adequacy - Total assets after the effects of mandatory restructuring plans publicly announced and fully committed and equity raised and fully committed by 30 April 2011 "; $Capital_s$ refers to the capital level each bank at the end of the stress test scenario, 31/12/2012, given by item 30035 "Capital adequacy - Core Tier 1 capital after government support, capital raisings and effects of restructuring plans fully committed by 30 April 2011".

Also as described in the methodology of previous figures The SRISK capital shortfall estimates were obtained by collecting the SRISK value provided by V-Lab for each bank on 31/12/2010 and converting these values to EUR by using the relevant historical USD/EUR exchange rate of 0.7518 obtained through Yahoo! Finance (2010).

Due to the same restrictions earlier mentioned, it was only possible to cross-reference 26 banks from the 90 banks included in the 2011 EBA stress test.

Table 3: Realized Volatility Regressions 2011

Realized volatility regressions

On the recreation of Table 3 from Acharya, Engle, and Pierret (2014), the six-month realized volatility after disclosure of the EBA stress test in July 2011 was regressed on the book-to-market ratios from 2011, the Tier 1 Leverage ratios (EBA T1LVGR), the EBA risk weights and the V-Lab risk weights.

The dependent variable: six-month realized volatility after disclosure of the EBA stress test in July 2011 is given by

$$6-Months\ Realized\ Volatility\ =\ \sqrt{\frac{1}{W}\sum_{t+1}^{t+1+W}\left(r_{it}-\overline{r_{it,W}}\right)^2} \quad (7)$$

Where W=130 days (six months) and $R_{it,W}$ is the six-month forward average stock return of bank i at time t (the stress test disclosure date 15/07/2011) (Acharya, Engle, and Pierret 2014). To approximate this value, Rob Capellini Director at V-Lab and VRI Technology

The Volatility and Risk Institute (VRI) in the NYU Stern School of Business inquired how the estimate of annualized volatility, for which it answered the following: “Each CSV file contains a 'var' column with the daily variance for the firm. To obtain annualized volatility figures, multiply the column values by 252 and take the square root.” Once the annualized volatility was obtained, it was divided by 2 in order to get the 6-month volatility that was our independent variable as shown in equation (7).

$$6-Months\ Volatility\ =\ \frac{\sqrt{var*252}}{\sqrt{2}} \quad (8)$$

The Book-to-market ratios in 2011 were obtained through LSEG Workspace.

The EBA T1LVGR is the ratio of Tier 1 capital to total assets at the end of the stress scenario (Acharya, Engle, and Pierret 2014), given by dividing item 30035 "Capital adequacy - Core Tier 1 capital after government support, capital raisings and effects of restructuring plans fully committed by 30 April 2011” by item 30029 “Capital adequacy - Total assets after the effects of mandatory restructuring plans publicly announced and fully committed and equity raised and fully committed by 30 April 2011 ” for each bank.

The EBA risk weight is the ratio of risk-weighted assets to total assets at the end of the stress scenario (Acharya, Engle, and Pierret 2014), 31/12/2012, given by dividing item 30025 “Capital adequacy - Risk-weighted assets after the effects of mandatory restructuring plans publicly announced and fully committed before 30 April 2011” by item 30029 “Capital

adequacy - Total assets after the effects of mandatory restructuring plans publicly announced and fully committed and equity raised and fully committed by 30 April 2011 " for each bank. The V-Lab risk weight estimates were obtained by collecting the LRMES value provided by V-Lab for each bank on 30/06/2011 and applying them to the formula below.

$$V - Lab\ Risk\ Weight\ = (1 - (1 - k) * LRMES)^{-1} \quad (9)$$

The book-to-market ratio was obtained by resourcing to Refinitiv Eikon. With this tool, it was possible to obtain the common shareholder equity and the market capitalization from 2011. The formula of the book-to-market ratio is the following:

$$Book\ to\ Market\ Ratio\ = \frac{Common\ Shareholder\ Equity}{Marekt\ Capitalization} \quad (10)$$

Due to restrictions on the availability of LMRES estimates, book-to-market ratios from 2011, or six-month realized volatility for some of the 90 banks participating in the 2011 EBA stress test at the required date, the regression has 37 data points, contrarily to the 53 data points presented in the original article.

5. Analysis of 2011 Results

Figure 3 a): EBA Disclosed Capital Shortfall vs SRISK 2011

The results of the 2011 recreation of Figure 3 a) are presented below in Figure 1. It is possible to verify that despite the strong limitation on the data available to conduct the recreation of Figure 3 a), the results closely resemble those of the original figure. Consistent with the original results, the recreated figure report values for the EBA Disclosed Capital Shortfall range between €0 and €720 million, with the majority of observations concentrated at the €0 level. Similarly, the SRISK values in the recreated Figure 3 a) align closely with the ones presented in the original figure, ranging between -€4,000 and €94,000 million.

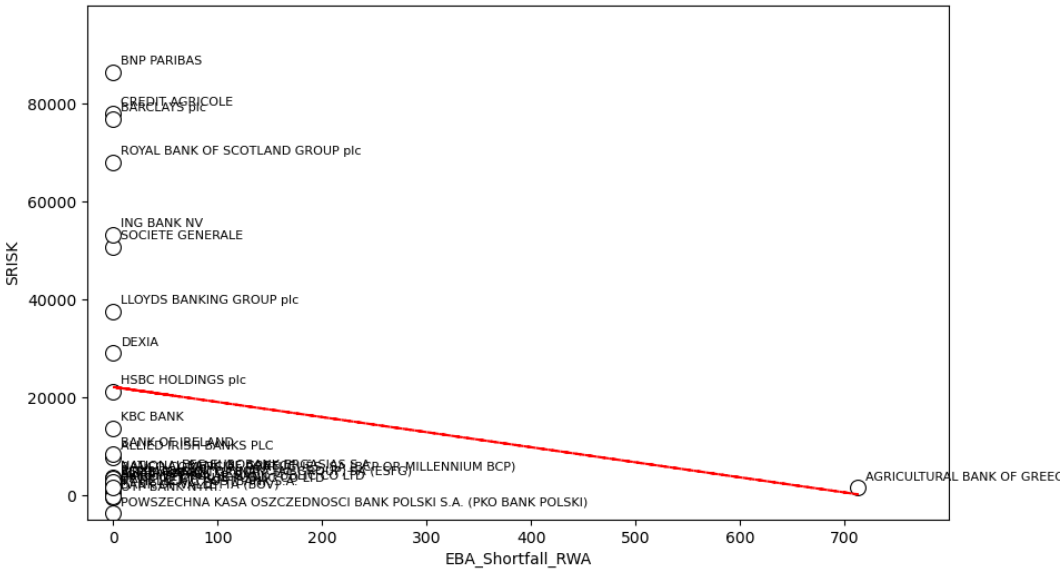


Figure 1: 2011 EBA Disclosed Capital Shortfall vs SRISK

Additionally, the recreated EBA Disclosed Capital Shortfall exhibits an average of approximately €29.64 million, whereas the SRISK value presents an approximate average of €21,189.00 million. These results confirm the conclusion presented in the article "*Testing Macroprudential Stress Tests: The Risk of Regulatory Risk Weights"* by Acharya, Engle, and Pierret (2014), which posits that shortfalls using the V-Lab approach tend to be larger than the ones computed through traditional regulatory stress tests.

The recreated Figure 3 a) presents a correlation coefficient between the two variables of approximately –0.149. However, probably due to the small sample size and the strong uniformization of null results, this metric is not statistically relevant at any conventional significance level.

Although it is not possible to derive confident conclusions from these results, they suggest a disagreement between the EBA stress test results and the SRISK. It should be also noted that the 10 banks that present the highest SRISK values always have a zero EBA Disclosed Capital Shortfall (please verify Annex A)

Figure 3 b): EBA Overall Capital Shortfall vs SRISK 2011

The 2011 recreated Figure 3 b) (figure 2) also closely resembles the corresponding one in the article "*Testing Macroprudential Stress Tests: The Risk of Regulatory Risk Weights*" by Acharya, Engle, and Pierret (2014). Also consistent with the original results, the recreated figure report values for the EBA Overall Capital Shortfall range between €0 million and €15,000, with the majority of observations concentrated between €0 and €4,000. The SRISK values in the recreated Figure 3 b) align closely with the ones presented in the original figure, ranging between -€3,000 and €96,000 million.

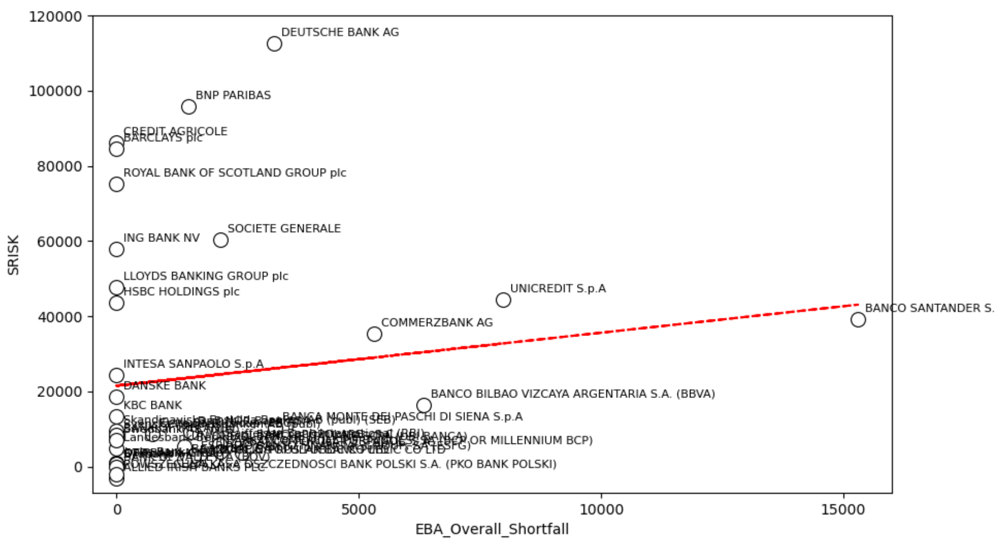


Figure 2: 2011 EBA Overall Shortfall vs SRISK

Furthermore, the recreated EBA Disclosed Overall Shortfall presents an average of approximately €1,619.13 million, whereas the SRISK value presents an approximate average of €23,781.43 million. Although these averages are closer than those observed in the 2011 recreated Figure 3 a), they still exhibit a significant disparity. Once more, this difference reinforces the conclusion presented in the original article, which asserts that shortfalls using the V-Lab approach tend to be larger than the ones computed through traditional regulatory stress tests.

The recreated Figure 3 b) exhibits a correlation coefficient between the two variables of approximately 0.132. Although this figure presents a higher sample size and weaker uniformity for EBA Overall Shortfall values, the correlation between the two variables was not strong enough to present statistically significant results at any conventional significance level.

However, it is essential to observe that six of the most vulnerable banks identified by V-Lab present a €0 Overall Shortfall according to EBA (verify Annex B), suggesting a clear misalignment between EBA and V-Lab stress test results.

Figure 4 a): EBA Absolute Risk-based Capital Shortfall vs SRISK 2011

The 2011 recreated Figure 4 a) (figure 3) also closely resembles the corresponding one in the referenced article. Similarly to the original results, the recreated figure reports values for the "absolute" EBA Disclosed Capital Shortfall range between -€37,00 million and €720, with the majority of observations concentrated between -€5,000 and €0. The SRISK values in the recreated figure also align closely with the ones presented in the original figure, ranging between -€4,000 and €94,000 million, similar to the 2011 recreated Figure 3 a).

Additionally, the recreated EBA Absolute Disclosed Capital Shortfall exhibits an average of approximately -€6,330.16 million, whereas the SRISK value presents an approximate average of €21,189.00 million. These results confirm the conclusion presented in the article "*Testing Macroprudential Stress Tests: The Risk of Regulatory Risk Weights"* by Acharya, Engle, and

Pierret (2014), which posits that shortfalls using the V-Lab approach tend to be extremely larger than the ones computed through traditional regulatory stress tests.

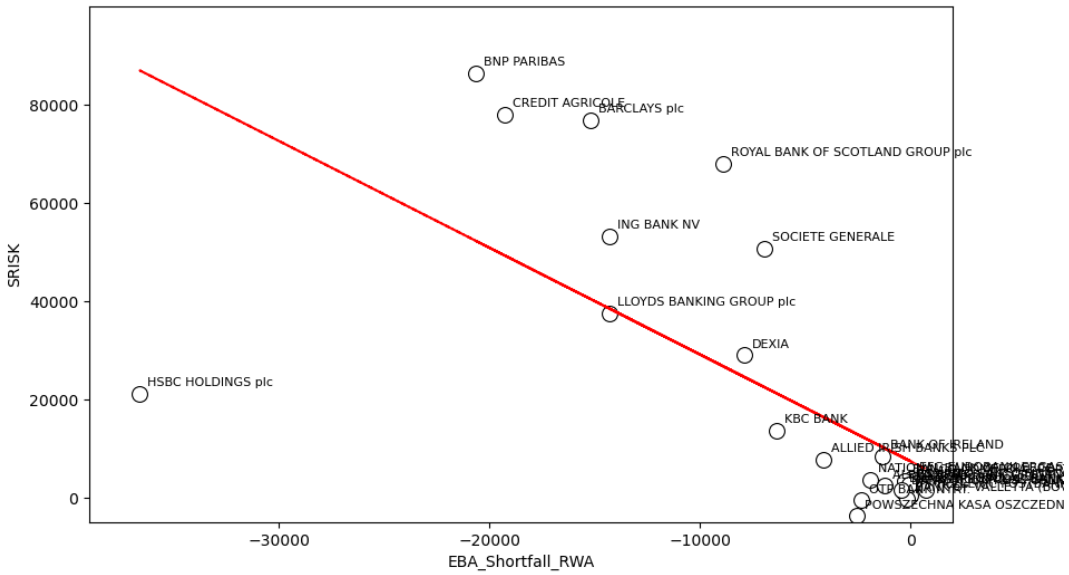


Figure 3: 2011 Absolute EBA Capital Shortfall vs SRISK

The recreated Figure 4 a) reveals a correlation coefficient of approximately –0.672, which is statistically significant at the 1% level. This strong negative correlation robustly emphasizes the divergence between EBA stress tests and V-Lab stress test results, reaffirming the conclusions presented by Acharya, Engle, and Pierret 2014. This misalignment is further reinforced by the observation that the 10 of the safest banks identified by the EBA are categorized as the least safe by the V-Lab (verify Annex C and D).

Figure 4 b): EBA Leverage-based Capital Shortfall vs SRISK 2011

The results of the 2011 recreation of Figure 4 b) are presented below in Figure 4. It is possible to verify that despite the strong limitation on the data available to conduct the recreation of the figure, the results closely resemble those of the original figure. Consistent with the original results, the recreated figure reports values for the EBA Leverage-based Shortfall ranging between -€8,300 million and €73,000 million, with most observations concentrated between

€0 and €8,000 million. Similarly, the SRISK values in the recreated Figure 4 b) align closely with the ones presented in the original figure, ranging between -€4,000 and €94,000 million.

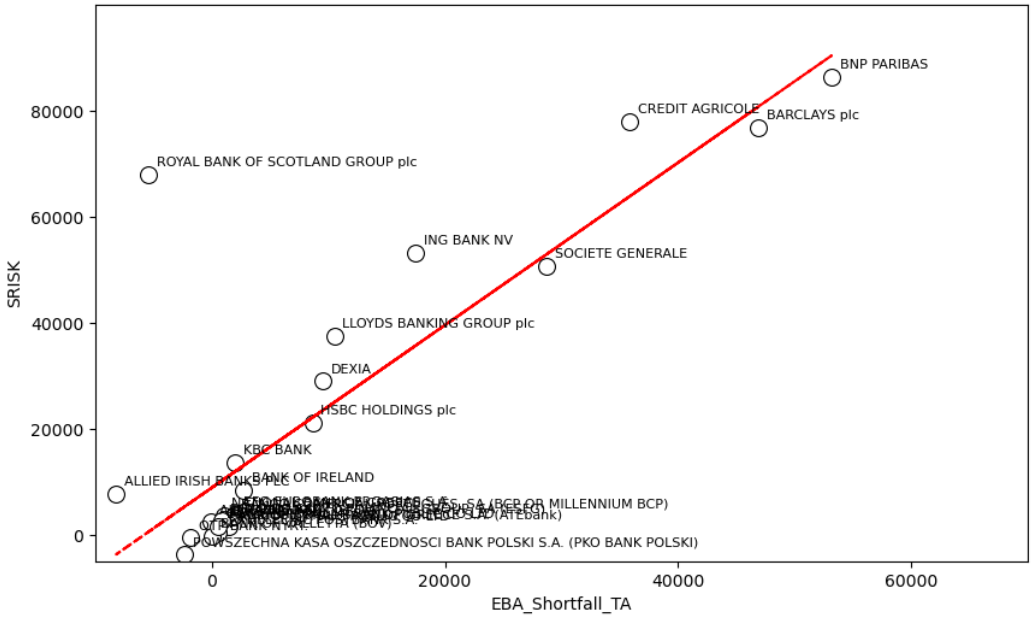


Figure 4: 2011 EBA Leverage-based Shortfall vs SRISK

Additionally, the recreated EBA Leverage-based Shortfall exhibits an average of approximately €8,001.12 million, whereas the SRISK value presents an approximate average of €21,189.00 million. These results confirm the conclusion presented in the article "*Testing Macroprudential Stress Tests: The Risk of Regulatory Risk Weights"* by Acharya, Engle, and Pierret (2014), which posits that shortfalls using the V-Lab approach tend to be larger than the ones computed through traditional regulatory stress tests.

The recreated Figure 4 b) exhibits a positive correlation coefficient of approximately 0.833, which is statistically significant at the 1% level. This result strongly reinforces the conclusions presented by Acharya, Engle, and Pierret 2014 that the correlation between the EBA regulatory Shortfall and SRIKS increases significantly when the EBA shortfall is measured in function of total assets and not risk-weighted assets. Furthermore, it is also possible to verify in Annexes

E and F, that there are eight common banks among the riskiest banks according to the V-Lab and EBA stress tests.

Table 3: Realized Volatility Regressions 2011

	1	2	3	4	5	6
Constant	0,343	-0,0022	0,3872	0,3418	0,0293	-0,0114
Book to Market	0,0481	0,0388	0,0459	0,048	0,0376	0,0309
Vlab Risk Weight		0,1858			0,183	0,1952
EBA T1 lvrg			-0,9503		-0,5707	-1,6097
EBA Risk Weight				0,0022		0,1314
F test	4,28	6,24	2,28	2,08	4,1	3,31
Adj R2	8,81%	23,55%	7,01%	5,96%	21,48%	21,39%

Table 1: 2011 Realized Volatility Regressions

The table represents regression results assessing the relationship between various financial indicators commonly used in banking and financial risk analysis. The constant values range from -0.0114 to 0.0481, providing baseline values for the dependent variable when all explanatory variables are set to 0, indicating a mix of positive and negative intercepts across different models. Among these explanatory variables, the book-to-market ratio shows a positive coefficient in all models, suggesting a consistent positive relationship with the dependent variable even though the magnitude of this effect varies. The V-lab risk weight displays a significant coefficient in certain models, particularly 0.1858, 0.1830, and 0.1952. Highlighting its role in explaining variation in the dependent variable. Conversely, the EBA Tier 1 leverage ratio shows a negative coefficient ranging from -0,5707 to -1,6097 indicating a strong inverse relationship. Implying that higher leverage ratios are associated with lower outcomes in the dependent variable. The EBA risk weight appears in two models with a

relatively small positive coefficient of 0.0022 and 0.1314, suggesting a limited direct effect in this specific context. The overall significance of the regression models is reflected in the F-test values, which range from 2.08 to 6.24 and indicate varying levels of model fit. The highest F-test value of 6.24 points to a more statistically significant model compared to others. The adjusted R^2 values spanning from 5.96% to 23.55%, suggest that while some model provides moderate explanatory power, others leave substitutional space for evolution. In the end, these results show a complex interplay between financial risk indicators and the dependent variable and show the need for further analysis and potential model refinement.

The recreation of Table 3 was made difficult by the data retrieving. Comparing our recreation to the table in the paper from Acharya, Engle, and Pierret (2014), I can see that the result is not the same. Still, I was able to find negative values were expected as well as logical results such as the fact that for example, the constant of model 3 was also in the paper from 2014 bigger than the constant in model 5. I, therefore decided to continue with these results and assume that our methodology was good for the rest of the paper.

After understanding how to recreate the different stress tests, and where to find the data. I had to choose a year after 2011 to recreate the same tests, so I could see if the banking risk in Europe had changed with some new regulations. Therefore, I did some research on the different changes in banking regulation.

6. Changes in Banking Regulation

After the 2008 Great Financial Crisis, a significant number of major regulations changed the financial markets. After some research here are the main regulations impacting the financial and banking market. And the years they have been implemented. All the regulations changes

can be found in annex X in a table retrieved from “The Decade of Financial Regulatory Reform: 2009 to 2019”. Doing such will help us choose a year to analyze.

2010-2011: Basel III

The paper "Testing Macroprudential Stress Tests: The Risk of Regulatory Risk Weights" by Acharya, Engle, and Pierret (2014) studies data from 2011, by doing so, it takes into account the Basel III agreements. “Basel III is an international regulatory accord for reforms designed to mitigate risk within the international banking sector by requiring banks to have more capital on hand.” says Peter Gratton in the article “Basel III: What It Is, Capital Requirements, and Implementation”. It increases capital requirements, introducing a minimum Common Equity Tier 1 (CET1) ratio of 7% and a Total Capital Ratio of 10.5%. Basel III also includes a 3% leverage ratio to prevent over-leveraging and liquidity standards like the Liquidity Coverage Ratio (LCR) and Net Stable Funding Ratio (NSFR) to ensure short- and long-term stability.

2016: Bail-In and Single Resolution Mechanism (SRM)

This regulation implemented the “bail-in” principle. This means that now, shareholders and creditors are the first to bear losses in the event of bankruptcy. This has changed the risk expectations of banks.

2018: MIFID II

A. Hayes in the article “Alternative Investment Fund Managers Directive (AIFMD)”, Mar 2021 stated that “MiFID II is one of the most important pieces of legislation enacted in finance and investing this century. Rolled out in 2018 by the European Union (EU) to regulate financial markets while increasing protections for investors, it aimed to standardize financial practices across the EU and restore confidence in the industry, especially after the 2008 financial crisis. It focuses on three key areas: service model, product development, and product placement.”. This has been implemented to enhance transparency, investor protection, and market integrity. Introducing stricter rules on trading and investment services.

2021: Basel IV requirements come into force (pre-Basel III adjusted)

Basel IV is following the Basel III agreements and is just an extension of it. The implementation of it still imposed stricter constraints on risk weights for banks. This had a direct impact on the bank's capital ratio and the risks faced.

External Elements

Coming with the choice of years to study, not only the different regulations changes are relevant. I also have to take into account the different external elements that happened over the last decade that could've impacted the financial market over the years. For example, the reference paper *"Testing Macroprudential Stress Tests: The Risk of Regulatory Risk Weights"* by Acharya, Engle, and Pierret (2014), takes into account the European debt crisis that affected the country such as Spain, Italy, Portugal, and most of Greece.

2014: Geopolitical tensions and sanctions against Russia

During that year, the European Union imposed economic sanctions on Russia, restricting the trade and investments made with them. This followed Russia's annexation of the Crimea region. Therefore, for European banks having customers in Russia, this created an increase in the risk of credit and liquidity and a loss of possible opportunities in this region of the world.

2016: Brexit

The Brexit was voted the 23/06/2016. The United Kingdom's leaving the European Union disrupted different markets such as the financial and banking market. This created a lot of uncertainties for banks operating in this region. After that, banks had to reorganize their operations. Some of them relocate their activities previously done in London to another part of Europe. Therefore, they had to meet new regulations and financial challenges.

2020: COVID-19 Pandemic

The COVID pandemic was unprecedented, and with it, a global recession came. Exposing banks to great credit risks, as different businesses or households were not able to meet their debts. Different governments around the world responded with supportive policies. But even with drastic measures, banks remain exposed to potential long-term credit defaults.

Also, over the years the question of sustainable finance and climate risks have been one of the main issues that banks faced. More pressure was put on banks to reassess the risks associated with their non-sustainable assets. They must now take into account the transition risk associated with climate change. With this comes an increase in the difficulty of risk management.

Decision of the Years

I therefore decided to analyze with the same method as 2011 the year 2016. I came to this conclusion by looking at what years have seen the most change in banking regulations as well as external elements that could have impacted the banking system and European banks. 2016 was a year seeing new regulations being implemented as well as the Brexit happening both of these created a new environment for European banks.

7. Comparative Macroprudential Stress Testing: Assessing European Banks in 2016

2016 Overview and Regulations

In chronological order, I have therefore decided to start with the year 2016. A turning point for the financial world and banks in Europe due to several major events that have had a profound impact on the sector. In 2016, a number of events had an impact on the banking world and several significant repercussions on the financial market and institutions took place. One of the major events of the year was the Brexit referendum. On 23 June 2016, the United Kingdom voted to leave the European Union, sending shockwaves through the markets. This decision led to massive volatility, a fall in sterling, and major economic uncertainties, in part for banks with significant exposure to the UK. To maintain their access to the single European market, major European banks have had to anticipate reorganizations, sometimes even going so far as to consider decolonizing their activities. Banks such as Bank of America have moved their European operations from London to Paris. Or Barclays, the British bank that relocated to Dublin after Brexit.

Italy also faced a major banking crisis. It was exasperated. By the high levels of bad loans, also known as NPLs (Non-Performing Loans), on the balance sheets of many Italian banks, notably Monte dei Paschi di Siena (MPS). I will be looking at these in the course of this study. This situation has given rise to complex discussions between the Italian government and the European Union regarding the granting of state aid. These negotiations have highlighted the challenges inherent in establishing a genuine European banking union, particularly as regards crisis resolution mechanisms. In terms of monetary policy, the European Central Bank (ECB) continued to act to support the eurozone economy in 2016, maintaining historically low interest

rates while expanding its quantitative easing (QE) program. While these measures have boosted credit and market liquidity, they have also put significant pressure on the profitability of banks, particularly those whose activities rely heavily on interest markets. Despite this, these policies have offered a respite to the European economy in a period of uncertainty.

Secondly, on the regulatory front, 2016 was also marked by the ongoing implementation of European directives such as Basel III and BRRD (Bank Recovery and Resolution Directive). These regulations have forced banks to strengthen their capital base and prepare for resolution mechanisms in the event of a crisis. However, this urgency has been accompanied by high compliance costs and has forced banks to shift their business model to meet these new requirements. To look at the Basel III accords, developed by the Basel Committee on Banking Supervision. They were introduced gradually after the 2008 financial crisis to strengthen the resilience of the global banking system. In 2016, several key requirements of the accords began to apply in full, marking a key milestone in their implementation. So, what is Basel III?

It is a banking regulatory framework designed to increase the level of bank capital to absorb potential losses. It also aims to improve banks' liquidity, reduce excessive leverage, and enhance the transparency and stability of the financial sector in general. In 2016, 4 main regulations were introduced. Firstly, the capital adequacy ratio. Banks will have to comply with higher levels of better-quality capital, known as Tier 1 capital. The aim is to achieve a minimum ratio of 6%. There was also an addition of conservation capital. Banks had to maintain an additional cushion of 2.5% to absorb losses in the event of a crisis. This brings the requirement to 10.5% instead of 8%. Next, the leverage ratio: banks were subject to a minimum leverage ratio of 3%. Calculated by dividing Tier 1 capital by total assets. Then finally the liquidity regulations. These are with the short-term liquidity ratio. Banks had to hold enough high-quality liquid assets to cover their financing needs over 30 days in the event of a liquidity crisis. Lastly, in 2016, European banks stepped up their restructuring efforts to cope with increased

competition from fintechs, pressure on margins, and a low-interest rate environment. This restructuring resulted in job cuts, branch closures, and accelerated digitalization of services. All in all, 2016 was a period of major challenges for European banks, with geopolitical changes such as Brexit and national crises such as those involving Italian banks. Economic pressures and new regulations have forced financial institutions to adapt quickly. These adjustments have been essential to ensure their resilience in a constantly changing environment.

2016 Methodology

Figures 3a and 3b

EBA Capital Shortfall vs SRISK (Figure 3a)

In the course of our group research, I learned how to recreate the different figures that the 2014 paper contains. However, some changes had to be made. Whether it was in the collection of data or the creation of the Python code that allowed me to recreate the different graphs to come. To do this, I first collected and consolidated the relevant data from the two sources, taking care to harmonize formats and correct any inconsistencies. For example, at this stage of my work, a problem arose. For the 2011 graphs, the EBA data was all grouped in the same file called DATA_DISCLOSURE. However, this was not the case for the 2016 data. With some research on the data_dictionary provided by the EBA website, I grouped the different CSV files that were made available to us and then kept only the 2016_TRA_OTH file which was the one that contained the information needed for the different variables I needed. As far as Figure 3a is concerned, these variables were respectively ‘Total risk exposure amount’ which was recorded in the file as ‘1690107’, and ‘Common Equity Tier 1 Capital’ recorded as item ‘1690106’.

As far as the data from the V-Lab site was concerned, this was similar to the extraction of data from the 2011 figures. The SRISK capital shortfall estimates were obtained by collecting the SRISK value provided by V-Lab for each bank on 31/12/2015.

I was therefore able to create two files for EBA and V-Lab respectively. The first is named 2016_TRA_OTH and the second is V-Lab Data 2016. (These indications are necessary to understand the Python code). In these two files, the banks, even if their names are sometimes similar, have been sorted and ordered by their LEI_Code. Similar in both files and therefore easy to understand for a program such as Python.

Next, I developed a Python script to automate the analysis process. The code includes a filter function that allows me to select data corresponding to precise criteria defined according to my research hypotheses. This enabled me to explore different combinations of indicators and visualize the relationships in the form of scatterplots. For the graphics, I used libraries such as Matplotlib and Seaborn, which offer advanced customization options and make it easy to format the graphs professionally. Integrating these tools made the visualization process more efficient while ensuring the reproducibility of the analyses.

I regressed the capital shortfall estimates in the EBA stress test disclosed in December 2015 (EBA_Shortfall.RWA) on the capital shortfall estimates SRISK under the V-Lab stress scenario, in € millions.

The disclosed capital shortfall estimates in the 2011 EBA stress test are given by

$$Disclosed\ Capital\ Shortfall\ = \max(0;\ [k' \cdot RWA_s - Capital_s])$$

Since I am trying to recreate the same figure, I had to use the same formula.

Where k' is the 5% prudential capital ratio used in the 2011 EBA stress test, RWAs are the risk-weighted assets of each bank at the end of the stress test scenario, 31/12/2012. So I've decided to use the same constant k of 5% and recreate as closely as possible the 2011 graph with the data collected for 2016.

EBA Overall Capital Shortfall vs SRISK (Figure 3b)

Unfortunately, after several attempts to recreate Figure 3b showing the overall present capital deficit on the EBA website compared with the SRISK, I encountered a problem that prevented me from reproducing this graph. After a great deal of analysis, I have identified the source of this difficulty. To construct Figure 3b, the authors used data from the 2011 EBA capital exercise. However, the site did not repeat this approach in the 2016 exercise. This limited our ability to directly compare these periods. Another notable difference lies in the reference period. The 2011 financial year covers 2 years, whereas the 2016 financial year covers 3 years. Although this temporal divergence could potentially influence the results, I assumed that it would not have a significant impact on our analysis, given the nature of the variables studied and the estimation methods used. This assumption enabled us to continue our work with a coherent analysis, despite the unavailability of comparable data for more recent periods. The only problem is that I cannot recreate Figure 3b for the years 2016.

Figures 4a and 4b

EBA Absolute Risk-based Capital Shortfall vs SRISK (Figure 4a)

To extend our analysis and create a comparable figure for 2016, I applied the methodology learned when replicating Figure 4a from Acharya, Engle, and Pierret (2014). Using Python, I performed a regression analysis between the capital shortfall estimates from the 2016 EBA stress test and the SRISK values provided by V-Lab. The objective was to assess whether the relationship observed in 2011 persisted in the subsequent stress test cycle, reflecting potential improvements or persistent vulnerabilities in the resilience of the European banking sector to financial distress.

As for Figure 3a, I used the same Excel files, that I had sorted and formatted earlier, so I only had to use these two files to reproduce all my figures during my study. The items studied in

Figure 4a are also the same as those in Figure 3a. Unlike Figure 3a, this time if the formula study, the absolute capital shortfall estimates are given by:

$$Disclosed\ Capital\ Shortfall\ = \max(0;\ [k' \cdot RWA_s - Capital_s])$$

Give a negative EBA_Shotfall if the result is negative. In Figure 3a, this result translates into 0 because I did not take into account the negative EBA shortfall results.

I used Python's Pandas library to organize the datasets, merging the SRISK and EBA results based on bank identifiers. After ensuring data consistency, I ran a linear regression using the statsmodels library, regressing the EBA capital shortfall estimates on the SRISK values. This allowed us to assess the predictive power of market-based estimates compared to regulatory stress test results. I obtained a scatter plot comparing the SRISK to the capital shortfall with no absolute values and this helped to realize that the capital shortfall of every bank in the dataset is negative.

EBA Leverage-based Capital Shortfall vs SRISK (Figure 4b)

To create a leverage-based comparison similar to Figure 4b in Acharya, Engle, and Pierret (2014), I performed a regression analysis between the leverage-based capital shortfall estimates from the 2016 EBA stress test and the SRISK values reported by V-Lab. This approach allowed us to assess the consistency between regulatory stress test results and market-based capital shortfall forecasts.

For this new test, this time the data required to recreate the graph was different from the previous graph. I previously used the items '1690107 - Total risk exposure amount' and '1690106 - Common Equity Tier 1 Capital'. With regard to Figure 4b, the items used to analyze it here are also present in file 2016_TRA_OTH but are classified under different items. Firstly, the 'Total Leverage Ratio Exposure' under item number '1690111' and the 'Tier 1 Capital' under item number '1690110'. With regard to the data from Vlab, I have once again used the

SRISK estimates previously used in the other tests, 3a and 4a. Using this data I was able to compute the leverage-based capital shortfall estimate given by:

$$Capital\ Shortfall(TA) = k \cdot TA_s - Capital_s$$

Once again, data processing was carried out using Python's Pandas library, allowing the EBA and SRISK datasets to be efficiently merged based on unique bank identifiers. Careful data cleansing and validation ensured consistency between variables and mitigated potential problems associated with differences in reporting standards or incomplete records. After constructing the final dataset, I ran a linear regression using the statsmodels library, regressing the leverage-based capital shortfall on the SRISK estimates.

Table 3

For Table 3 of the 2011 study, the database required was larger and more complex to produce. This required the six-month realized volatility as a dependent variable. But also, EBA Risk Weight, EBA T1 Leverage Ratio, V-lab Risk Weight, and finally the Book to Market Ratio.

All these data are not directly given in the CSV files on the EBA or V-lab websites. And are data that I had to calculate thanks to some formulas available or the help of people I contacted at V-lab. In addition to the EBA or V-lab database, I also had to retrieve data from Refinitiv Eikon concerning the book-to-book-to-market ratio.

Six-Month Realized Volatility:

The dependent variable: six-month realized volatility is given by:

$$Realized\ Volatility = \sqrt{\frac{1}{W}\sum_{t+1}^{t+1+W}\left(r_{it} - \overline{r_{it,W}}\right)^2}$$

Where W=130 days (six months) and $R_{it,W}$ is the six-month forward average return of bank i at time t.

To approximate this value, I ask to Rob Capellini Director atV-Lab and VRI Technology

The Volatility and Risk Institute (VRI) in the NYU Stern School of Business showed us how to get the annualized volatility, here is what he answered: “Each CSV file contains a 'var' column with the daily variance for the firm. To obtain annualized volatility figures, multiply the column values by 252 and take the square root.” Once I had the annualized volatility, I just had to divide it by 2 to get the 6-month volatility that was our independent variable.

EBA Risk Weight:

The EBA risk weight is the ratio of risk-weighted assets to total assets given by dividing item 1690110 “Total exposure amount” which is the direct match to the risk-weighted capital by item 1690857 “Total leverage exposure amount” which is a proxy of the total assets for each bank. For each bank. The Total leverage exposure amount is a proxy of the total assets of the company. The value that I need to calculate is the EBA risk weight. Even though it is a proxy of the value I are looking for, I didn’t have the variable needed on the EBA database. Therefore, using a proxy was the best option and I considered that it would not change the results and the overall picture of the analysis.

EBA T1 Leverage Ratio:

The EBA T1LVGR is the ratio of Tier 1 capital to total assets at the end of the stress scenario, given by dividing item 1690110 " Tier 1 capital” by item 1690857 “Total leverage exposure amount” which is a proxy of the total assets for each bank. As for the variable EBA risk weight, I assumed that the proxy of the total assets would not change the results and the overall picture of the analysis.

Vlab Risk Weight:

The V-Lab risk weight estimates were obtained by collecting the LRMES value provided by V-Lab for each bank on 30/06/2011 and plugging them into the formula below.

$$V - Lab\ Risk\ Weight\ =\ (1 - (1 - k) \cdot LMRES)^{-1}$$

Where LMRES is the Long Run Marginal Expected Shortfall.

Book to Market Ratio:

I got the book-to-market ratio with the help of Refinitiv Eikon. With this tool, I was able to get the common shareholder equity and the market capitalization from 2016. The formula of the book-to-market ratio is the following:

Book to Market Ratio = Common Shareholder Equity / Market Capitalization

Unfortunately, not all the banks in the EBA and Vlab datasets were public in 2016 or still are not. So, some of the common shareholder equity and the market capitalization were not available on Refinitv Eikon and got a dataset of Book to Market Ratio of 32 banks.

To recreate Table 3 from Acharya, Engle, and Pierret (2014) I regressed the six-month realized volatility after disclosure of the EBA stress test in July 2011 on the book-to-market ratios from 2011, the Tier 1 Leverage ratios (EBA T1LVGR), the EBA risk weights and the V-Lab risk weights.

2016 Analysis of Results

EBA Capital Shortfall vs SRISK (Figure 3a)

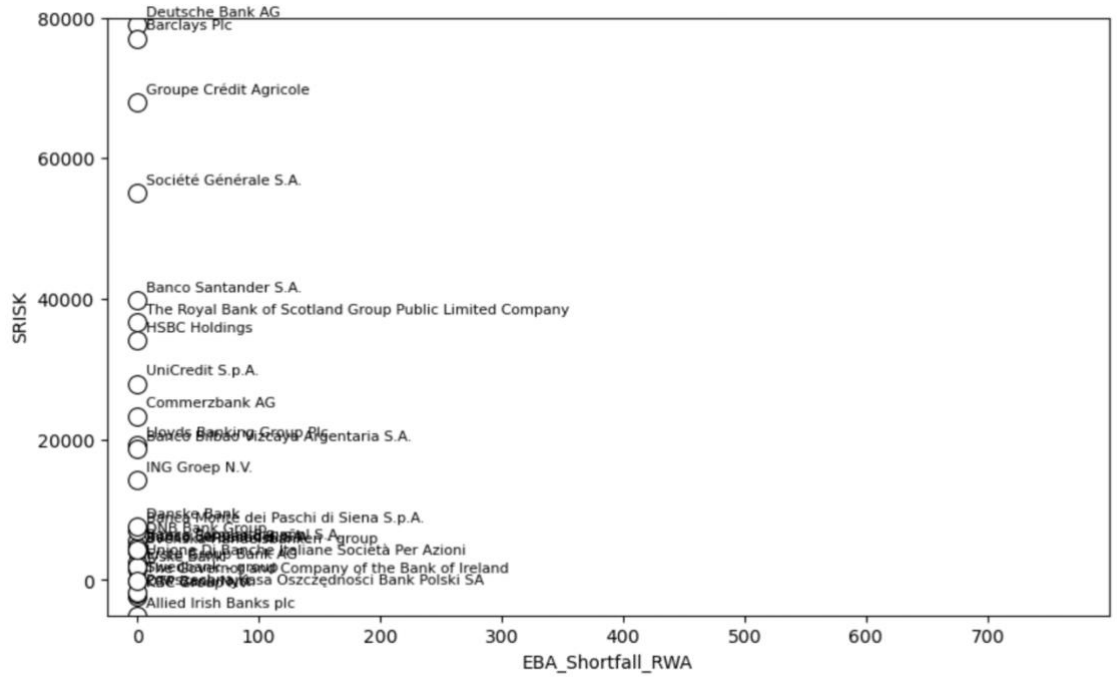


Figure 5: EBA Disclosed Capital Shortfall vs SRISK

It appears to be a weak positive correlation between the EBA shortfall and the SRISK. However, the scatter plot reveals significant discrepancies between the two metrics. At the highest of these discrepancies, I can see the Deutsche Bank and Barclays showing a non-negligible systemic risk under stress scenario even though the EBA shortfall is at 0 like the other bank variable. This is also the case for approximately half of the studied banks. However, I can see a cluster of banks on which both measures estimated a low capital shortfall. These findings highlight potential limitations in the EBA stress test's ability to capture systematic risk. As it may underestimate risk for certain large institutions, such as Deutsche Bank or Barclays, for example. The analysis underscores the importance of integrating alternative methodologies, such as the one from V-lab and their SRISK variable. To provide a more correct assessment of the financial reliabilities of the different banks.

EBA Absolute Risk-based Capital Shortfall vs SRISK (Figure 4a)

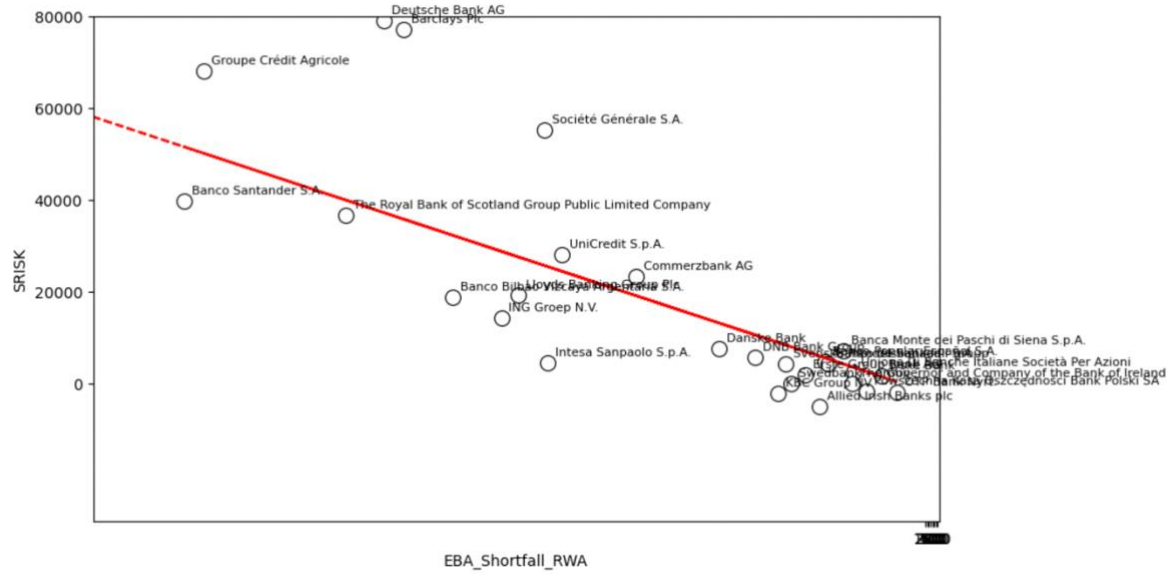
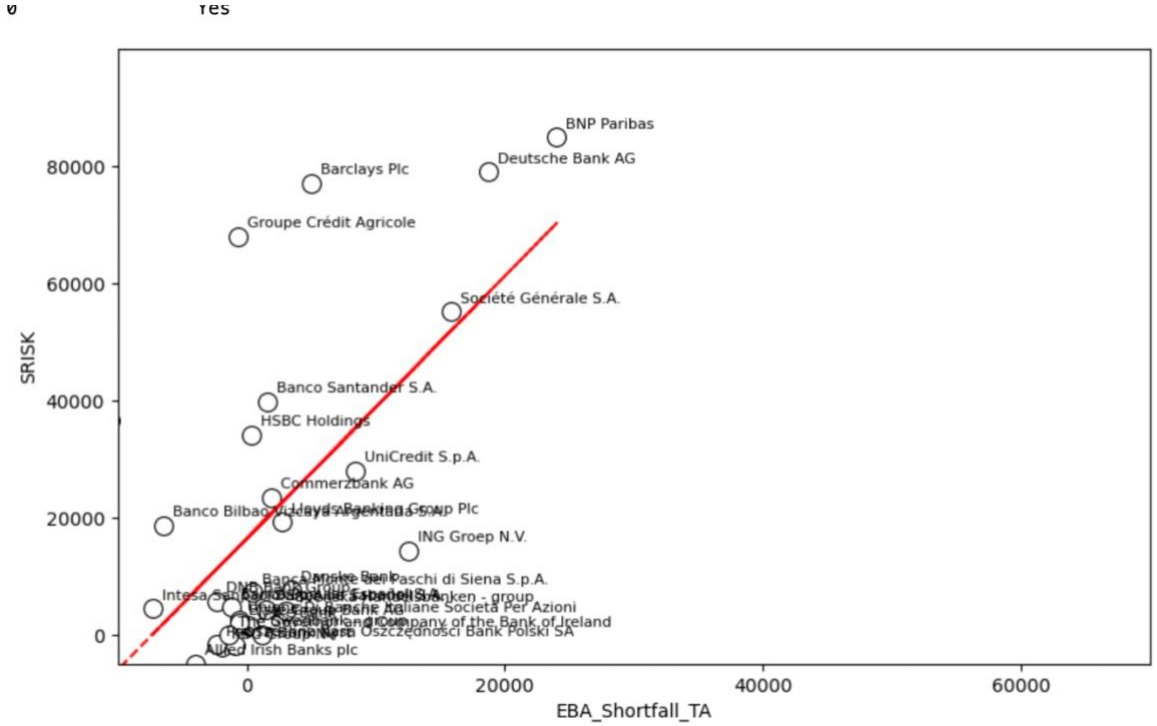


Figure 6: 2016 EBA Absolute Capital Shortfall vs SRISK

The key difference from Figure 3a lies in the inclusion of a negative capital shortfall estimate, reflecting instances where banks have surplus capital relative to the prediction requirement. The regression analysis indicated by the red trend line suggests a weakly negative relationship between the two measures. This indicates that when the SRISK increased the EBA shortfall estimate tended to decrease or remain negative for some banks. Once again this shows the divergence between market-based and regulatory assessment. Notable patterns include once again banks like Deutsche Bank or Barclays, which maintain SRISK values despite minimal or negative EBA shortfall values. This presence of negative EBA shortfall emphasizes systemic risk that might not be adequately captured in stress test results. Conversely, smaller banks cluster near the origin with both low SRISK and EBA shortfall values. The presence of negative EBA shortfalls suggests that these institutions have excess capital in regulatory terms but may still face systemic vulnerabilities under market-based stress scenarios. This analysis underlines the complementary nature of the two metrics and suggests that the regulatory stress tests may underestimate risk for systematically important banks. Once again, this finding highlights the importance of integrating SRISK data into risk assessment frameworks to capture a larger

dimension of financial vulnerability. By extending the methodology of the paper of Acharya, Engle, and Pierret (2014), I can see that the figure provides a nuanced view of the European Bank sector resilience on ongoing disappearances between regulatory and market-based capital adequacy measures.

EBA Leverage-based Capital Shortfall vs SRISK (Figure 4b)



The scatter plot shows a positive relationship between the large-based capital shortfall estimate from the EBA stress test and the SRISK estimate from the lab. This relationship is virtually represented by the upward-sloping red regression line. The slope of the regression line indicates that as the EBA shortfall increases, the corresponding risk estimate tends to rise. Testing that regulatory shortfalls and market-based systemic risk measures are positively correlated. For instance, Deutsche Bank, BNP Bariba, and Société Générale are among the banks with the highest value on both axes. BNP Paribas. For example, as an EBA shortfall of approximately 22,000 million euro. The value exceeding 80,000 displaced significantly above the regression line, indicating that its SRISK is higher than what might be predicted based on this EBA shortfall. Similarly, Deutsche Bank is positioned with comparable EBA and SRISK values

reflecting its systemic importance. On the other hand, smaller banks such as Allied Irish Banks plc and Bank Ochrony Środowiska for example, are clustered near their origin, their EBA shortfall is close to 0, and their SRISK estimates are also minimal. Reflecting lower systemic importance or less exposure to leverage base risk. The dispersion of points around the regression line suggests variability in the relationship between the two metrics. While some banks closely followed the predicted trend others diverged significantly. For instance, some banks with moderate EBA shortfall exhibit much higher SRISK value, which could imply that market-based risk perceptions are influenced by factors not captured by the regulatory framework, such as market volatility or bigger macroeconomic conditions. Quantitatively, the slope of the regression line would provide a measure of how much the SRISK increases for each unit increase in EBA shortfall. The alignment of points near the regression line supports the consistency between the two measures for many banks, but the spread of the data suggests that this relationship is not deterministic. Overall, this scatter plot reveals a general positive alignment between the EBA shortfall and the SRISK with notable outliers and variability. These patterns show both the strengths and the limitations of using regulatory and market-based metrics to assess systemic risk.

Table 3

	1	2	3	4	5	6
Constant	0,5028	1,9367	1,6723	1,4734	3,7212	3,8153
Book to Market	0,03584	0,0806	0,028	0,0373	0,0827	0,0837
Vlab Risk Weight		-0,7993			-1,0044	-1,0455
EBA T1 lvrg			-20,6973		-25,0697	-28,034
EBA Risk Weight				-2,5024		0,3792

F test	0,3	0,65	0,79	0,9	1,06	0,77
Adj R2	-2,55%	-2,56%	-1,54%	-0,70%	-0,63%	-3,47%

The recreated table free from the study reflects regression with six-month realized volatility as the dependent variable. The constant term ranges from 0.5 to 3.82. Indicating baseline volatility when all explanatory variables are 0. The book-to-market ratio shows a positive and consistent coefficient across all models, ranging from 0,028 to 0,037. Suggesting that higher book-to-market ratios are associated with increased volatility. The V-lab risk weight has a negative coefficient in models 2, 5, and 6, indicating that V-lab risk weight reduces volatility aligning with theoretical expectations. The EBA Tier 1 leverage ratio displays strong negative coefficients. Implying that higher Tier 1 leverage reduced volatility significantly. Reflecting a stabilizing effect, however, the EBA risk weights produce mixed results, negative in Model 4 and positive in Model 6, indicating an inconsistent influence on realized volatility. Even though the methodology has been the same as the recreation table from 2011, in 2016, the model doesn't seem significant with the F test values ranging from 0.3 to 1.06 indicating that none of the model are statistically significant at standard confidence level. Additionally, the adjusted R^2 values are all negative, going from -2.55% to -3.47%, suggesting that the models explain less variance than using the mean as a predictor reflecting a poor model fit. Several factors could explain this result. The data limitation, including missing book-to-market ratio for many banks, may have reduced statistical power. The use of proxy variables for the EBA risk weight and Tier 1 leverage ratio might not fully capture the intended. Risk exposure model specification could be improved by considering interaction terms or additional control variables. There could also be a nonlinear relationship that the current linear regression framework does not capture.

8. Limitations

During the recreation of the methodology used for the 2011 analysis in the paper *"Testing Macroprudential Stress Tests: The Risk of Regulatory Risk Weights"* by Acharya, Engle, and Pierret (2014). I found some limitations when applying this methodology to the different years studied in our paper.

First of all, I have encountered the same limitations the authors of the article from 2014 did. Namely, the risk-based requirements limitations "It highlights that capital requirements based solely on risk assessments may not adequately protect against changing risk levels over time, particularly for assets like sovereign bonds or mortgages". This suggests that the capital requirements approach may not fully account for evolving financial risks." Acharya, Engle, and Pierret (2014). As well as the fact that I also compare different stress test methodologies with publicly available data. Therefore, the data for some banks were not available. It might also be not as precise as non-public data. This is considered a data limitation. This was visible also in the collection of the Book-to-market ratio of each bank.

But I also encountered new limitations. Limitations that were not present in the 2014 paper. Firstly, the fact that some data needed and used in the stress test methodology of 2011 were not the same or not available in the year I chose to study. For example, the data provided by EBA changed slightly over the years. Which made retrieving data harder than before. Specifically, some data like the total assets of the bank were not available and I had to conduct the analysis with some proxies of the data needed. Therefore, it may not transcript fully the actual values of the desirable variables. Secondly, for specific examples, like the recreation of Table 3, I can also look into the fact that linear regression cannot capture every correlation possible between variables. Finally, with a more critical eye, I can say that the methodology

applied to data in 2011 can be outdated now because of the new financial world we live in today. Therefore, the methodology might not capture what I was expecting as did for the 2011 analysis.

9. Conclusion & Recommendations

The purpose of this report was to critically evaluate the conclusions presented in the article *"Testing Macroprudential Stress Tests: The Risk of Regulatory Risk Weights"* by Acharya, Engle, and Pierret (2014) and further its application to future years. The main point under analysis was the precision of the traditional regulatory stress tests used to evaluate the resilience of European Banks under adverse economic conditions, more specifically its reliance on risk-based measures of capital adequacy.

Although the limitations above mentioned have not allowed for an exact replication of the analysis conducted on the referred article, the conclusions presented in our analysis for 2011 closely resemble the ones presented in the article. Firstly, the required capitalization under the V-Lab approach indeed presented always higher values compared with the EBA regulatory approach, as it is possible to verify in the figures presented and the average shortfalls computed. Secondly, it is possible to see when considering the total assets as the baseline for the regulatory capital requirements, this measure indeed presented a better correlation with the market-based approach, the V-Lab, and similar ranks.

When conducting the same analysis for the further years the following conclusions can be made. In 2016 the EBA Disclosed Capital Shortfall only presented 0 zero values for all the banks in the sample, indicating that no bank will fall short on the EBA capital requirements under adverse scenarios. Although the resilience of banks has indeed improved over the years, it is not reasonable to state that no bank would exhibit a shortfall under an adverse scenario, which indicates that EBA regulatory shortfalls are underestimated.

Furthermore, the comparison of the EBA Absolute Capital Shortfall with SRISK highlighted the divergences in the results presented by the two stress test methods. This difference was only surpassed when the EBA capital shortfall was computed as a function of total assets. With this adjustment is possible to verify a positive correlation between the two variables for 2016, even though the results between the two tests are still unequal.

The biggest limitation in the analysis of 2016 was observed in the recreation of Table 3. Due to the limitations already referred to reach statistically relevant results, it was not possible to state secure conclusions on the relevance of the different risk factors. Besides that, it was also not possible to identify a pattern between the 3 years that confirmed the conclusions presented in the article *"Testing Macroprudential Stress Tests: The Risk of Regulatory Risk Weights"* by Acharya, Engle, and Pierret (2014) regarding the relationship between the regulatory risk weights and the 6-months realized volatility.

Overall, all the results from 2016 indicate the same conclusion as 2011 and therefore, confirm the fact that "stress tests would be more effective if capital requirements were measured differently from the current static risk-weighted approach" *"Testing Macroprudential Stress Tests: The Risk of Regulatory Risk Weights"* by Acharya, Engle, and Pierret (2014). I can conclude by saying that, even with multiple changes in the financial and banking system over the years. With new regulations coming up over the last decade, I have not verified a drastic change in regulatory stress test results as seen after the global crisis in 2008. And that the regulatory stress tests conducted by financial organizations are still not taking into account the "risk that will change".

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11. Annexes

Annex A: Top 10 highest SRISK and corresponding EBA Shortfall in 2011 Figure 3 a)

Bank Name	SRISK	EBA_Shortfall_RWA
BNP PARIBAS	86,428.998	0.00
CREDIT AGRICOLE	77,916.705	0.00
BARCLAYS plc	76,839.364	0.00
ROYAL BANK OF SCOTLAND GROUP plc	68,062.534	0.00
ING BANK NV	53,162.198	0.00
SOCIETE GENERALE	50,781.814	0.00
LLOYDS BANKING GROUP plc	37,473.025	0.00
DEXIA	28,988.879	0.00
HSBC HOLDINGS plc	21,042.349	0.00
KBC BANK	13,715.006	0.00

Annex B: Top 10 highest SRISK and corresponding EBA Shortfall in 2011 Figure 3 b)

Bank Name	SRISK	EBA_Overall_Shortfall
DEUTSCHE BANK AG	112,576.25	3,238.59
BNP PARIBAS	95,887.32	1,476.32
CREDIT AGRICOLE	86,201.62	0.00
BARCLAYS plc	84,619.16	0.00
ROYAL BANK OF SCOTLAND GROUP plc	75,092.54	0.00
SOCIETE GENERALE	60,436.38	2,130.75
ING BANK NV	57,906.49	0.00
LLOYDS BANKING GROUP plc	47,759.36	0.00
UNICREDIT S.p.A	44,381.82	7,974.04
HSBC HOLDINGS plc	43,499.88	0.00

Annex C: Bottom 10 lowest EBA Shortfalls in 2011 Figure 4 a)

Bank Name	EBA_Shortfall_RWA
HSBC HOLDINGS plc	-36,594.566
BNP PARIBAS	-20,636.614
CREDIT AGRICOLE	-19,281.563
BARCLAYS plc	-15,170.073
LLOYDS BANKING GROUP plc	-14,296.968
ING BANK NV	-14,296.355
ROYAL BANK OF SCOTLAND GROUP plc	-8,914.800
DEXIA	-7,882.038
SOCIETE GENERALE	-6,944.726
KBC BANK	-6,368.865

Annex D: Top 10 highest SRISK in 2011 Figure 4 a)

Bank Name	SRISK
BNP PARIBAS	86,428.998
CREDIT AGRICOLE	77,916.705
BARCLAYS plc	76,839.364
ROYAL BANK OF SCOTLAND GROUP plc	68,062.534
ING BANK NV	53,162.198
SOCIETE GENERALE	50,781.814
LLOYDS BANKING GROUP plc	37,473.025
DEXIA	28,988.879
HSBC HOLDINGS plc	21,042.349
KBC BANK	13,715.006

Annex E: Top 10 highest EBA Shortfalls in 2011 Figure 4 b)

Bank Name	EBA_Shortfall_TA
BNP PARIBAS	53,176.521
BARCLAYS plc	46,875.001
CREDIT AGRICOLE	35,786.506
SOCIETE GENERALE	28,678.422
ING BANK NV	17,458.567
LLOYDS BANKING GROUP plc	10,492.759
DEXIA	9,508.985
HSBC HOLDINGS plc	8,633.162
BANK OF IRELAND	2,675.660
EFG EUROBANK ERGASIAS S.A.	2,011.938

Annex F: Top 10 highest SRISK in 2011 Figure 4 b)

Bank Name	SRISK
BNP PARIBAS	86,428.998
CREDIT AGRICOLE	77,916.705
BARCLAYS plc	76,839.364
ROYAL BANK OF SCOTLAND GROUP plc	68,062.534
ING BANK NV	53,162.198
SOCIETE GENERALE	50,781.814
LLOYDS BANKING GROUP plc	37,473.025
DEXIA	28,988.879
HSBC HOLDINGS plc	21,042.349
KBC BANK	13,715.006

Annex G: Different changes in Financial Regulations over the last 14 years. Their dates and names.

Exhibit 1: Key Post-GFC Financial Regulatory Reforms

US	
Feb 2010	SEC Liquidity Reform of Money Market Funds (MMFs)
Jul 2010	Dodd-Frank Act – created FSOC,* OTC derivatives reform, private fund reform, etc.
Oct 2011	SEC and CFTC Reporting Requirements for Private Funds
Oct 2012	OCC Reforms for Short Term Investment Funds (STIFs)
Jul 2014	SEC Structural Reform of MMFs
Aug 2016	SEC Investment Adviser Data Enhancements
Oct 2016	SEC Rule on Liquidity Risk Management Programs and Swing Pricing
Oct 2016	SEC Investment Company Reporting Modernization Rules
Sep 2019	SEC Exchange-Traded Funds Rule

EU	
Jul 2011	Alternative Investment Fund Managers Directive (AIFMD)
Jul 2011	UCITS IV requirements on governance and risk management, eligible assets, investor information
Nov 2012	Short Selling Regulation
Dec 2012	ESMA Guidelines on ETFs and other UCITS issues
Mar 2013	European Market Infrastructure Regulation (EMIR) central clearing requirements
Aug 2014	UCITS V requirements for depositories and remuneration
Jul 2017	EU Money Market Fund Reform
Jan 2018	MiFID II pre- and post-trade reporting and transparency requirements
Jan 2019	Simple, Transparent, and Standardized (STS) securitization requirements
Jul 2019	ESMA guidelines on liquidity stress testing for MMFs
Sep 2019	ESMA guidelines on liquidity stress testing for AIFs and UCITS

Annex H: Bottom 10 lowest EBA Shortfalls in 2016 Figure 4 a)

Bank Name	EBA_Shortfall_RWA
HSBC Holdings	-69573,802
Banco Santander S.A.	-44564,207
Groupe Crédit Agricole	-43375,759
BNP Paribas	-38080,744
The Royal Bank of Scotland Group Public Limite...	-34853,080
Deutsche Bank AG	-32555,880
Barclays Plc	-31364,175
Banco Bilbao Vizcaya Argentaria S.A.	-28385,508
ING Groep N.V.	-25494,417
Lloyds Banking Group Plc	-24452,234

Annex I: Top 10 highest SRISK in 2016 Figure 4 a)

Bank Name	SRISK
BNP Paribas	84865,158
Deutsche Bank AG	78950,580
Barclays Plc	77050,783
Groupe Crédit Agricole	67893,699
Société Générale S.A.	55070,792
Banco Santander S.A.	39733,317
The Royal Bank of Scotland Group Public Limite...	36599,011
HSBC Holdings	34070,919
UniCredit S.p.A.	27902,469
Commerzbank AG	23309,976

Annex J: Top 10 highest EBA Shortfalls in 2016 Figure 4 b)

Bank Name	EBA_Shortfall_TA
BNP Paribas	24042,739
Deutsche Bank AG	18714,123
Société Générale S.A.	15855,890
ING Groep N.V.	12548,197
UniCredit S.p.A.	8429,261
Barclays Plc	5014,115
Danske Bank	3424,074
Svenska Handelsbanken - group	3038,763
Lloyds Banking Group Plc	2743,164
Commerzbank AG	1930,809

Annex K: Top 10 highest SRISK in 2016 Figure 4 b)

Bank Name	SRISK
BNP Paribas	84865,158
Deutsche Bank AG	78950,580
Barclays Plc	77050,783
Groupe Crédit Agricole	67893,699
Société Générale S.A.	55070,792
Banco Santander S.A.	39733,317
The Royal Bank of Scotland Group Public Limite...	36599,011
HSBC Holdings	34070,919
UniCredit S.p.A.	27902,469

Commerzbank AG	23309,976