Testing Macroprudential Stress Tests: The Risk of Regulatory Risk Weights

Viral Acharya, Robert Engle and Diane Pierret

NYU Stern School of Business - The Volatility Institute

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Why do we need macroprudential stress tests? (1/2)

Crises occur when

- Common asset shock (Shleifer and Vishny (1992))
- Short-term debt rollover problems (Diamond and Dybvig (1983))

Why don't we obtain privately efficient outcomes?

- Externalities (Acharya, Pedersen, Philippon and Richardson (2010))
- Debt-overhang problem (Jensen and Meckling (1976), Myers (1977)): undercapitalized banks do not raise capital on their own

Macroprudential stress tests can help address this market failure:

- Bring capitalization of the financial sector in line with market perceptions of risk
- Restore financial sector's access to short-term funding

Why do we need macroprudential stress tests? (2/2)

Regulators assess capital requirements in "normal" times by

- attaching risk weights to different asset classes
- requiring a fraction of risk-weighted assets be funded with equity

Regulatory risk weights are, however, currently static in nature

Risks of asset classes change over time, especially in "stress" times

- changing the ability to fund assets with leverage in private markets

Stress tests could potentially help in dealing with this "risk that risks will change" (Engle (2009))

Recent Concerns on Macro Stress Tests

Macroprudential stress tests: part of the macroprudential toolkit (Greenlaw et al. (2012))

Concerns on macro stress tests:

- Stress tests remain microprudential (Greenlaw et al. (2012))
- Basel risk regulation (capital ratios)
  - Capital ratios are not a binding constraint (Hanson et al. (2011))
  - Regulatory risk weights are inconsistent (Basel Committee on Banking Supervision (2013); Haldane (2011, 2012))

An alternative to stress tests: Vlab

We provide a test of regulatory macro stress tests by comparing their outcomes to those from a simple methodology (Vlab) that relies on publicly available market data.

The Volatility Laboratory (Vlab): vlab.stern.nyu.edu/welcome/risk/ ▸ Vlab

SRISK: the capital a firm would need to raise in the event of a crisis (Acharya et al. (2010, 2012); Brownlees and Engle (2011))

$$\begin{aligned} SRISK_{it} &= \mathrm{E}_t\left[k(Debt_{it+h} + MV_{it+h}) - MV_{it+h} | R_{mt+h} \leq -40\%\right] \\ &= kDebt_{it} - (1-k)(1-LRMES_{it}) * MV_{it} \end{aligned}$$

where MV_{it} is the market value of equity of the bank, $LRMES_{it}$ is its long-run marginal expected shortfall, and k is the prudential capital ratio.

The Risk of Regulatory Risk Weights

Static regulatory risk weights are flawed

- Actual and stressed regulatory risk weights have no link with the realized risk of banks during a crisis
- Regulatory risk weights are informative only when we control for other more important risk factors (leverage ratio, market risk)
- Provide perverse incentives to build exposures to low-risk weight asset categories (see Acharya and Steffen (2013) for empirical evidence).

Outline

Outline

US and EU-wide macro stress tests

In the US: the Board of Governors of the Federal Reserve

- Supervisory Capital Assessment Programme (SCAP) 2009
- Comprehensive Capital Analysis and Review (CCAR) 2011 - 2012 - 2013

EU-wide stress tests:

- Committee of European Banking Supervisors (CEBS) 2009 - 2010
- European Banking Authority (EBA, ex-CEBS) 2011
- EBA Capital Exercise 2011 (not a stress test)

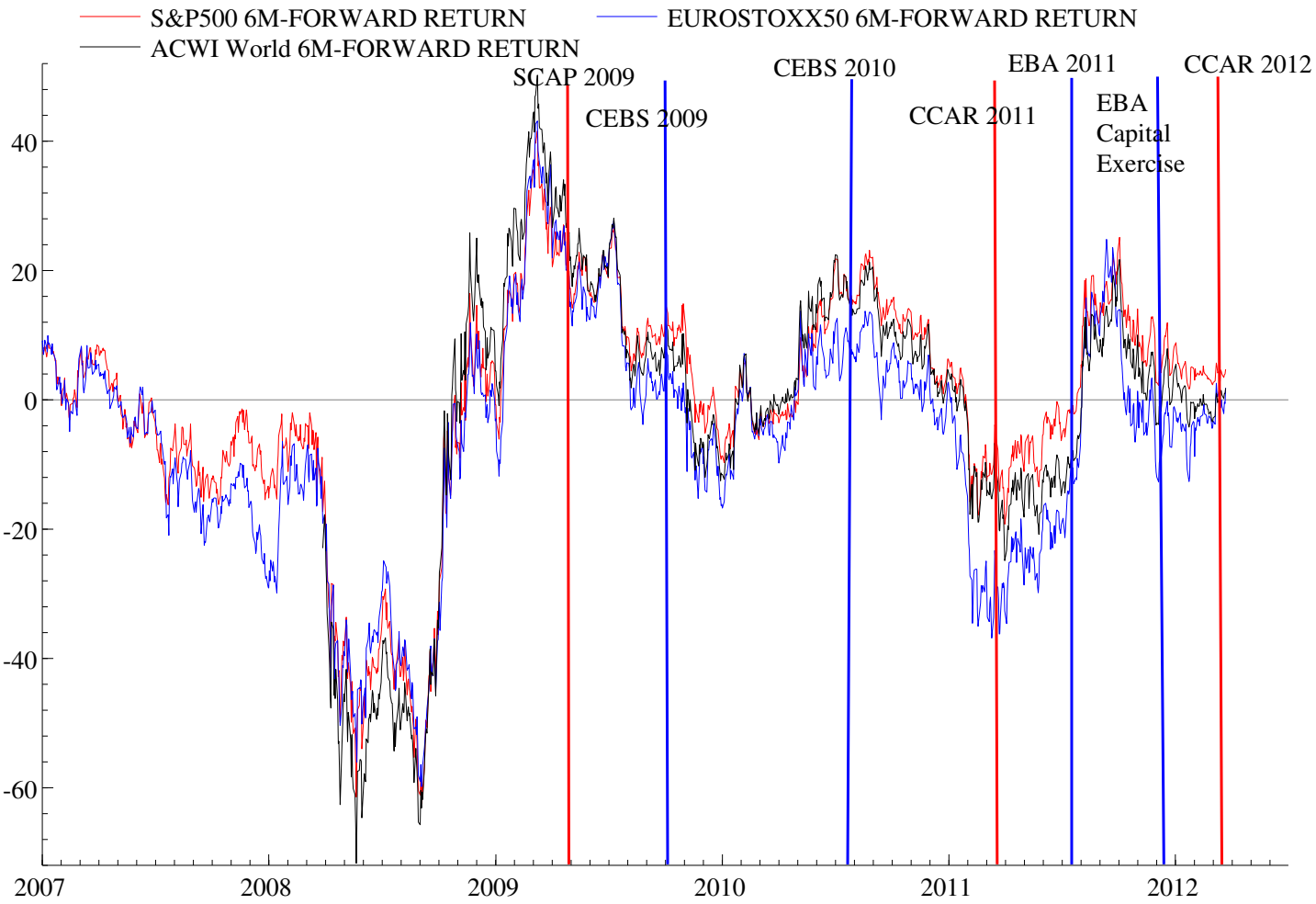
Stress tests with bank-level disclosure

	Disclosure	Institutions	Tier 1 Capital	Scenario horizon
SCAP 2009	May 2009	19 US BHCs	837 $ bn	2009 - 2010
CCAR 2012	March 2012	19 US BHCs	907 $ bn	Q4 2011 - Q4 2013
CCAR 2013	March 2013	18 US BHCs		Q4 2012 - Q4 2014
CEBS 2010	July 2010	91 banks, 65% of EU-27 assets	1162 € bn	2010 - 2011
EBA 2011	July 2011	90 banks, 65% of EU-27 assets	1218 € bn	2011 - 2012
EBA Capital Exercise	Dec 2011	65 banks, excl. Greek banks	1190 € bn	no scenario

The context of stress tests disclosure

2 stress tests are followed by an economic recession: CCAR 2011 (US) and EBA 2011 (EU). Only EBA 2011 discloses bank-level output of the stress test.

6-month realized return after disclosure of EBA 2011: S&P500 -4.89%; EUROSTOXX50 -20.67%; ACWI World -13.47%



Outline

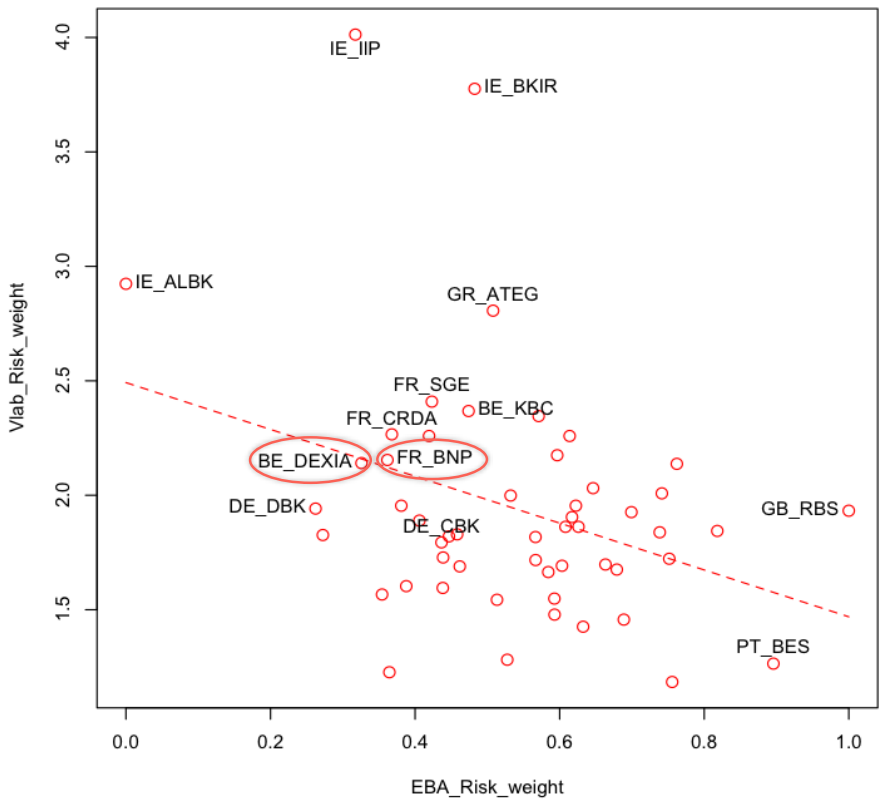
Regulatory risk weight vs. market risk weight (EBA 2011)

Stressed regulatory risk weight $= RWA_S / TA_S$

Vlab RWA: $SRISK \leq 0 \Leftrightarrow MV \geq \frac{k}{1-(1-k)LRMES} TA$ (Acharya, Engle and Richardson (2012))

Vlab risk weight $= (1-(1-k)LRMES)^{-1}$ (rank correlation: -0.238)

Dexia and BNP: below 25% quantile of RWA_S / TA_S, above the 75% quantile of Vlab risk weight distribution



Forecasting risk: realized volatility regression (EBA 2011)

	1	2	3	4	5	6
Constant	4.39**	-0.12	6.34**	5.34**	1.70	0.12
	(0.27)	(1.82)	(0.83)	(0.88)	(1.89)	(1.90)
Book-to-market	0.03**	0.03**	0.03**	0.03**	0.03**	0.04**
	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.004)
Vlab risk weight		2.50*			2.62**	2.99**
		(0.96)			(0.79)	(0.78)
EBA T1 LVGR, scenario end			-39.99*		-41.39*	-62.44*
			(16.82)		(19.02)	(26.39)
EBA risk weight, scenario end				-1.75		3.56
				(1.52)		(2.08)
F-test	11.48**	10.2**	11.88**	6.43**	12.72**	11.25**
Adj. R^2 (%)	16.78	26.14	29.50	17.28	40.34	44.10

* Significant parameters at 5%; ** at 1%. Standard errors in parentheses. Sample size: 53

Outline

Stress tests vs. Vlab losses

- Vlab MV loss = $LRMES * MV$
- Stress test "Loss" is the projected loss over the stress scenario horizon
- Stress test "Net Loss" = $\max(0, \textit{Projected Loss} - \textit{Projected Revenue})$

		Stress tests estimates		**Vlab estimates**
US	Sample	Loss	Net loss	MV loss
SCAP 2009	18 US BHCs	590 $ bn	229 $ bn	438 $ bn
CCAR 2012	18 US BHCs	529 $ bn	226 $ bn	447 $ bn
CCAR 2013	17 US BHCs	457 $ bn	197 $ bn	525 $ bn
EU	Sample	Loss	Net loss	MV loss
CEBS 2010	50 EU banks	425 € bn	39 € bn	399 € bn
EBA 2011	53 EU banks	381 € bn	70 € bn	402 € bn

Stress tests vs. Vlab losses: rank correlations

- Vlab MV loss = $LRMES * MV$
- Stress test "Total Loss" is the projected loss over the stress scenario horizon
- Stress test "Total Net Loss" = *Projected Loss* – *Projected Revenue*
- Loan losses and trading losses are the most important sources of losses (85% in the CCAR 2012)

Panel A: Rank correlations with Vlab MV loss

Stress tests losses	SCAP 2009	CCAR 2012	CCAR 2013	CEBS 2010	EBA 2011
Loan losses	0.580*	0.555*	0.662**	0.837**	0.751**
Trading losses	0.477*	0.660**	0.589*	0.731**	0.694**
Total Loss	0.682**	0.851**	0.842**	0.830**	0.760**
Total Net Loss	0.280	0.604**	0.507*	-0.296*	-0.476**

* Significant parameter at 5%; ** at 1%.

Forecasting losses during the European sovereign debt crisis (EBA 2011)

$$\text{Realized loss}_{i,t,W} = -MV_{it} * \sum_{t+1}^{t+1+W} \ln(p_{it}/p_{it-1})$$

where $t = 06/30/2011$ and $W = 130$ (six months).

Panel A: Performance in predicting the 6-month realized EUR loss

		Rank correlations			RMSE of losses
	Estimated losses	Large	Small	All	All
Vlab	MV loss	0.293	0.610	0.832	5086
		(0.289)	(0.000)	(0.000)	
EBA	Total Loss	0.557	0.527	0.803	4945
		(0.000)	(0.000)	(0.000)	
EBA	Total Net Loss	0.329	-0.100	-0.272	11202
		(0.232)	(0.549)	(0.048)	

P-values in parentheses.

Forecasting returns during the European sovereign debt crisis (EBA 2011)

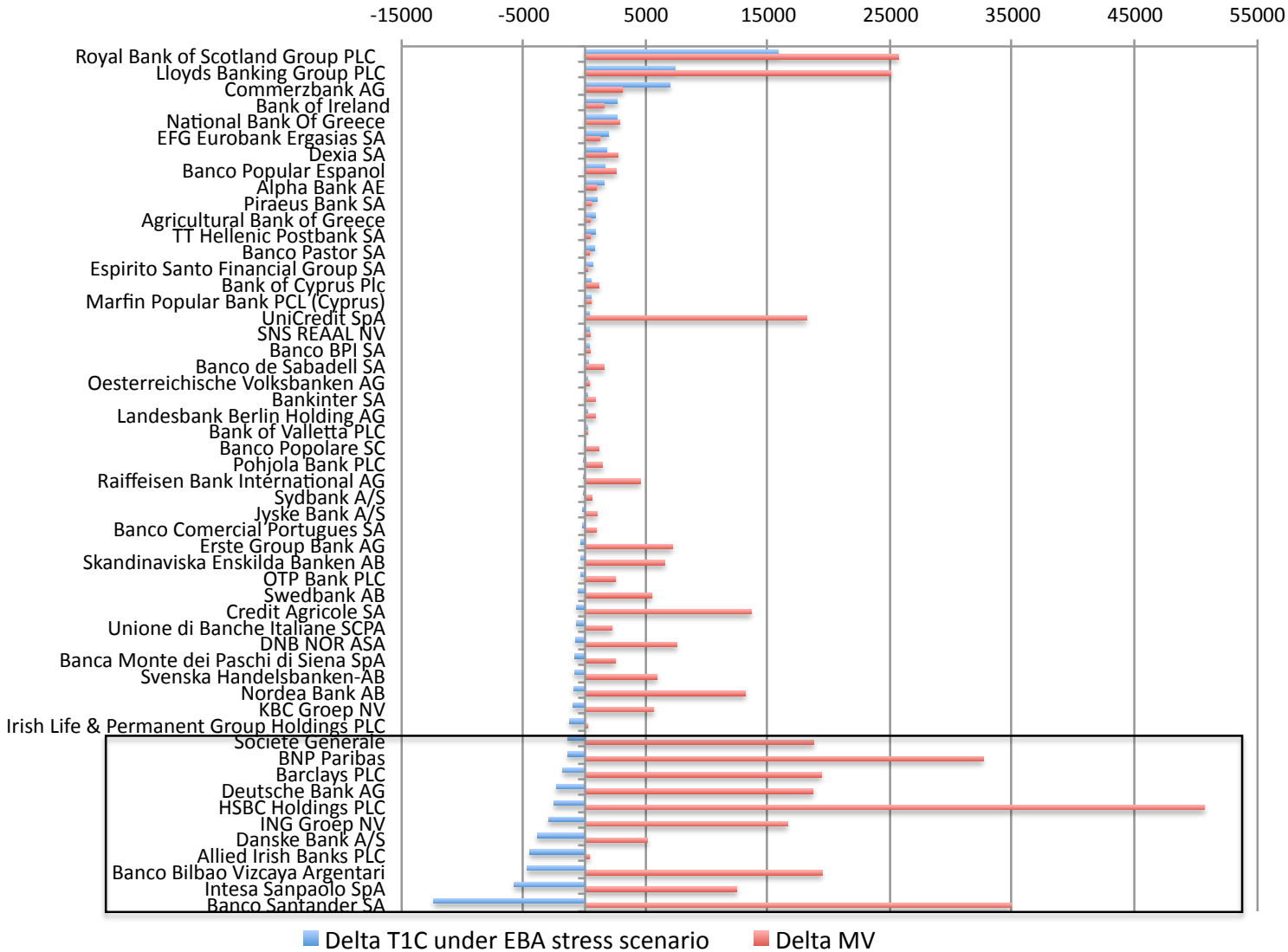
Panel B: Performance in predicting the 6-month realized returns

		Rank correlations			RMSE of returns
	Estimated losses	Large	Small	All	All
Vlab	LRMES	0.350	0.314	0.299	0.553
		(0.201)	(0.055)	(0.029)	
EBA	T1C return	0.546	0.339	0.354	0.767
		(0.035)	(0.038)	(0.009)	

P-values in parentheses. EBA T1C return: change in T1C (%) from the EBA stress scenario

EBA capital increase under stress (EBA 2011)

The projected profits under the EBA stress scenario lead to increasing Tier 1 capital levels for many SRISK top banks



Stress tests assumptions on revenues (EBA vs. CCAR)

Some banks are making profits during the EBA stress scenario

- EBA stress scenario is a deviation of the baseline scenario
- The net interest income is increasing for some banks due to higher interest rates
- Directional market risk stress test: "depending upon the size and direction of their exposures, banks may make gains on certain portfolios"

Different assumptions on the projected PPNR (Pre-Provision Net Revenue) in the CCAR

- low net interest income due to low interest rate, flat yield curve environment
- low non-interest income due to falling asset prices and sharply contracting economic activity
- higher operational losses included in the PPNR

Outline

Stress tests capital shortfalls vs. SRISK

Vlab $SRISK = kDebt – (1-k)(1-LRMES) * MV$

Stress test disclosed capital shortfall $= \max(0, [k' * RWA_S - Capital_S])$

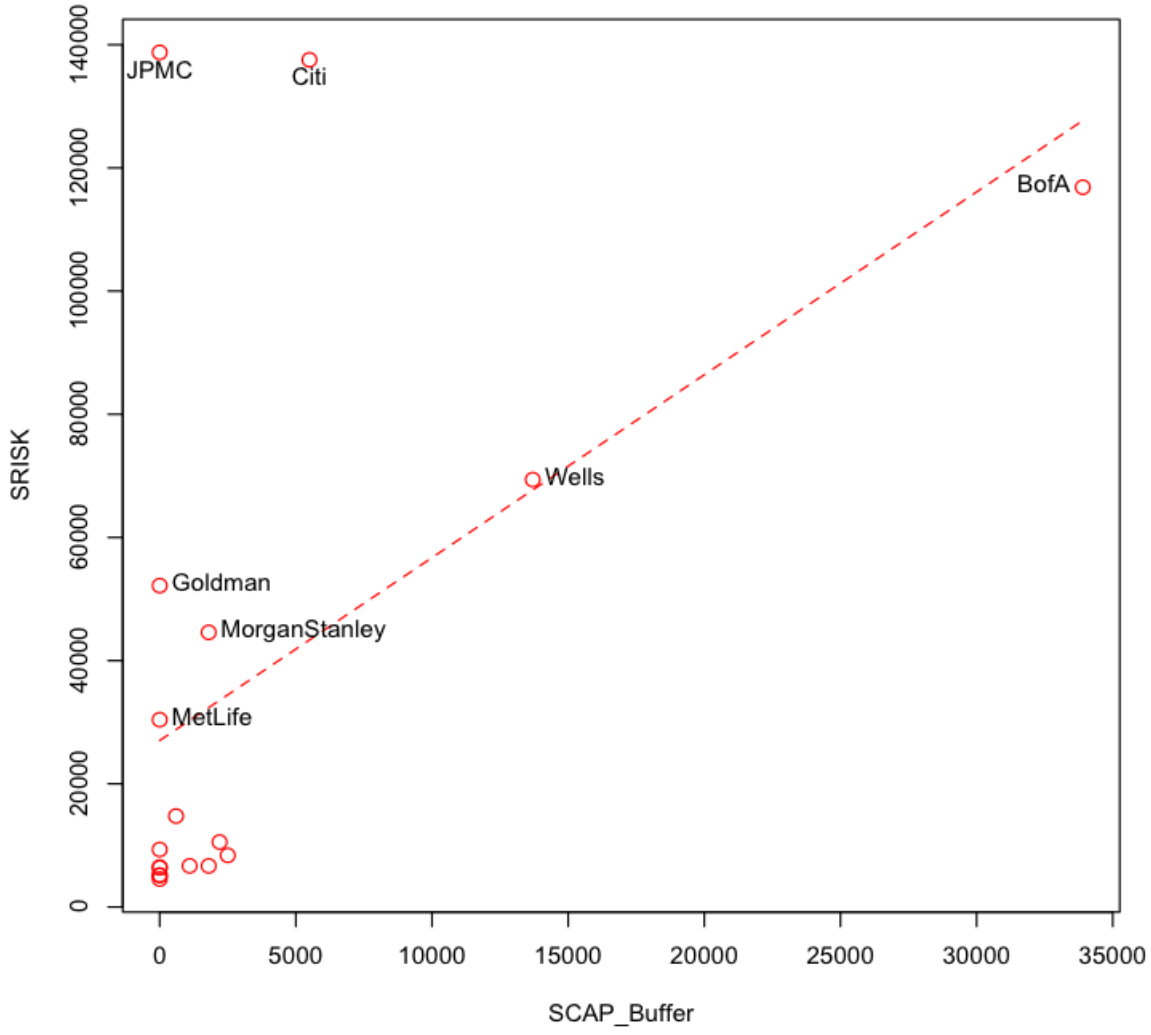
		Stress tests estimates		**Vlab estimates**
US	Sample	Threshold k'	Shortfall	SRISK (k=8%)
SCAP 2009	18 US BHCs	4% T1CR	63.1 $ bn (9)	674 $ bn (18)
EU	Sample	Shortfall	Shortfall	SRISK (k=5.5%)
CEBS 2010	50 EU banks	6% T1R	0.2 EUR bn (1)	796 EUR bn (48)
EBA 2011	53 EU banks	5% T1CR	1.2 EUR bn (4)	886 EUR bn (51)
EBA Capital Exercise	44 EU banks	9% T1CR	72 EUR bn (22)	1059 EUR bn (42)

In parentheses: number of banks with capital shortfall > 0 under stress. T1R = Tier 1 Capital ratio, T1CR = Tier 1 Common Capital ratio (US), Core Tier 1 Capital ratio (EU).

SCAP capital buffer vs. SRISK (SCAP 2009)

Vlab $SRISK = kDebt–(1-k)(1-LRMES)*MV$

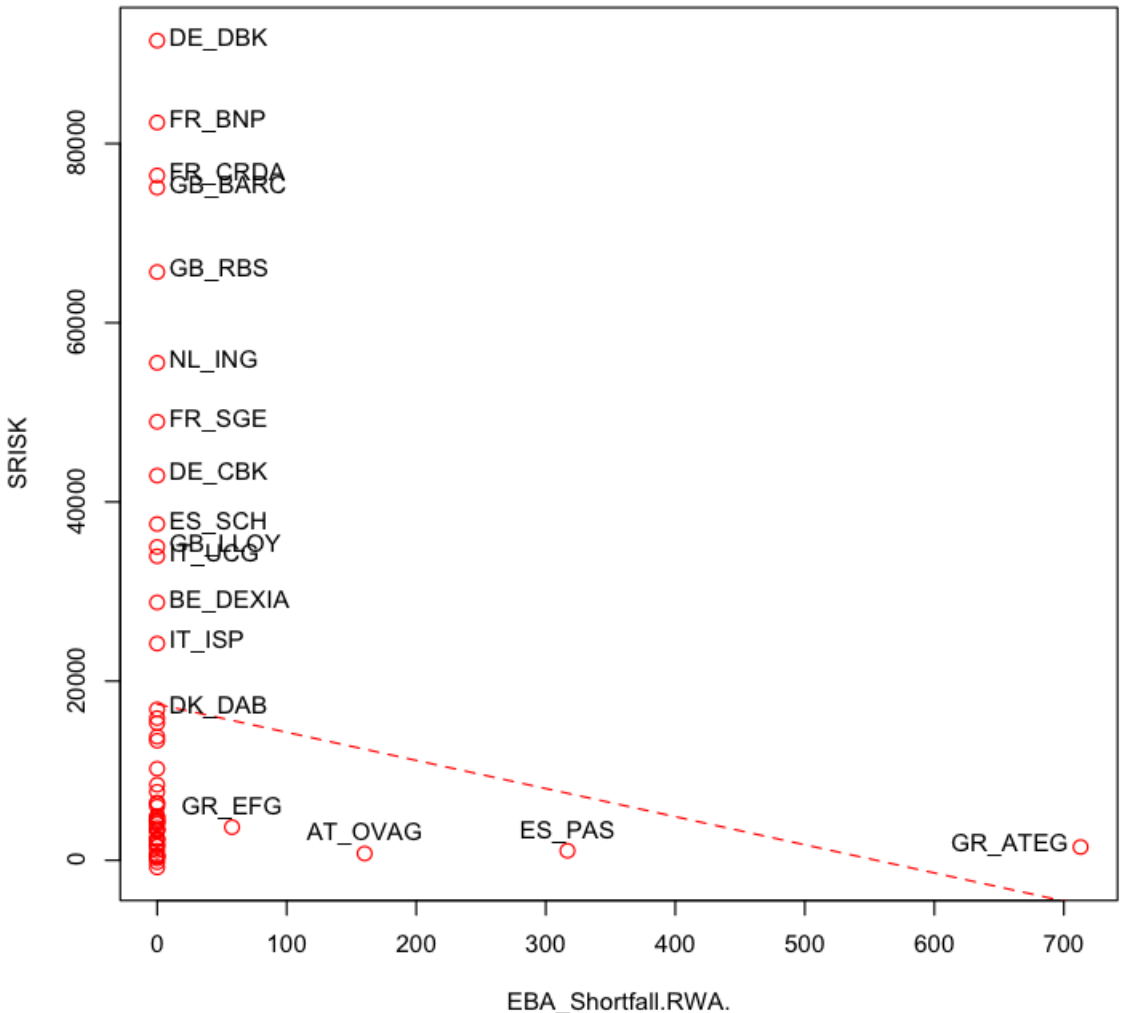
SCAP capital buffer $= \max(0, [k' * RWA_S - Capital_S])$
(k=0.08, k'=0.04, rank correlation: 0.507)



EBA capital shortfall vs. SRISK (EBA 2011)

Vlab $SRISK = kDebt – (1-k)(1-LRMES) * MV$

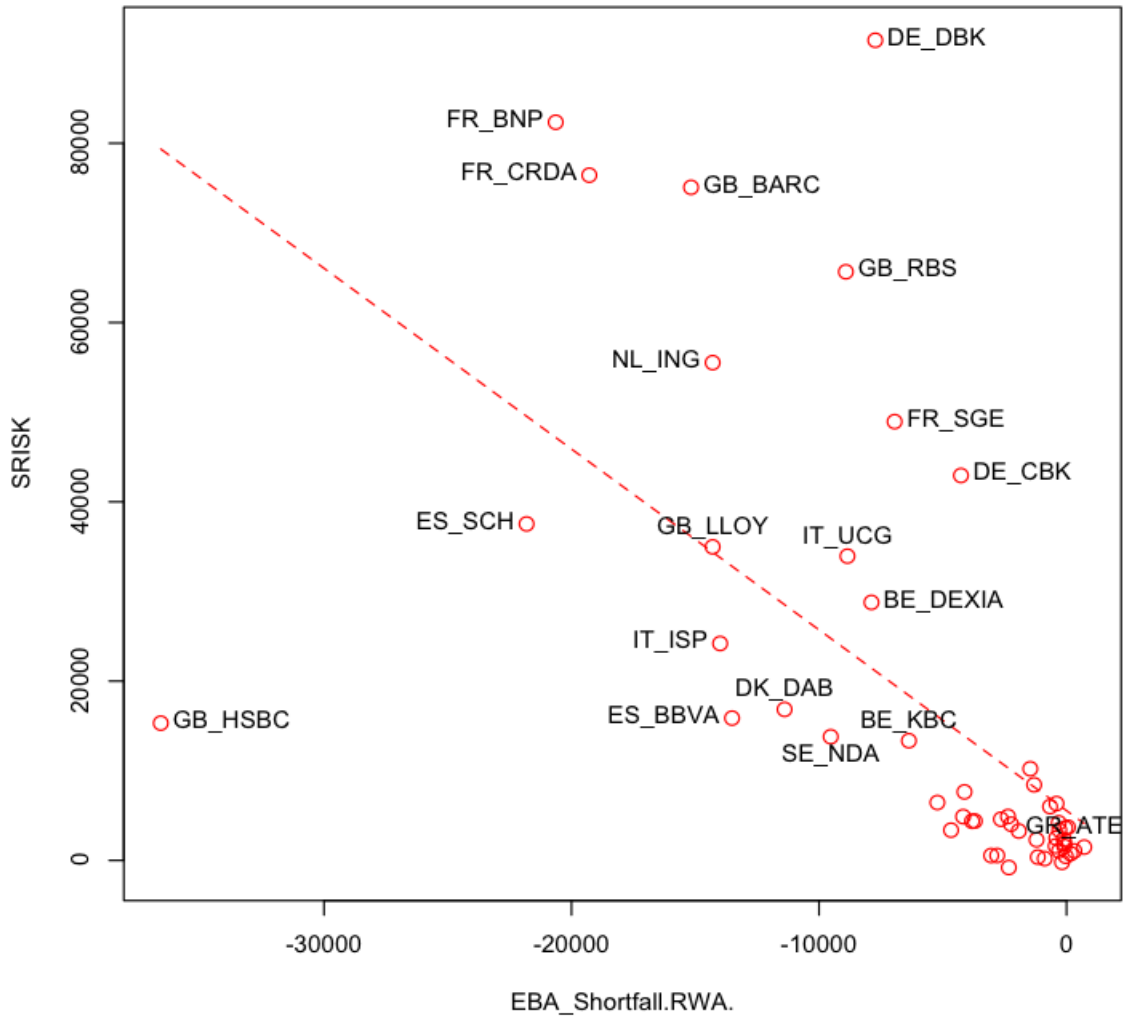
EBA disclosed capital shortfall $= \max(0, [k' * RWA_S - Capital_S])$
(k=0.055, k'=0.05, rank correlation: -0.273)



EBA capital excess vs. SRISK (EBA 2011)

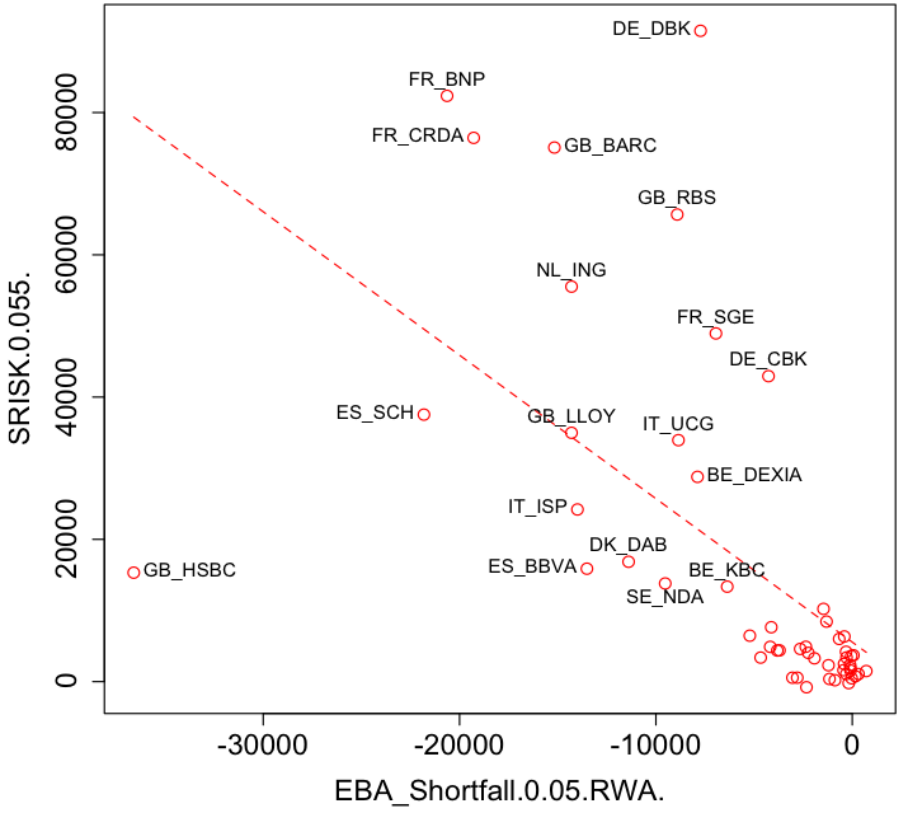
Vlab $SRISK = kDebt – (1-k)(1-LRMES) * MV$

EBA 'absolute' capital shortfall (RWA) $= k' * RWA_S - Capital_S$
(k=0.055, k'=0.05, rank correlation: -0.790)

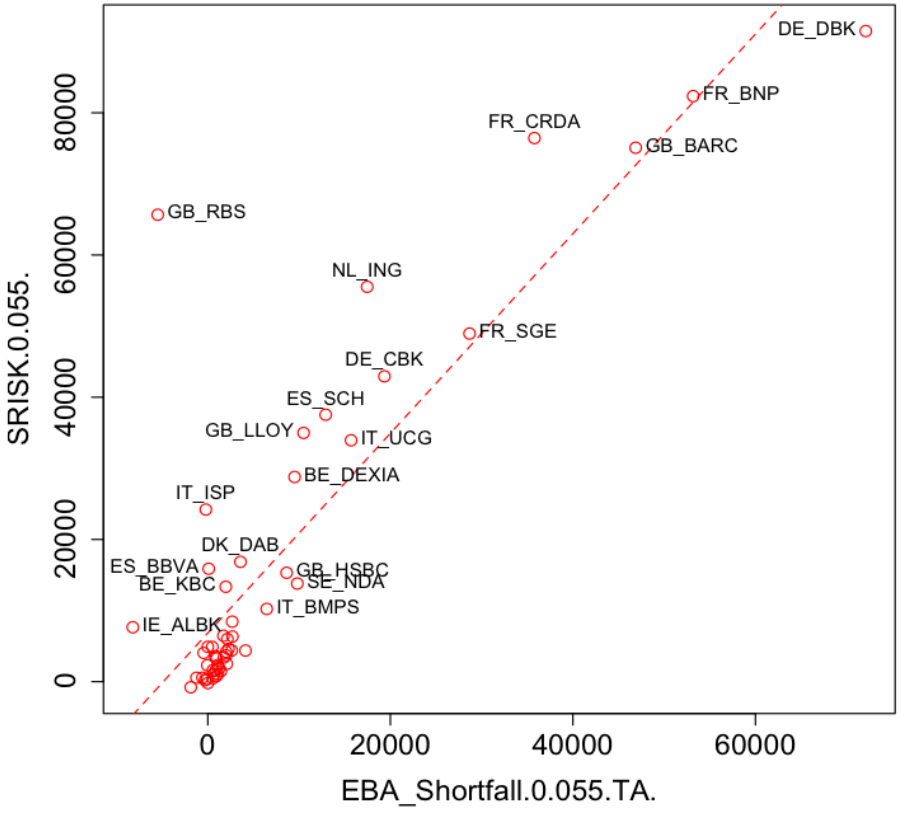


Risk-based capital vs. leverage-based capital shortfall (EBA 2011)

Risk-based shortfall
$k' * RWA_S - Capital_S$
(correlation with SRISK: -0.790)
Total shortfall (53 banks): 1.2 EUR bn



Leverage-based shortfall
$k * TA_S - Capital_S$
(correlation with SRISK: 0.679)
Total shortfall: 390 EUR bn



Conclusion

- Vlab and stress tests *projected losses* are well correlated & both predict well the actual realized losses during the European sovereign debt crisis.
- The *required capitalization* in stress tests is found to be inadequate ex post (especially in Europe), compared to SRISK.
- This discrepancy arises due to the reliance on *regulatory risk weights*.

Static regulatory risk weights are flawed and provide perverse incentives to build exposures to low-risk weight asset categories (Acharya and Steffen (2013)).

Recommendations:

- complement the assessment of banks and system risks with market measures of risk
- use multiple ratios in bank capital requirements to reduce regulatory arbitrage (e.g. T1CR *and* T1 LVGR)

Benchmarking the European Central Bank's Asset Quality Review and Stress Test (2014)

A Tale of Two Leverage Ratios

Viral V Acharya and Sascha Steffen, Dec 2014

Summary statistics of EBA stress test banks (2014)

Country	Number of banks	C Tier 1	Equity/Assets	RWA/Assets	Assets
France	11	11.22%	4.45%	26.67%	6,953,127
Germany	24	14.40%	4.43%	24.92%	4,649,092
Spain	16	11.40%	6.72%	44.98%	3,151,436
Italy	15	10.49%	6.45%	48.02%	2,361,707
Netherlands	7	17.05%	3.91%	33.02%	1,957,744
Belgium	5	15.85%	3.79%	25.71%	721,652
Austria	6	11.17%	7.71%	53.74%	474,248
Finland	3	16.29%	4.54%	23.50%	432,422
Greece	4	12.43%	8.27%	61.25%	354,223
Ireland	4	13.09%	8.83%	55.13%	328,384
Portugal	4	12.53%	6.11%	59.19%	318,278
Luxembourg	5	15.52%	7.62%	23.88%	96,388
Cyprus	3	10.58%	8.12%	67.51%	41,288
Slovakia	3	18.07%	11.26%	50.64%	32,724
Slovenia	3	12.05%	10.55%	74.36%	21,260
Estonia	2	35.17%	19.94%	47.27%	13,375
Malta	2	10.67%	7.70%	49.44%	12,979
Latvia	3	19.46%	13.02%	58.10%	12,642
Total	120	12.73%	5.19%	33.93%	21,932,969

- Substantial differences in capitalization between regulatory and book capital; on average balance reduces by a third on a risk-weighted basis.

Summary statistics of *publicly listed* EBA stress test banks (2014)

Country	Market Equity/Assets	Market-to-Book	RWA/Assets	MarketCap
France	3.23%	0.68	0.26	127,696
Germany	2.19%	0.61	0.23	50,570
Italy	4.29%	0.61	0.48	83,000
Spain	7.05%	1.00	0.48	146,082
Belgium	6.89%	1.18	0.31	17,305
Austria	5.31%	0.72	0.49	11,453
Greece	8.26%	0.95	0.58	26,945
Portugal	4.03%	0.91	0.51	4,978
Ireland	6.11%	0.98	0.43	9,816
Cyprus	3.75%	0.57	0.69	229
Malta	11.97%	1.58	0.49	1,557
Slovakia	9.20%	0.70	0.59	964
Total	**4.27%**	**0.75**	**0.35**	**539,083**

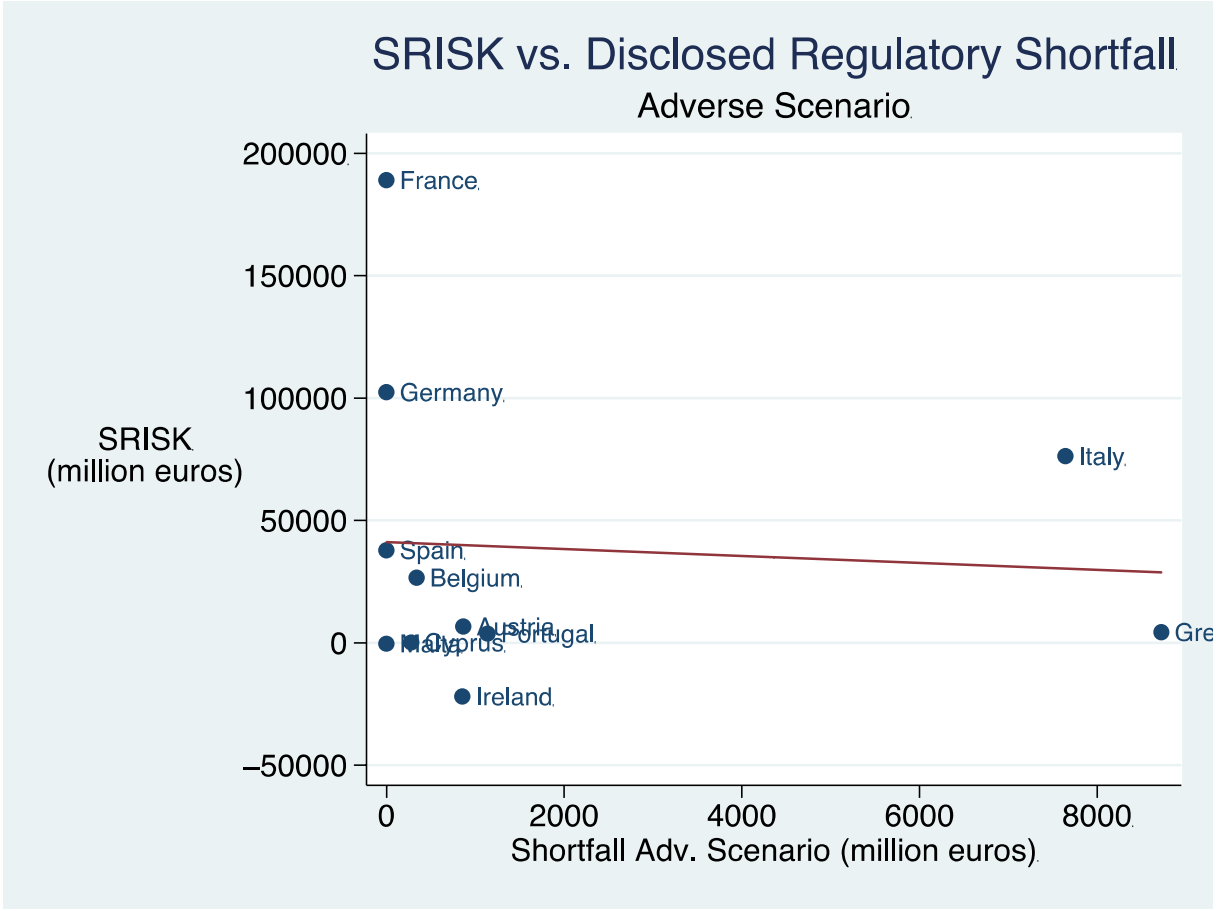
- Average M/B ratio is 0.75 suggesting markets are heavily discounting banks' asset values.

SRISK suggests that shortfalls are 20 times higher than regulatory shortfalls

Country	Market Equity/Assets	Market-to-Book	RWA/Assets	MarketCap	SRISK	ECB Shortfall Adverse Scenario
France	3.23%	0.68	0.26	127,696	189,042	0
Germany	2.19%	0.61	0.23	50,570	102,406	0
Italy	4.29%	0.61	0.48	83,000	76,287	7,640
Spain	7.05%	1.00	0.48	146,082	37,914	0
Belgium	6.89%	1.18	0.31	17,305	26,616	339
Austria	5.31%	0.72	0.49	11,453	6,677	865
Greece	8.26%	0.95	0.58	26,945	4,360	8,721
Portugal	4.03%	0.91	0.51	4,978	3,821	1,137
Ireland	6.11%	0.98	0.43	9,816	3,053	855
Cyprus	3.75%	0.57	0.69	229	167	277
Malta	11.97%	1.58	0.49	1,557	0	0
Slovakia	9.20%	0.70	0.59	964	0	0
Total	**4.27%**	**0.75**	**0.35**	**539,083**	**450,343**	**19,834**

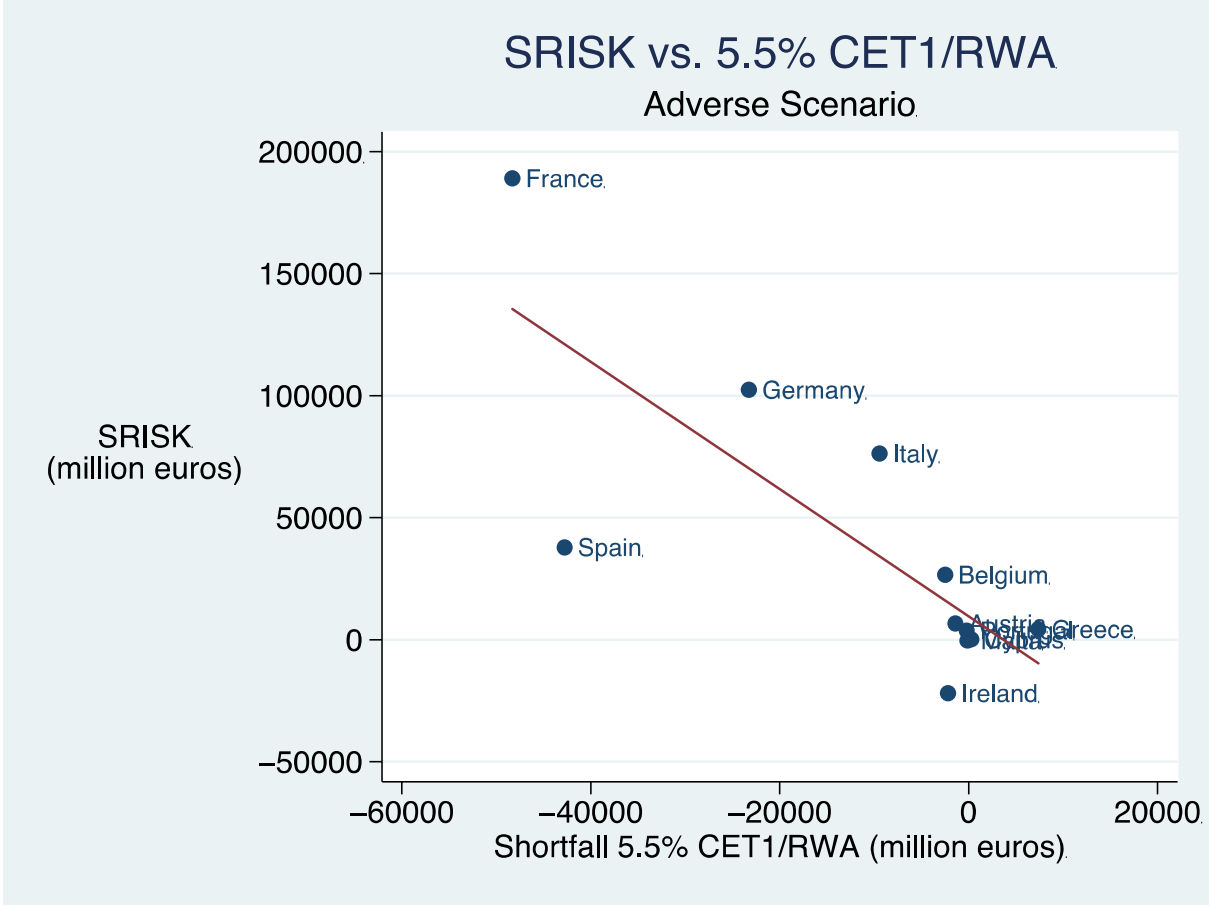
- Magnitude is a function of assumption about size of shock and LVG ratio
- Banks with high SRISK have low MTB and RWA/TA.

SRISK versus disclosed regulatory shortfall suggests even a somewhat negative correlation



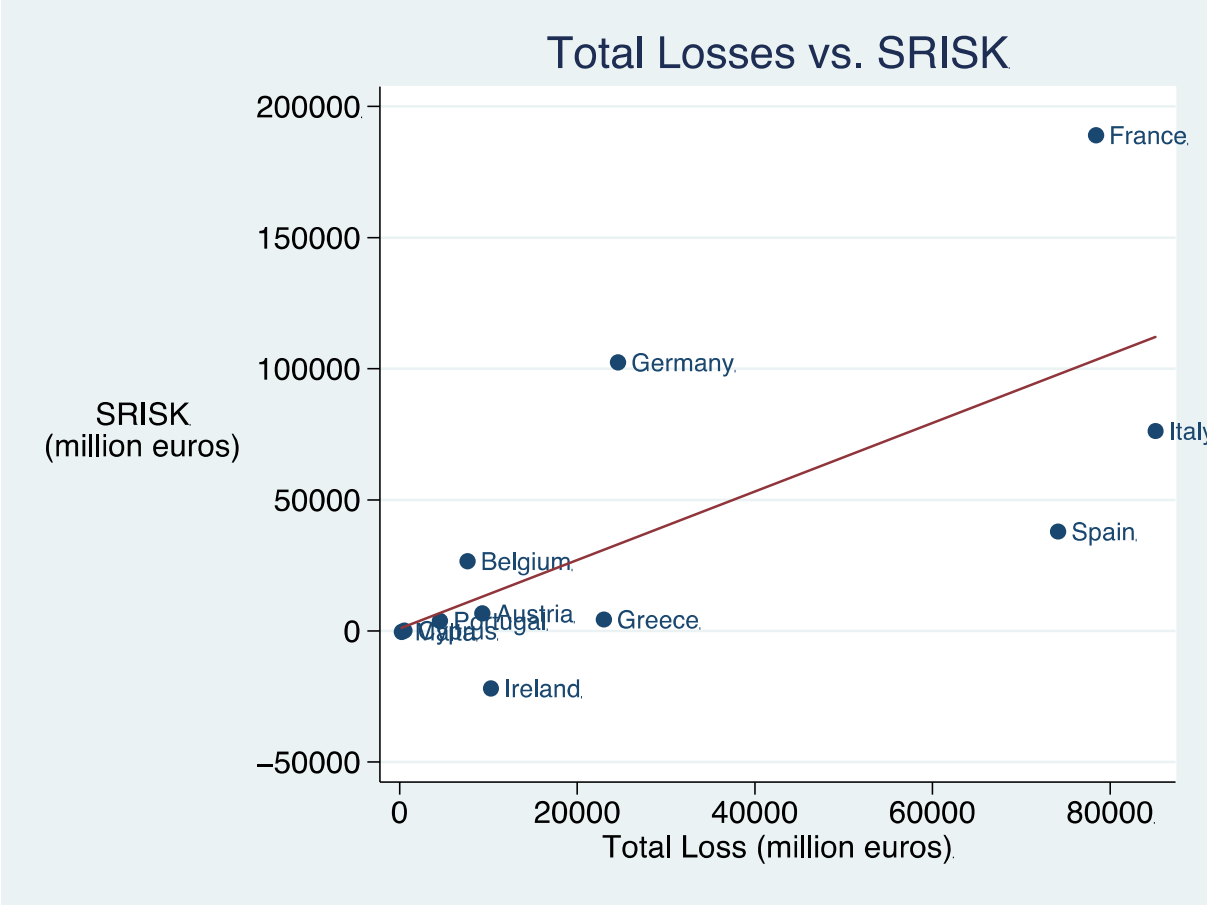
- Regulatory capital shortfall = **max[0, 5.5% x RWA – CET1]**

SRISK versus un-truncated regulatory shortfall suggests even significant negative correlation



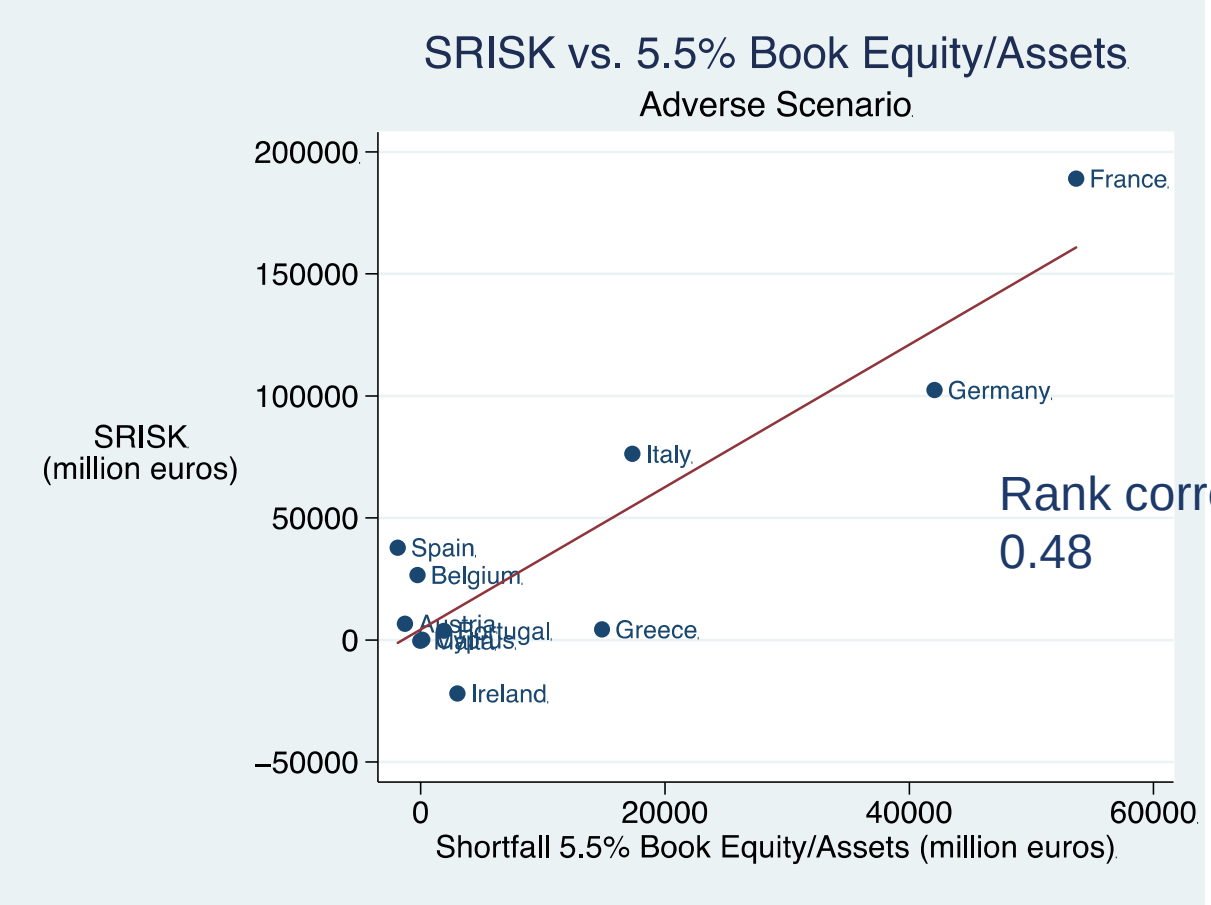
- *Un-truncated* regulatory capital shortfall = **5.5% x RWA – CET1**
- Rank correlation -0.77

SRISK is *positively* correlated with total losses in the banking and trading book in the adverse scenario



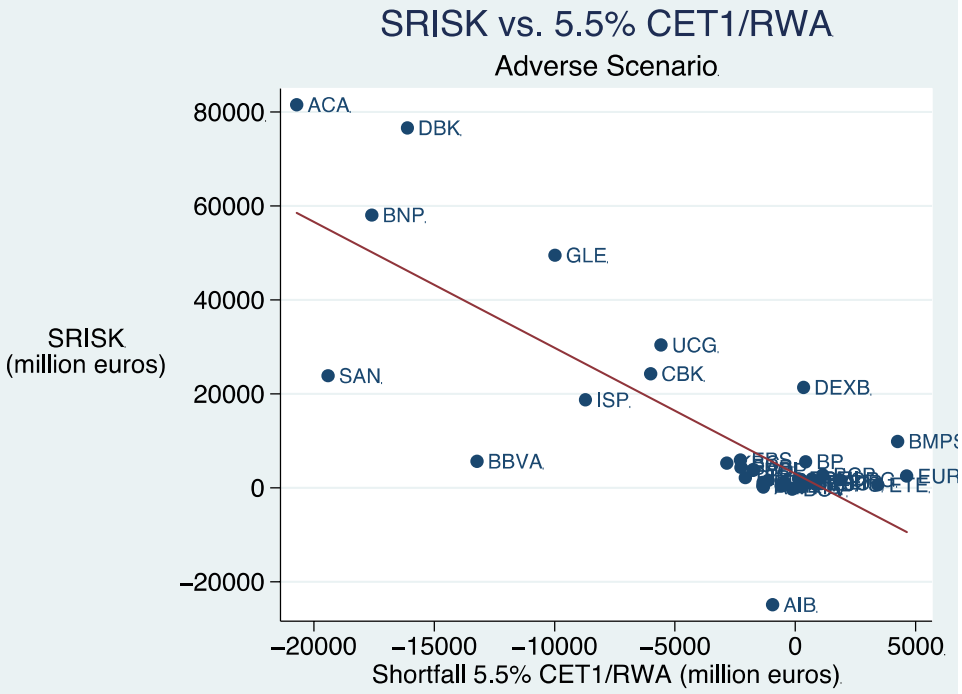
- It is not losses driving negative correlation but specification of prudential capital requirement

SRISK highly correlated with Book Equity shortfall after applying losses in adverse scenario

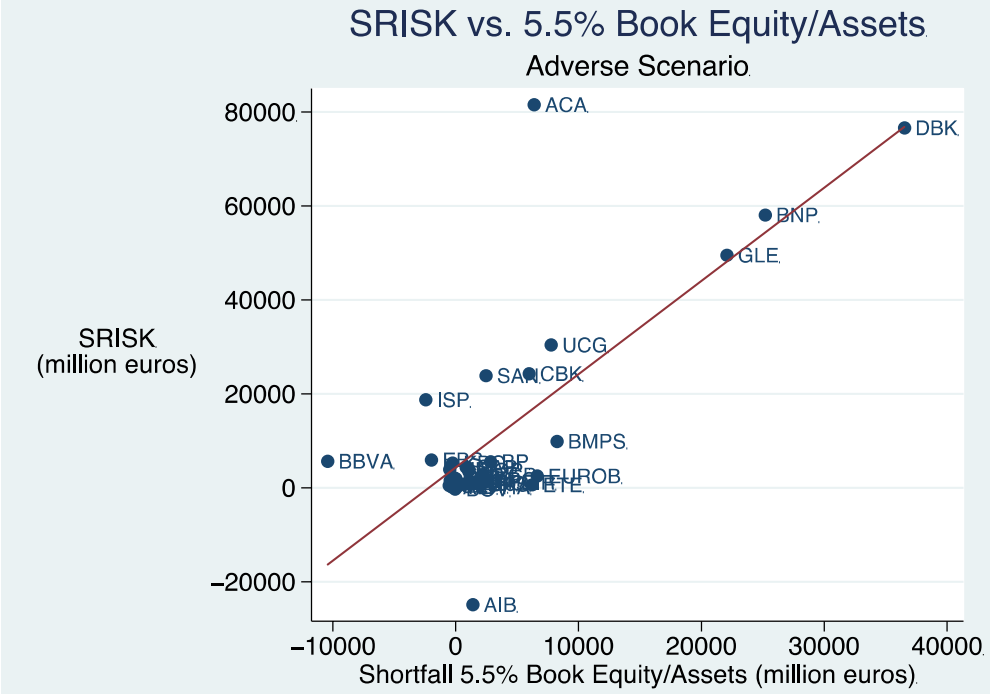


- Book capital shortfall = **5.5% x TA – Book Equity**
- Total shortfall: €129 billion (only public banks!)

Bank-level shortfall estimates strikingly show the effect of risk-weighting



Rank Correlation: -0.57



Rank Correlation: 0.38

Implications

- A crucial weakness has not been addressed in 2014: use of static risk weights

- Is a bank adequately capitalized?
  - This question has two answers dependent on the leverage ratio
    - Risk-weighted LVG
    - *Not* risk-weighted LVG -> corresponds to market-based assessment more closely

- Future stress tests should incorporate a robust approach
  - Using multiple leverage ratios
  - Who is doing particularly well on risk-weighted leverage ratio but particularly poorly on not risk-weighted leverage ratios?
  - Are they “gaming” risk-weights?

Implications (cont'd)

- Advantages of regulatory stress test
  - Detailed portfolio data shows problem assets, non-traded institutions
  - But: different accounting standards, needs scenario, (still) micro-prudential

- Advantages of stress tests using market data
  - Market prices are forward looking, less discretion, no specific scenario necessary, incorporates systemic risk
  - But: market-based measures are highly volatile and procyclical, large fraction of banking sector is privately-held

Capital Shortfalls of European Banks since the Start of the Banking Union

Viral V. Acharya (NYU, NBER and CEPR)[1]
Diane Pierret (University of Lausanne)[2]
Sascha Steffen (University of Mannheim and ZEW)[3]

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Abstract

Since the start of the Banking Union in November 2014, European banks lost nearly half their market capitalization. Important risks in bank balance sheets are still unaccounted for requiring an even larger recapitalization compared to the capital shortfall estimates of November 2014. The market's assessment of banks' risky assets is still decoupled from their book valuation and associated Basel risk-weights, causing a divergence between market and regulatory assessments of bank capital. Not only Italian but also German and French banks show large capital shortfalls, some of which may require public backstops if losses are not to be passed onto non-subordinated debt holders of banks.

Figure 1. Euro Stoxx Banks

This figure shows the evolution of the Euro Stoxx Banks index (based on 30 largest banks in the EU) from 3 November 2014 until 30 June 2016.

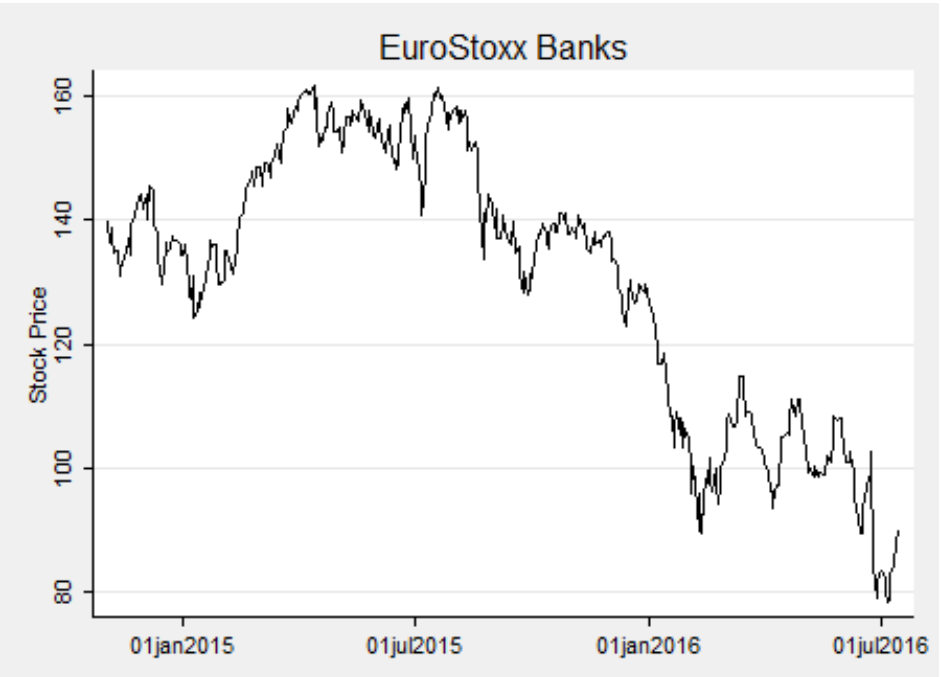


Figure 2. Capital Shortfall in a Systemic Crisis: 2014 versus 2016

This figure shows the evolution of the estimated capital shortfall measure *SRISK* by country between November 2014 and June 2016. *SRISK* represents the expected capital shortfall of a bank in the scenario where the market index drops by 40% over six months. *SRISK* by country is summed over all public banks participating in the 2016 EBA stress test in each country.

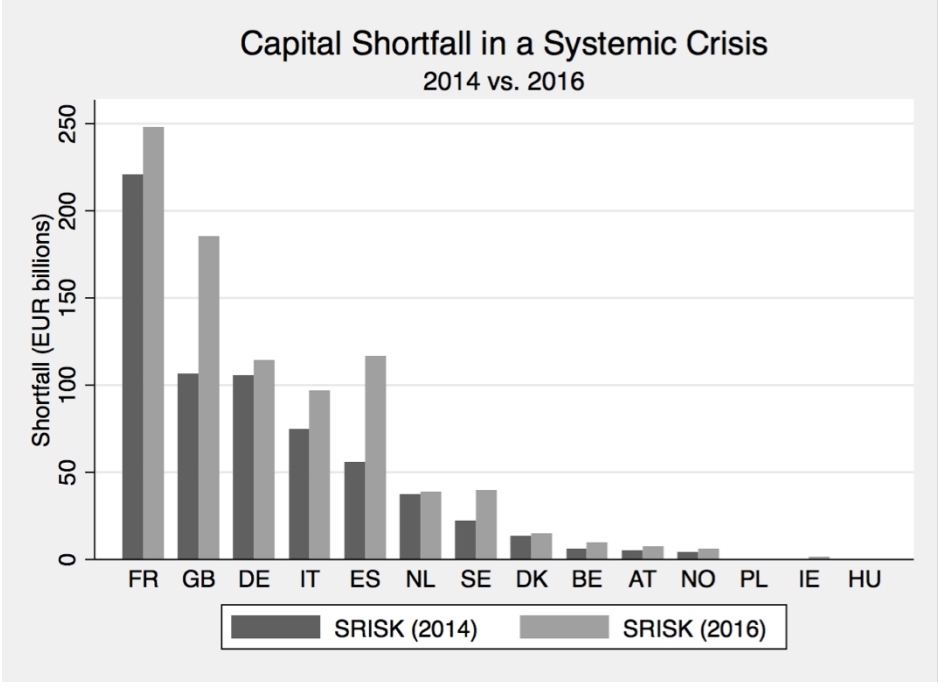
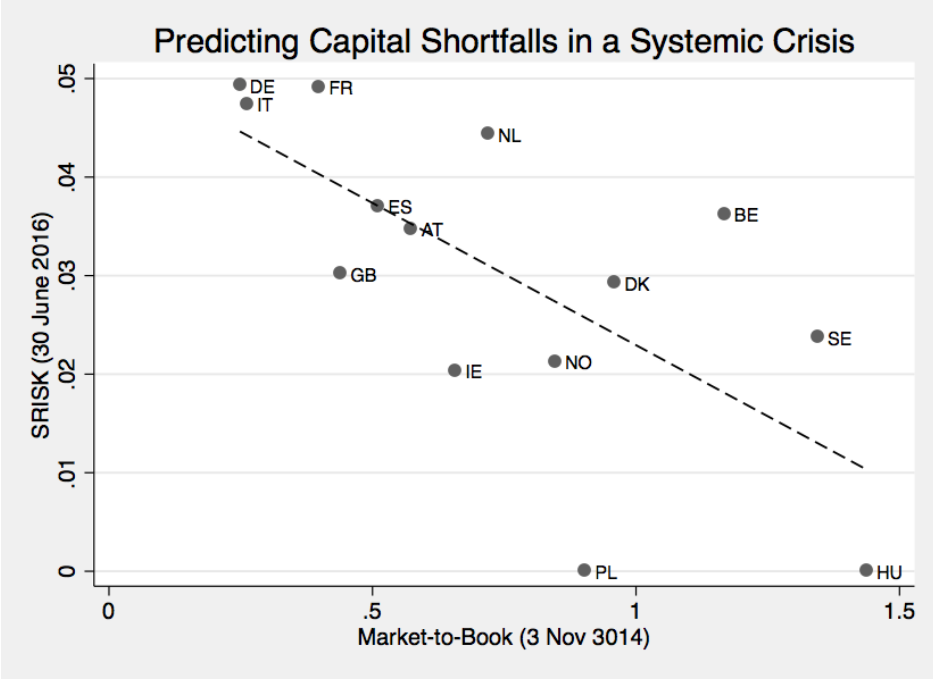


Figure 3. Predicting Capital Shortfalls in a Systemic Crisis
This figure shows the correlation between *SRISK* in June 2016 and bank characteristics measured in November 2014. Panel A: correlation between the ratio of country total *SRISK* to country total banks assets in June 2016 and the average market-to-book ratio of banks of the country in November 2014. Panel B: correlation between the ratio of country total *SRISK* to country total banks assets in June 2016 and the same ratio measured in November 2014.



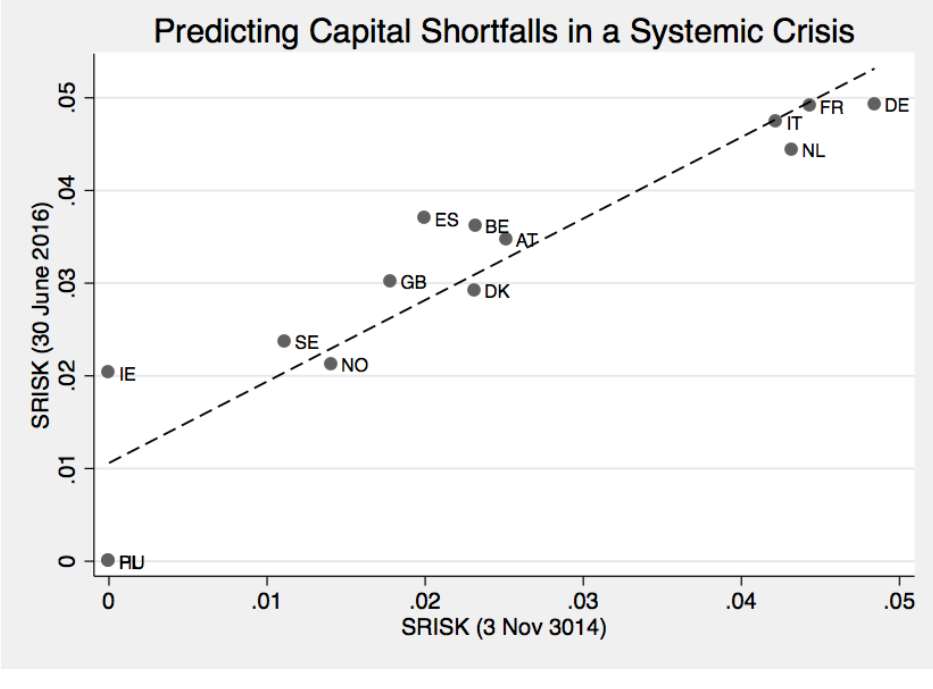


Figure 4. Predicting Market-to-Book Ratios

This figure shows the correlation between the average market-to-book ratio of banks located in a country in June 2016 and the same ratio measured in November 2014.

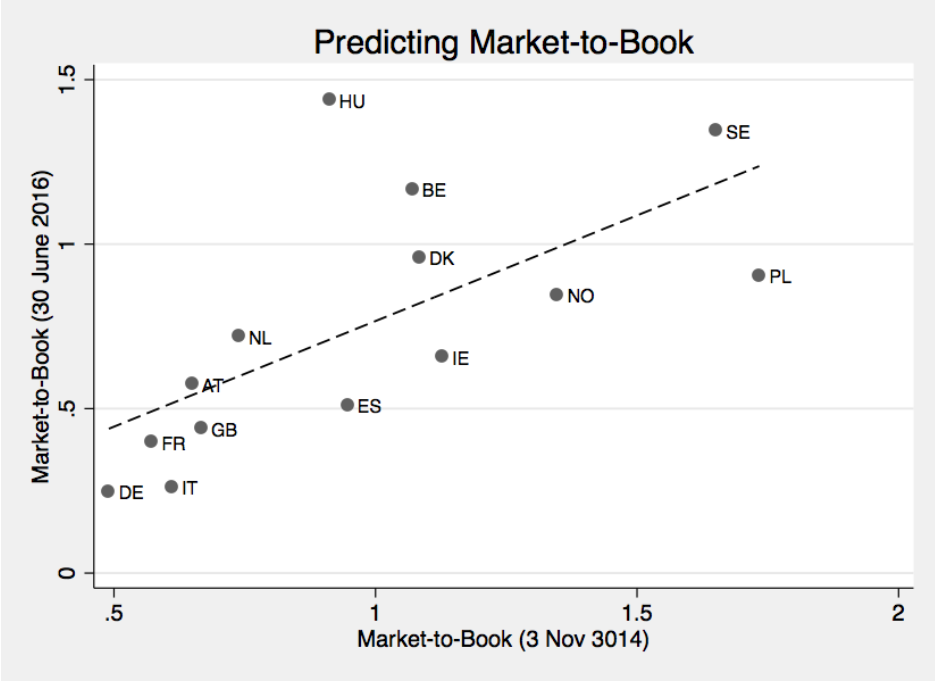
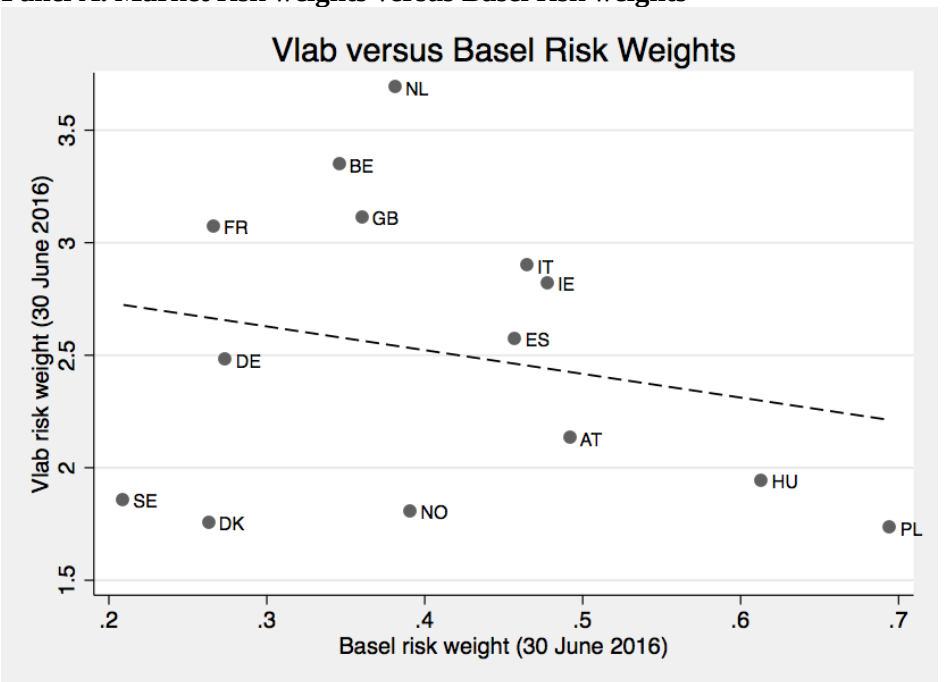


Figure 5. Vlab risk weights versus regulatory risk weights

This figure shows the correlation between the market risk weight implied by the *SRISK* capital shortfall measure (Vlab risk weight) and the regulatory risk weight (ratio of RWA/Assets). Panel A: correlation between the average June 2016 Vlab risk weight by country and the average regulatory risk weight as of December 2015 (Basel risk weight). Panel B: correlation between the average June 2016 Vlab risk weight by country and the average regulatory risk weight projected in the stress scenario of the 2014 EBA stress test (EBA risk weight).

Panel A. Market risk weights versus Basel risk weights



Panel B. Market risk weights versus EBA stressed risk weights

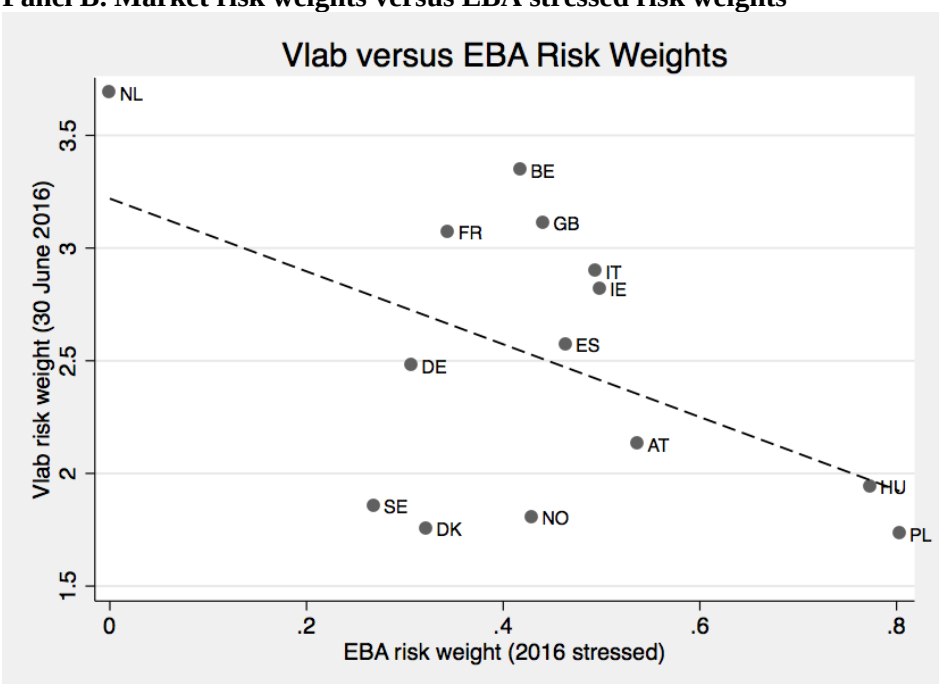


Table 1
Descriptive Statistics: Book Capitalization

This table reports descriptive statistics of the banks participating in the EU-wide stress test conducted by the European Banking Authority (EBA) in 2016 (data are available for 50 out of the 51 banks included in the 2016 EBA stress test). Panel A: descriptive statistics by country as of December 2015. Panel B: Average capital ratios as of November 2014. C Tier 1 is the Core Tier 1 ratio and is the ratio of Core Tier 1 Capital divided by Risk-Weighted Assets (RWA). Equity/Assets is book equity over total assets. IFRS Tier 1 LVG is C Tier 1 Capital divided by total assets minus intangible assets minus derivative liabilities. Tangible Equity/Tangible Assets is defined as book equity minus intangible assets divided by total assets minus intangible assets. RWA/Assets is RWA divided by total assets. Net Impaired Loans/C Tier 1 Capital is the amount of impaired loans net of reserves over Common Tier 1 Capital. Assets are total assets and measured in million euros. Banks are the number of banks per country participating in the EBA stress test and for which data are available.

Panel A. Book measures of capital

Country	Number of banks	C Tier 1	IFRS Tier1 LVG	Equity/ Assets	Tan. equity/ Tan. assets	RWA/Assets	Net Impaired Loans / C Tier 1 Capital	Assets
Austria	2	11.5%	6.0%	7.1%	6.5%	50.1%	28.9%	344,795
Belgium	2	15.1%	5.2%	5.6%	5.3%	31.0%	34.4%	438,513
Denmark	3	16.3%	4.4%	4.7%	4.6%	24.9%	19.4%	717,806
Finland	1	19.5%	7.1%	7.6%	6.5%	34.3%	1.4%	124,296
France	5	11.6%	3.7%	4.6%	4.1%	26.6%	24.2%	6,480,940
Germany	9	14.0%	5.3%	5.1%	4.7%	29.9%	10.5%	3,481,186
Hungary	1	13.2%	8.4%	11.5%	10.2%	62.4%	32.8%	34,132
Ireland	2	14.4%	7.2%	9.1%	8.8%	47.8%	65.2%	234,082
Italy	5	11.6%	5.4%	6.6%	5.8%	42.6%	57.2%	2,004,914
Netherlands	4	16.1%	4.7%	5.4%	5.2%	31.3%	26.0%	2,045,712
Norway	1	17.0%	6.5%	7.4%	7.1%	35.7%	7.4%	280,108
Poland	1	14.1%	10.0%	11.6%	10.5%	69.3%	20.0%	63,004
Spain	6	12.3%	6.1%	7.3%	5.7%	45.4%	32.7%	2,977,022
Sweden	4	19.5%	4.1%	4.5%	4.1%	19.3%	8.7%	1,536,929
United Kingdom	4	12.4%	5.4%	6.5%	6.0%	33.9%	13.8%	6,007,405
	50	13.3%	5.0%	5.8%	5.2%	32.7%	22.9%	26,770,845

Panel B. Comparison November 2014 to June 2016

Capital Measures	Obs	2014	2016
Tangible equity/Tangible assets	15	4.9%	5.2%
IFRS Tier1 LVG	15	4.8%	5.0%
C Tier 1	15	12.6%	13.3%
Equity/Assets	15	5.6%	5.8%
RWA/Assets	15	33.7%	32.7%
Net Impaired Loans / C Tier 1 Capital	15	26.4%	22.9%

Table 2
Descriptive Statistics: Market Capitalization

This table reports descriptive statistics of market-based measures of capitalization on a country level. Panel A: descriptive statistics by country as of June 30, 2016. Panel B: Average capital ratios as of November 3, 2014. LRMES is the expected six-month return of a bank in the scenario where the MSCI World Index drops by 40% over six months. Std. Dev. is the annualized standard deviation of the bank equity return. Beta is the beta of the bank with respect to the MSCI World Index. Correlation is the correlation of the bank stock return with respect to the MSCI World Index return. Market-to-Book is market value over book value of equity. Market Equity/Assets is a market leverage ratio defined as market equity divided by asset minus book equity plus market equity. Assets are total assets measured in million euros. Market Cap is the market value of equity measured in million euros. Number of banks is the number of public banks participating in the EBA stress test in each country.

Panel A. Market measures of capital

Country	LRMES	Std. Dev.	Beta	Correlation	Market-to-Book	Market Equity / Assets	Assets	MarketCap	Number of banks
Austria	0.56	3.9%	1.61	0.60	0.57	4.3%	206,369	8,735	1
Belgium	0.74	8.4%	2.65	0.69	1.17	6.8%	261,551	18,374	1
Denmark	0.46	2.4%	1.19	0.57	1.07	4.9%	529,863	26,438	2
France	0.71	8.1%	2.49	0.73	0.42	2.0%	5,065,221	93,631	3
Germany	0.63	4.7%	1.94	0.76	0.25	1.1%	2,276,393	24,309	2
Hungary	0.51	2.3%	1.41	0.78	1.44	15.4%	34,132	5,636	1
Ireland	0.48	8.1%	1.48	0.33	1.07	11.6%	234,082	20,933	2
Italy	0.78	15.6%	3.07	0.70	0.41	2.9%	2,004,914	44,309	5
Netherlands	0.77	7.9%	2.89	0.79	0.72	4.1%	868,897	35,611	1
Norway	0.47	2.5%	1.25	0.49	0.85	6.1%	280,108	17,418	1
Poland	0.45	2.0%	1.16	0.54	0.90	10.4%	63,004	6,616	1
Spain	0.63	11.3%	2.02	0.67	0.53	3.9%	2,977,022	112,842	6
Sweden	0.49	3.7%	1.31	0.48	1.32	5.9%	1,536,929	89,065	4
United Kingdom	0.57	8.2%	1.84	0.63	0.61	4.3%	6,007,405	189,055	4
	0.61	**7.9%**	**1.98**	**0.63**	**0.70**	**4.4%**	**22,345,892**	**692,972**	**34**

Panel B. Comparison November 2014 to June 2016

Capital Measures	Obs	2014	2016
Market-to-Book	14	1.03	0.7
Market Equity / Assets	14	7.1%	4.4%

Table 3
Book Capital Shortfall

This table reports the banks' capital shortfall derived from different capital requirement rules based on several measures of book capitalization. We assume a prudential capital ratio for all book leverage measures of 4% as well as 7%. C Tier 1 is the Core Tier 1 ratio defined as Core Tier 1 Capital over Risk-Weighted Assets (RWA). Equity/Assets is book equity divided by total assets. Tangible Equity/Tangible Assets is book equity minus intangible assets divided by total assets minus intangible assets. IFRS Tier 1 LVG is Tier 1 Capital divided by total assets minus intangible assets minus derivative liabilities. Assets are total assets measured in million euros. Shortfalls are reported in million euros and are summed over all banks in each country.

		Shortfall Assuming 4% threshold			Shortfall Assuming 7% threshold		
Country	**Assets**	**Equity/Assets**	**Tan. equity/ Tan. assets**	**IFRS Tier1 LVG**	**Equity/Assets**	**Tan. equity/ Tan. assets**	**IFRS Tier1 LVG**
Austria	344,795	-	-	-	394	1,622	3,293
Belgium	438,513	-	-	-	6,301	7,372	7,320
Denmark	717,806	-	-	-	16,431	17,290	17,119
Finland	124,296	-	-	-	-	631	-
France	6,480,940	2,064	17,027	26,391	152,800	189,155	185,742
Germany	3,481,186	3,077	12,587	-	81,932	95,318	53,944
Hungary	34,132	-	-	-	-	-	-
Ireland	234,082	-	-	-	54	543	1,788
Italy	2,004,914	-	-	-	11,407	24,343	29,301
Netherlands	2,045,712	2,254	2,256	1,780	33,078	36,134	43,101
Norway	280,108	-	-	-	-	-	1,296
Poland	63,004	-	-	-	-	-	-
Spain	2,977,022	-	-	-	3,246	37,632	24,545
Sweden	1,536,929	-	1,061	925	37,876	44,293	41,180
United Kingdom	6,007,405	-	-	3,218	44,589	66,779	76,003
	26,770,845	**7,394**	**32,931**	**32,314**	**388,109**	**521,111**	**484,631**

Table 4
Book Capital vs. Market Capital Based Measures

This table reports the banks' capital shortfall derived from different capital requirement rules based on measures of book and market capitalization for the 34 publicly listed banks participating in the 2016 EBA stress test. Equity / Assets is book equity over total assets. Market Equity / Assets is a market leverage ratio and defined as market equity over asset minus book equity + market equity. The less stringent benchmark is a leverage ratio of 4% and the more stringent benchmark is a leverage ratio of 7%. For comparison, we report the shortfall using the unstressed capital ratios (Equity/Assets and Market Equity/Assets) of 3%. Shortfalls are reported in million euros and are summed over all banks in each country.

	Stressed Book Capital Ratios			Stressed Market Capital Ratios		
Country	**Equity/Assets**	**Equity/Assets**	**Equity/Assets**	**Market Equity / Assets**	**Market Equity / Assets**	**Market Equity / Assets**
	3%	**4%**	**7%**	**3%**	**4%**	**7%**
Austria	0	0	0	0	0	5,650
Belgium	0	0	2,574	0	0	648
Denmark	0	0	12,153	0	0	11,378
France	0	2,064	128,363	58,248	108,900	260,856
Germany	0	3,077	62,561	43,767	66,530	134,822
Hungary	0	0	0	0	0	0
Ireland	0	0	54	0	0	2,901
Italy	0	0	11,407	21,382	35,276	95,423
Netherlands	0	0	11,343	0	0	25,527
Norway	0	0	0	0	0	2,409
Poland	0	0	0	0	0	0
Spain	0	0	3,246	0	8,475	94,428
Sweden	0	0	37,876	0	0	23,818
United Kingdom	0	0	44,589	18,700	34,456	187,091
	0	**5,141**	**314,166**	**142,097**	**253,637**	**844,951**

Table 5
SRISK or Capital Shortfall in a Systemic Crisis

This table reports the banks' capital shortfall derived from different capital requirement rules based on the market capitalization of banks in the scenario where the market index drops by 40% over six months. Sample: 34 publicly listed banks participating in the 2016 EBA stress test. Market Cap is the total market capitalization as of 30 June 2016 in million euros. Market Equity / Total Assets is market capitalization over total assets. *LRMES* is the expected six-month return of a bank in the scenario where the MSCI World Index drops by 40% over six months. *LRMES**Market Equity is the absolute market value loss in a systemic financial crisis in million euros. *SRISK* is the expected shortfall of a bank in a systemic crisis over a six-month period considering both *LRMES* and market leverage. By default, *SRISK* is calculated assuming a 5.5% prudential capital ratio (which is the measure available on the NYU Stern Vlab website). *SRISK* 3%, 4%, 7% are capital shortfall estimates in a systemic crisis under different prudential capital ratio assumptions. Panel A reports the absolute shortfalls in million euros for each country sorted by the largest absolute *SRISK* (5.5%) value (in bold). Panel B reports the shortfalls scaled by each country's GDP and sorted by the highest relative *SRISK*.

Panel A. Absolute SRISK (in million euros)

Country	MarketCap	Market Equity / Assets	LRMES	LRMES * Market Equity	SRISK	SRISK 3%	SRISK 4%	SRISK 7%
					Prudential Capital Ratio			
					5.50%	3%	4%	7%
France	93,631	2.0%	71.5%	66,939	247,951	123,113	173,048	322,854
United Kingdom	189,055	4.3%	57.1%	107,991	185,347	64,251	112,690	258,005
Spain	112,842	3.9%	63.2%	71,321	116,626	44,741	73,495	159,757
Germany	24,309	1.1%	62.8%	15,273	114,467	58,330	80,785	148,150
Italy	44,309	2.9%	78.1%	34,608	96,657	48,312	67,650	125,663
Sweden	89,065	5.9%	48.8%	43,488	39,767	5,186	16,491	63,043
Netherlands	35,611	4.1%	77.1%	27,470	38,564	17,334	25,826	51,302
Denmark	26,438	4.9%	45.5%	12,039	14,896	1,580	6,906	22,885
Belgium	18,374	6.8%	74.2%	13,635	9,477	3,015	5,600	13,355
Austria	8,735	4.3%	56.2%	4,907	7,173	2,173	4,173	10,174
Norway	17,418	6.1%	47.2%	8,222	5,955	0	1,823	10,087
Ireland	20,933	11.6%	48.0%	10,045	5,330	2,317	3,522	7,137
Hungary	5,636	15.4%	51.3%	2,894	0	0	0	0
Poland	6,616	10.4%	44.8%	2,962	0	0	0	600
	692,972	**4.4%**	**60.9%**	**421,793**	**882,210**	**370,353**	**572,010**	**1,193,010**

Panel B. Relative SRISK (Scaled by GDP)

Country	MarketCap	Market Equity / Assets	LRMES	LRMES * Market Equity	SRISK	SRISK 3%	SRISK 4%	SRISK 7%
					Prudential Capital Ratio			
					5.5%	3%	4%	7%
France	93,631	2.0%	71.5%	3.1%	11.4%	5.7%	7.9%	14.8%
Spain	112,842	3.9%	63.2%	6.6%	10.8%	4.1%	6.8%	14.8%
Sweden	89,065	5.9%	48.8%	9.8%	9.0%	1.2%	3.7%	14.2%
United Kingdom	189,055	4.3%	57.1%	4.2%	7.2%	2.5%	4.4%	10.1%
Italy	44,309	2.9%	78.1%	2.1%	5.9%	3.0%	4.1%	7.7%
Netherlands	35,611	4.1%	77.1%	4.1%	5.7%	2.6%	3.8%	7.6%
Denmark	26,438	4.9%	45.5%	4.5%	5.6%	0.6%	2.6%	8.6%
Germany	24,309	1.1%	62.8%	0.5%	3.8%	1.9%	2.7%	4.9%
Ireland	20,933	11.6%	48.0%	4.7%	2.5%	1.1%	1.6%	3.3%
Belgium	18,374	6.8%	74.2%	3.3%	2.3%	0.7%	1.4%	3.3%
Austria	8,735	4.3%	56.2%	1.5%	2.1%	0.6%	1.2%	3.0%
Norway	17,418	6.1%	47.2%	2.4%	1.7%	0.0%	0.5%	2.9%
Hungary	5,636	15.4%	51.3%	2.7%	0.0%	0.0%	0.0%	0.0%
Poland	6,616	10.4%	44.8%	0.7%	0.0%	0.0%	0.0%	0.1%
	692,972	**4.4%**	**60.9%**	**4.8%**	**7.6%**	**2.7%**	**4.6%**	**10.7%**

Table 6. Capital shortfalls comparison: November 2014 versus June 2016

This table reports the evolution of the market capitalization and the capital shortfall measure *SRISK* from November 2014 until June 2016. Market Cap is the total market capitalization of banks by country in million euros. *SRISK* is the total expected capital shortfall of banks located in the country in the scenario where the market index drops by 40% over six months. Change is the percentage change between November 2014 and June 2016 measures.

	MarketCap			SRISK		
Country	**2014**	**2016**	**Change**	**2014**	**2016**	**Change**
France	122,489	93,631	-23.6%	220,554	247,951	12.4%
United Kingdom	278,434	189,055	-32.1%	106,565	185,347	73.9%
Germany	48,076	24,309	-49.4%	105,573	114,467	8.4%
Italy	83,600	44,309	-47.0%	74,796	96,657	29.2%
Spain	193,564	112,842	-41.7%	55,541	116,626	110.0%
Netherlands	43,879	35,611	-18.8%	37,537	38,564	2.7%
Sweden	110,056	89,065	-19.1%	23,227	39,767	71.2%
Denmark	26,031	26,438	1.6%	13,157	14,896	13.2%
Belgium	17,684	18,374	3.9%	6,060	9,477	56.4%
Austria	8,730	8,735	0.1%	5,182	7,173	38.4%
Norway	23,619	17,418	-26.3%	3,939	5,955	51.2%
Ireland	68,448	20,933	-69.4%	2,818	5,330	89.2%
Hungary	3,641	5,636	54.8%	0	0	0.0%
Poland	11,140	6,616	-40.6%	0	0	0.0%
	1,039,391	**692,972**	**-33.3%**	**654,948**	**882,210**	**34.7%**

Table 7. Capital shortfalls and "Bail-Ins"

This table reports the banks' capital shortfall in a systemic crisis (*SRISK*) relative to market equity and market equity plus subordinated debt. *SRISK* is the expected capital shortfall in the scenario where the market index drops by 40% over six months and assuming a prudential capital ratio of 5.5%.

Country	SRISK/Market Equity	SRISK/(Market Equity+Sub Debt)
Germany	470.9%	249.6%
France	264.8%	162.1%
Italy	218.1%	100.7%
Netherlands	108.3%	73.3%
Spain	103.4%	74.1%
United Kingdom	98.0%	59.2%
Austria	82.1%	47.1%
Denmark	56.3%	47.1%
Belgium	51.6%	42.9%
Sweden	44.7%	36.1%
Norway	34.2%	28.9%
Ireland	25.5%	18.1%
Hungary	0.0%	0.0%
Poland	0.0%	0.0%
	111.3%	67.1%

Appendix I

This table is a list of all banks participating in the 2016 stress tests and for which data are available from SNL Financial as of Q1 2016.

Bank	Country	Ticker	Total Assets (€ mn)	CET 1 (%)	Equity/Assets (%)	RWA/Assets (%)
Erste Group Bank	Austria	EBS	199,743	12.35	7.41	49.21
Raiffeisen Zentralbank	Austria		138,426	10.58	6.72	52.11
KBC Group	Belgium	KBC	252,356	15.16	6.27	34.61
Belfius Banque	Belgium		176,962	15.90	4.89	26.57
Danske Bank	Denmark	DANSKE	441,188	16.12	4.88	25.32
Nykredit Realkredit	Denmark		185,403	19.45	4.73	22.49
Jyske Bank	Denmark	JYSK	72,806	16.06	5.53	32.56
OP Financial Group	Finland		125,145	19.55	7.45	33.42
BNP Paribas	France	BNP	1,994,193	11.05	5.02	31.57
Crédit Agricole SA	France	ACA	1,529,294	10.79	3.89	19.98
Société Générale	France	GLE	1,334,391	11.42	4.70	26.73
Groupe BPCE	France		1,166,535	13.02	5.59	33.55
La Banque Postale	France		218,708	13.20	4.18	24.79
Deutsche Bank	Germany	DBK	1,629,130	13.19	4.15	24.39
Commerzbank	Germany	CBK	532,641	13.77	5.71	37.22
DZ Bank AG	Germany		408,341	13.85	4.83	23.96
Landesbank Baden-Württemberg	Germany		234,015	16.36	5.83	31.82
Bayerische Landesbank	Germany		215,711	15.14	5.13	32.27
NORD/LB	Germany		180,998	13.07	4.70	35.18
Landesbank Hessen-Thüringen	Germany		172,256	13.79	4.46	31.85
NRW.BANK	Germany		141,175	42.58	13.27	30.58
Volkswagen Financial Svcs AG	Germany		121,251	11.97	12.22	89.35
DekaBank Deutsche Girozentrale	Germany		107,981	13.51	4.56	28.88
National Bank of Greece	Greece	ETE	111,232	14.52	8.83	55.56
OTP Bank	Hungary	OTP	33,916	13.28	11.51	61.35
Governor and Co. of the bank	Ireland	BKIR	130,960	13.30	6.96	40.70
Allied Irish Banks	Ireland	AIB	103,122	15.86	11.78	56.78
UniCredit	Italy	UCG	860,433	10.59	6.22	45.40
Intesa Sanpaolo	Italy	ISP	676,496	12.98	7.18	42.03
Banca Monte dei Paschi	Italy	BMPS	169,012	12.01	5.69	41.91
Banco Popolare	Italy	BP	120,510	13.15	7.09	37.13
UBI Banca	Italy	UBI	117,201	12.08	8.97	52.34
ING Groep	Netherlands	INGA	841,769	12.94	5.76	38.15
Rabobank	Netherlands		670,373	13.49	6.16	31.79
ABN AMRO Group	Netherlands		390,317	15.53	4.51	27.67
Nederlandse Waterschapsbank	Netherlands		91,314	65.07	1.53	2.19
DNB ASA	Norway	DNB	270,076	16.03	7.33	39.12
PKO Bank Polski	Poland	PKO	62,265	13.27	11.34	69.48
Banco Santander	Spain	SAN	1,340,262	12.55	7.37	43.70
BBVA	Spain	BBVA	750,078	12.10	7.39	53.50
CaixaBank	Spain	CABK	344,255	12.90	7.32	41.63
Banco de Sabadell	Spain	SAB	208,628	11.50	6.12	42.55
Bankia SA	Spain	BKIA	206,970	13.89	6.13	39.28
Banco Popular Español	Spain	POP	158,650	13.11	7.89	47.96
Nordea Bank	Sweden	NDA	646,868	16.45	4.80	22.15
Handelsbanken	Sweden	SHB.A	275,323	21.25	5.09	18.76
Skandinaviska Enskilda Banken	Sweden	SEB.A	272,466	18.84	5.72	22.87
Swedbank	Sweden	SWED.A	234,575	24.14	5.74	18.11
HSBC Holdings	UK	HSBA	2,218,570	11.86	8.20	45.77
Barclays	UK	BARC	1,519,816	11.37	5.88	32.00
Royal Bank of Scotland Group	UK	RBS	1,106,479	15.51	6.64	29.76
Lloyds Banking Group	UK	LLOY	1,094,647	12.81	5.82	27.62

Appendix II

This table is a list of all publicly listed banks participating in the 2016 stress tests and for which data are available from SNL Financial as of 30 June 2016.

Bank	Country	Ticker	Market Cap (€ mn)	Market Equity / Total Assets (%)	MTB	SRISK
Erste Group Bank	Austria	EBS	8,735	4.81	0.57	7,173
KBC Group	Belgium	KBC	18,374	7.18	1.17	9,477
Danske Bank	Denmark	DANSKE	23,207	5.04	1.11	12,580
Jyske Bank	Denmark	JYSK	3,231	4.45	0.81	2,316
BNP Paribas	France	BNP	49,581	2.51	0.48	101,683
Société Générale	France	GLE	22,798	1.77	0.36	68,369
Crédit Agricole SA	France	ACA	21,252	1.40	0.35	77,900
Deutsche Bank	Germany	DBK	17,010	1.02	0.26	88,985
Commerzbank	Germany	CBK	7,298	1.39	0.24	25,482
OTP Bank	Hungary	OTP	5,636	16.57	1.44	0
Allied Irish Banks	Ireland	AIB	14,942	16.85	1.23	0
Governor and Co. of the bank	Ireland	BKIR	5,991	4.70	0.66	5,330
Intesa Sanpaolo	Italy	ISP	27,010	4.62	0.54	31,940
UniCredit	Italy	UCG	12,178	1.51	0.23	45,177
UBI Banca	Italy	UBI	2,232	2.15	0.21	4,924
Banco Popolare	Italy	BP	1,776	1.61	0.22	5,943
Banca Monte dei Paschi	Italy	BMPS	1,113	0.57	0.11	8,672
ING Groep	Netherlands	INGA	35,611	4.36	0.72	38,564
DNB ASA	Norway	DNB	17,418	5.83	0.85	5,955
PKO Bank Polski	Poland	PKO	6,616	10.68	0.90	0
Banco Santander	Spain	SAN	49,527	4.15	0.50	55,400
BBVA	Spain	BBVA	32,837	4.66	0.60	28,462
CaixaBank	Spain	CABK	11,633	3.38	0.47	13,055
Bankia SA	Spain	BKIA	7,445	3.75	0.59	7,122
Banco de Sabadell	Spain	SAB	6,567	3.37	0.51	6,976
Banco Popular Español	Spain	POP	4,834	3.21	0.39	5,611
Nordea Bank	Sweden	NDA	30,525	4.59	1.05	21,472
Handelsbanken	Sweden	SWED.A	21,144	7.83	1.55	4,040
Swedbank	Sweden	SHB.A	20,568	6.89	1.55	6,208
Skandinaviska Enskilda Banken	Sweden	SEB.A	16,829	5.77	1.23	8,047
HSBC Holdings	United Kingdom	HSBA	111,144	5.01	0.63	60,043
Lloyds Banking Group	United Kingdom	LLOY	46,458	4.60	0.75	43,807
Barclays	United Kingdom	BARC	28,221	1.92	0.33	79,182
Royal Bank of Scotland Group	United Kingdom	RBS	3,231	2.32	0.05	2,316