Testing Macroprudential Stress Tests: The Risk of Regulatory Risk Weights

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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

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))

$$\begin{aligned} SRISK &= \mathrm{E}\left[k(Debt + MV) - MV | crisis\right] \\ &= kDebt – (1-k)(1-LRMES) * MV \end{aligned}$$

where MV is the market value of equity of the bank, $LRMES$ is its long-run marginal expected shortfall, and k is the prudential capital ratio.

Testing Macro Stress Tests against 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.

1. Vlab and stress tests *projected losses* are well correlated & both predict well the actual realized losses during the European sovereign debt crisis.

2. The *required capitalization* in stress tests is found to be rather low, and inadequate ex post, compared to that implied by market data (Vlab).

3. This discrepancy arises due to the reliance on *regulatory risk weights*.

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)

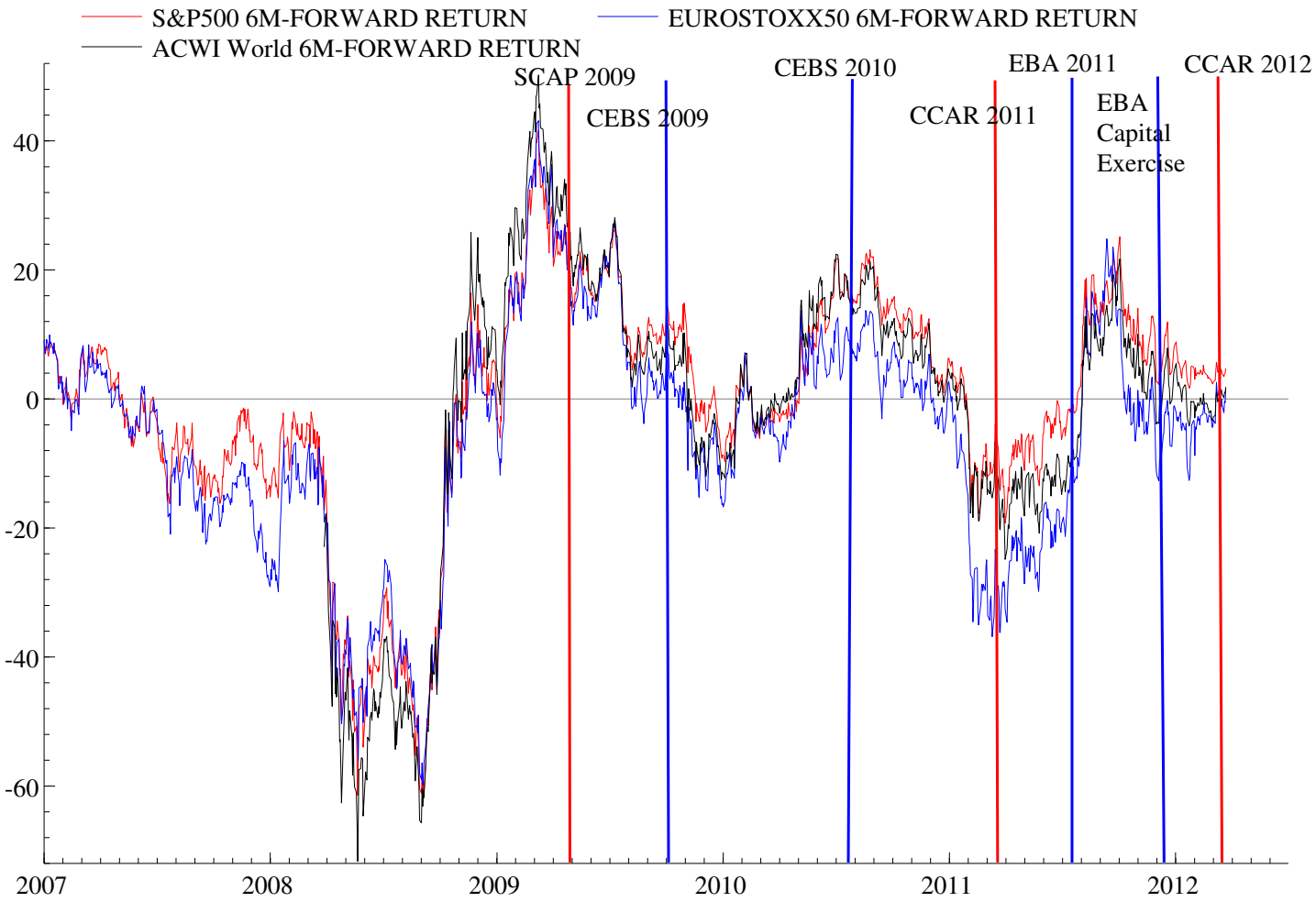
Stress tests with bank-level disclosure

	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%



CCAR 2012 scenario

CCAR 2012: Supervisory Stress Scenario (25 variables) over 13 quarters

- Macro variables: real and nominal GDP, unemployment rate, personal income, CPI
- Financial variables: house price index, commercial real estate price index, DJ index, VIX
- Interest rates: 3-month T-bill, 10-year Treasury bond yield, 10-year BBB corporate security yield, 30-year mortgage interest rate
- Non-US: 4 blocs of countries (EUR, UK, dev. Asia, Japan) * 3 variables (GDP growth, inflation, FX rate)

+ Global financial market shock for the 6 BHCs with large trading activities

See Schuermann (2012) for a comparison of macro stress scenarios (SCAP 2009, CCAR 2011, CCAR 2012)

EBA 2011 scenario

EBA 2011: macro and market scenarios over 2 years developped by the ECB

- Macro stress scenario: deviation from EC forecasts (baseline scenario)
  - GDP growth, inflation, unemployment rate (country-specific, EU and rest of the world)
  - gvt bond yields (65.8%), stock prices (-14.3%), house prices (country-specific, EU)
- Market stress scenario (conditional on the macro scenario)
  - Calibrated market risk parameters (0.25/0.75 percentile of density forecast): interest rates, exchange rates, equity, commodities, dividends and volatilities
  - Country-specific shocks to sovereign credit spreads

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).

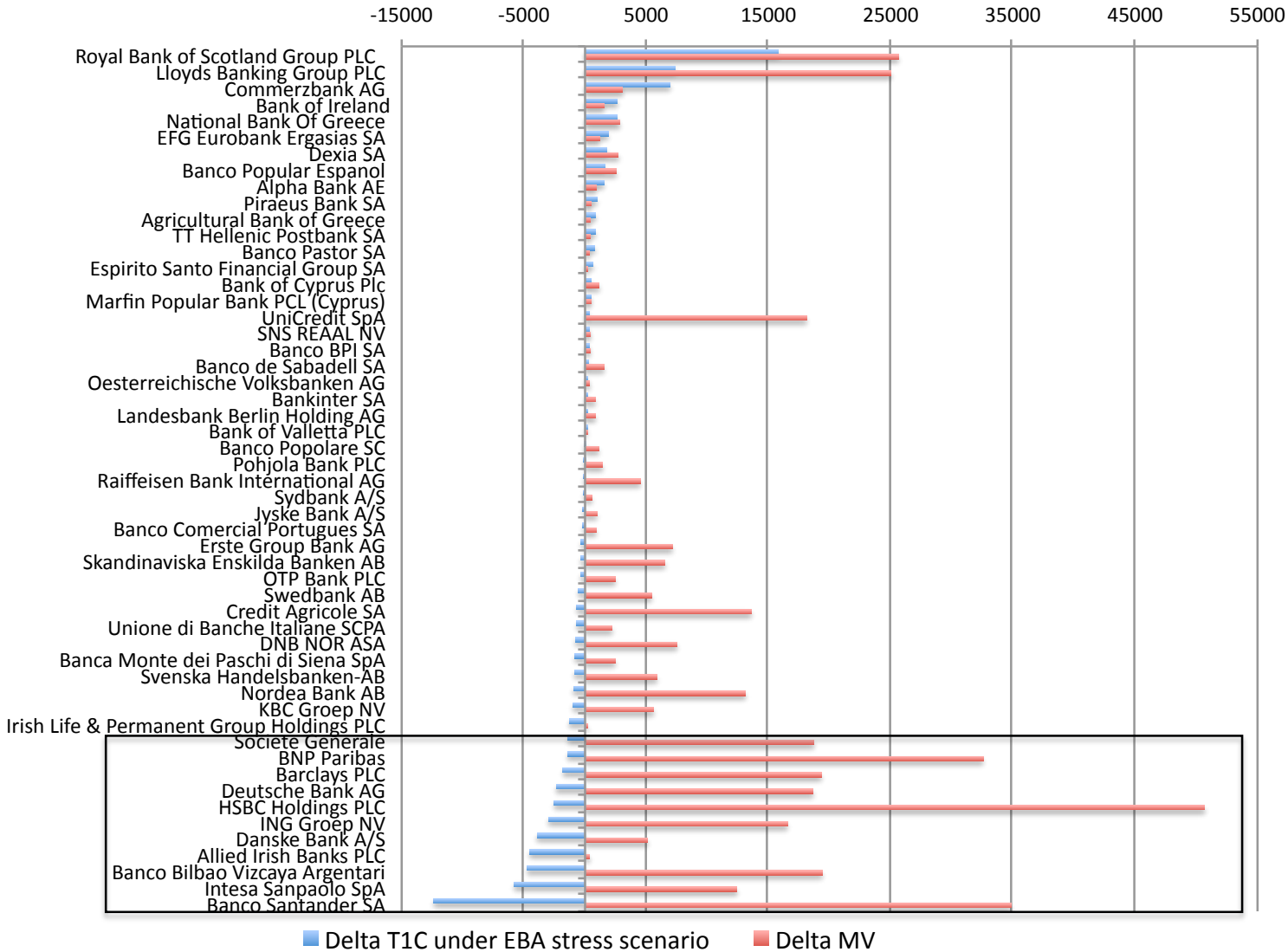
Panel A: Rank correlations with the 6-month realized EUR loss

	Estimated losses	Large	Small	All	RMSE
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.

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 $= \max(0, [k' * RWA_S - Capital_S])$

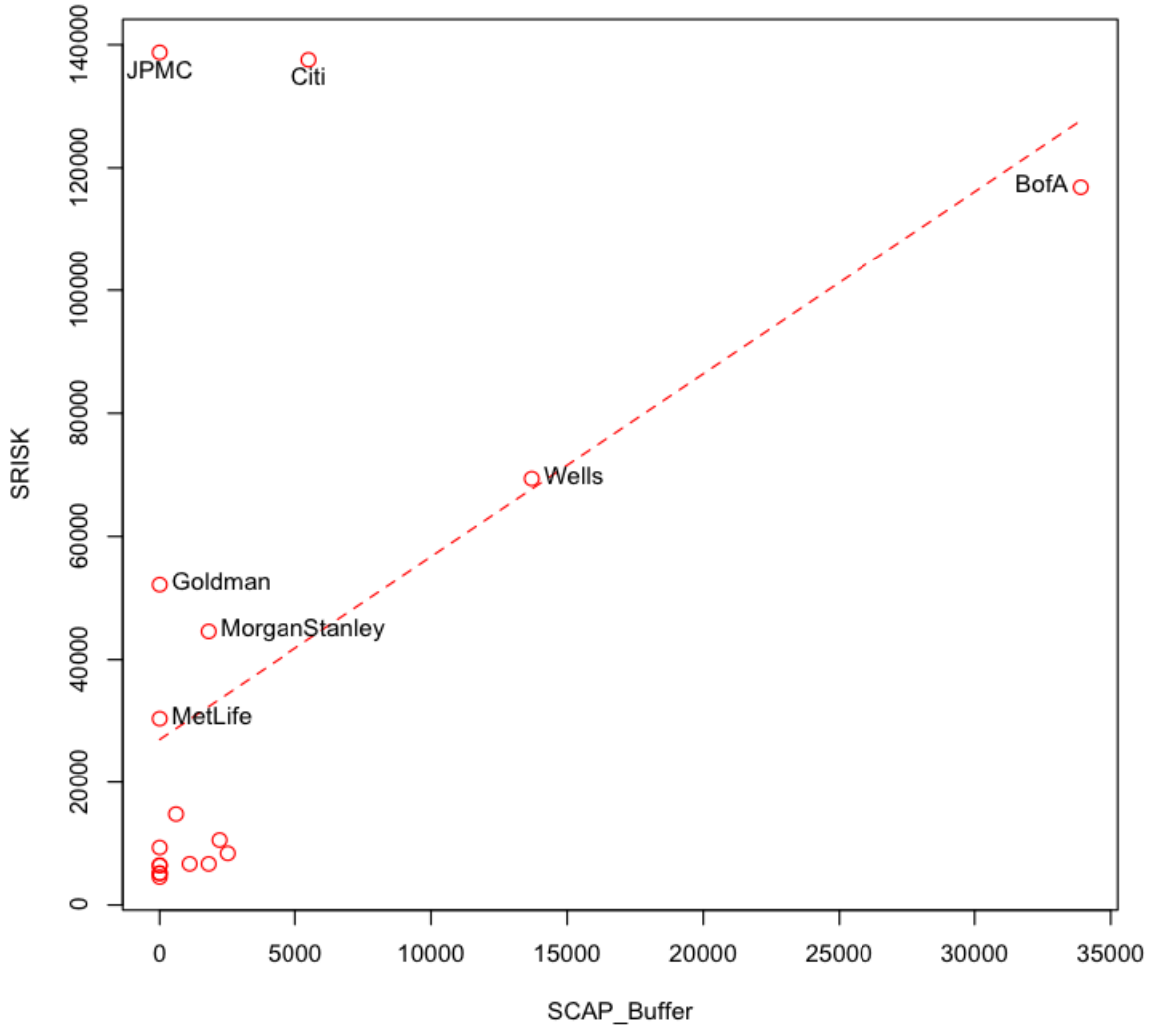
		Stress tests estimates		**Vlab estimates**
US	Sample	Threshold k'	Shortfall	SRISK (k=8%)
SCAP 2009	18 US BHCs	4% T1CR	63.1 $ bn (9)	674 $ bn (18)
EU	Sample	Shortfall	Shortfall	SRISK (k=5.5%)
CEBS 2010	50 EU banks	6% T1R	0.2 EUR bn (1)	796 EUR bn (48)
EBA 2011	53 EU banks	5% T1CR	1.2 EUR bn (4)	886 EUR 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 $SRISK = kDebt – (1-k)(1-LRMES) * MV$

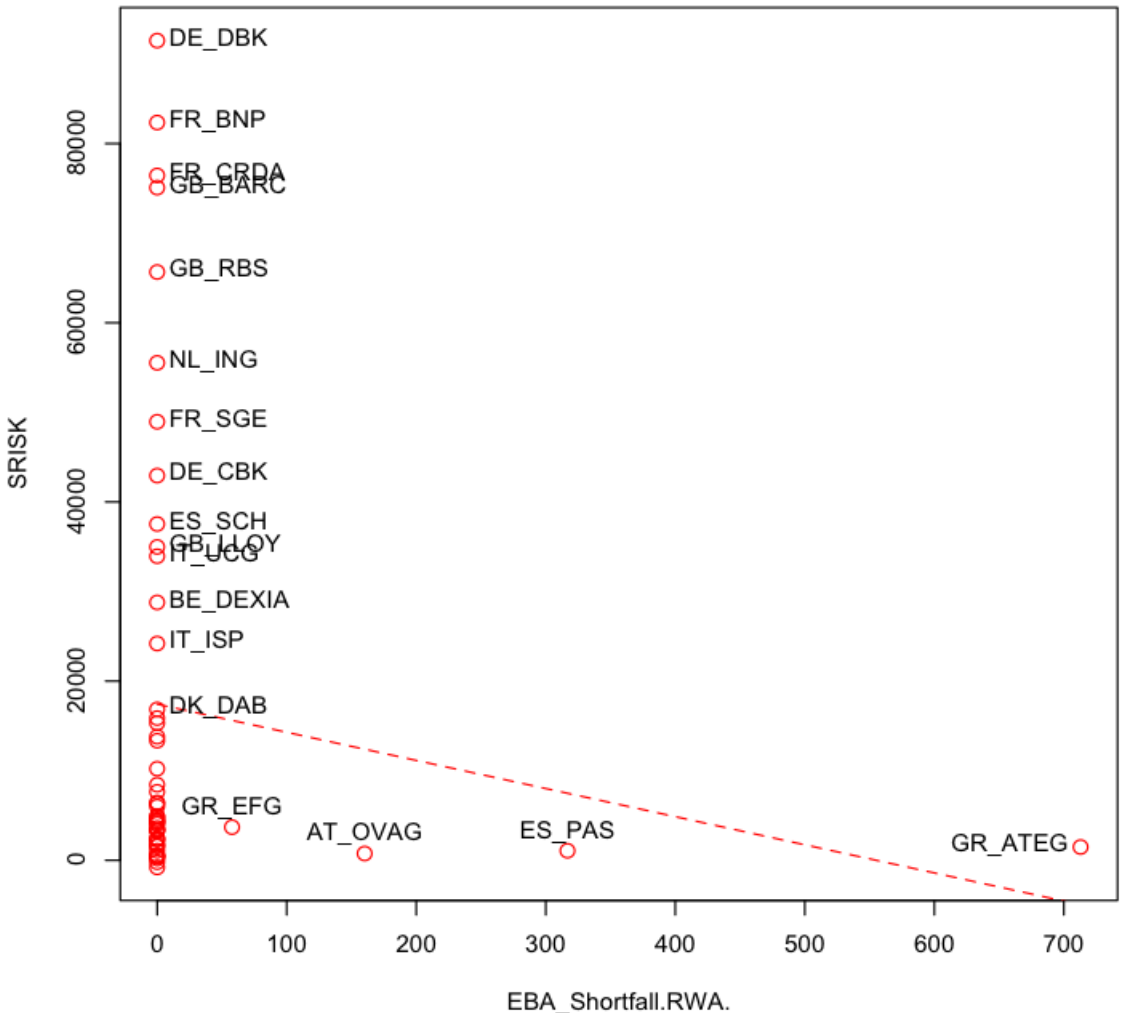
SCAP capital buffer $= \max(0, [k' * RWA_S - Capital_S])$
(k=0.08, k'=0.04, rank correlation: 0.507)



EBA capital shortfall vs. SRISK (EBA 2011)

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

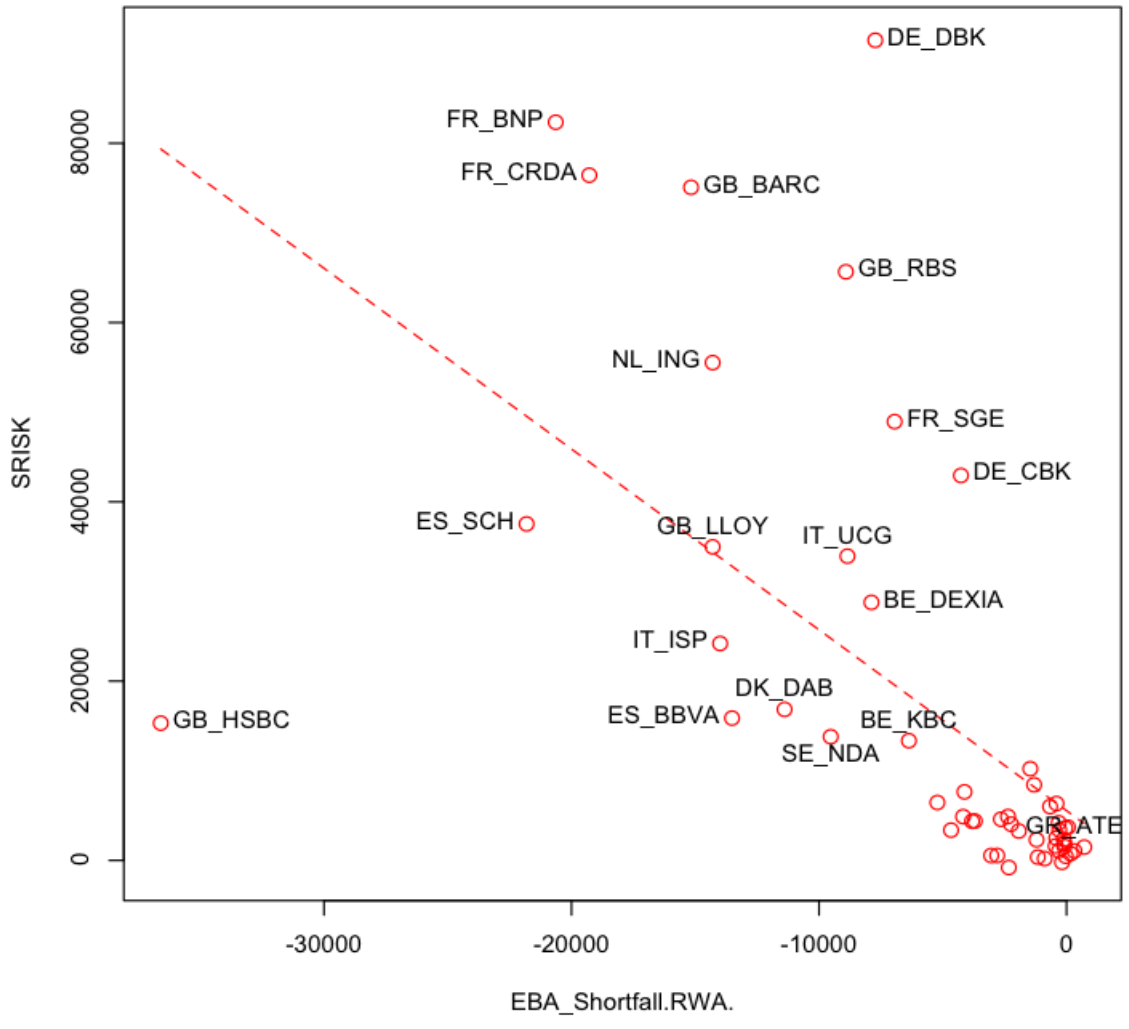
EBA disclosed capital shortfall $= \max(0, [k' * RWA_S - Capital_S])$
(k=0.055, k'=0.05, rank correlation: -0.273)



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)



Evidence of the EBA failure

EBA stress test disclosed in July 2011

Dexia's bail-out in Oct 2011: EBA capital excess of Dexia was 7.9 EUR bn vs. 26 EUR bn SRISK.

In Dec 2011, the EBA discloses a new capital shortfall estimate

$$\text{EBA Overall Shortfall} = \max(0, [0.09 * RWA - T1C]) + BuffSOV,$$

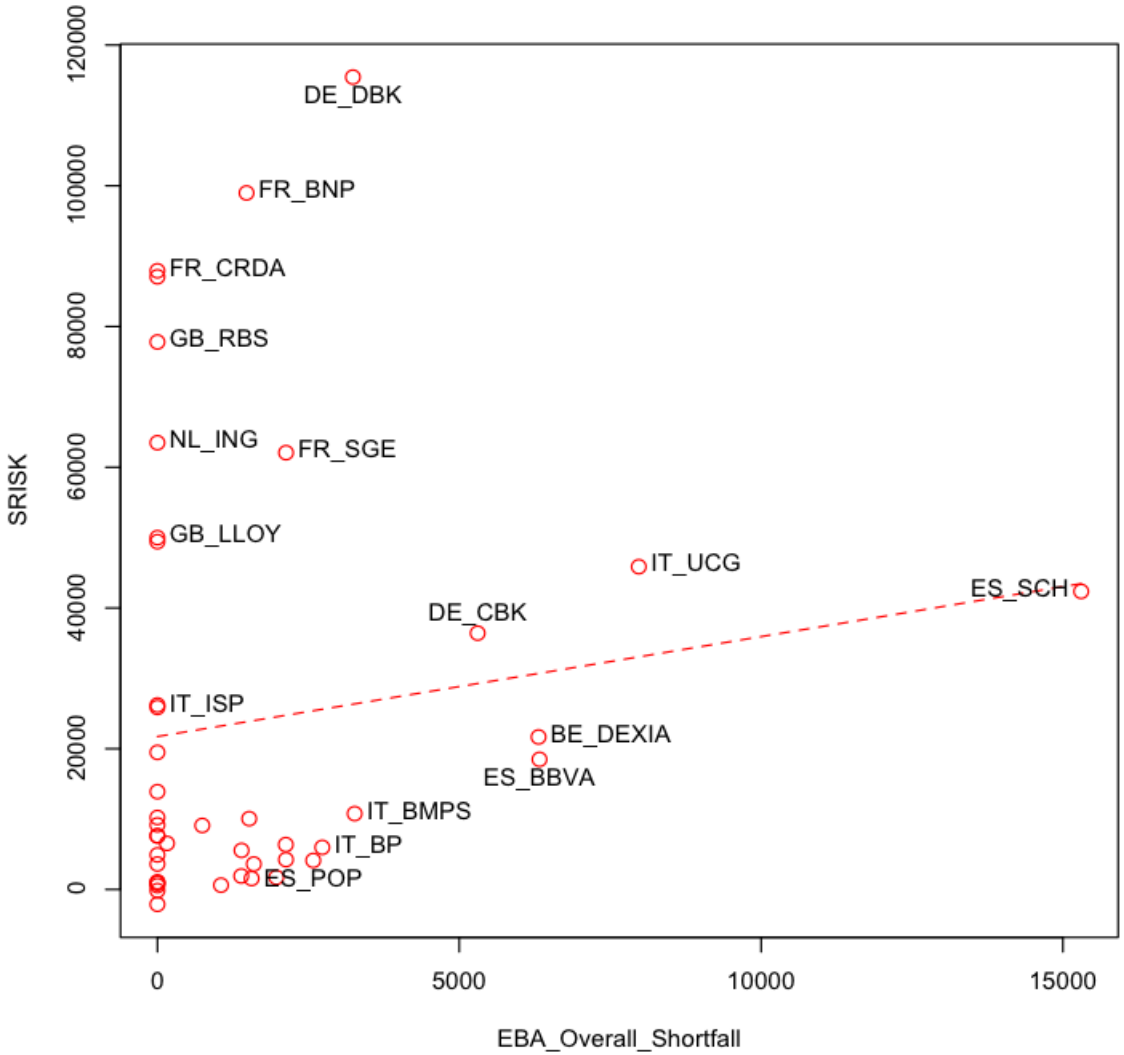
3 main drivers of the overall shortfall:

- moving k' from 5% to 9%,
- RWA derived under Basel 2.5 (higher capital requirement for market risk),
- the sovereign buffer *BuffSOV* on EEA sovereign debt exposures

EBA Overall shortfall, still too low? (EBA Capital Exercise)

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

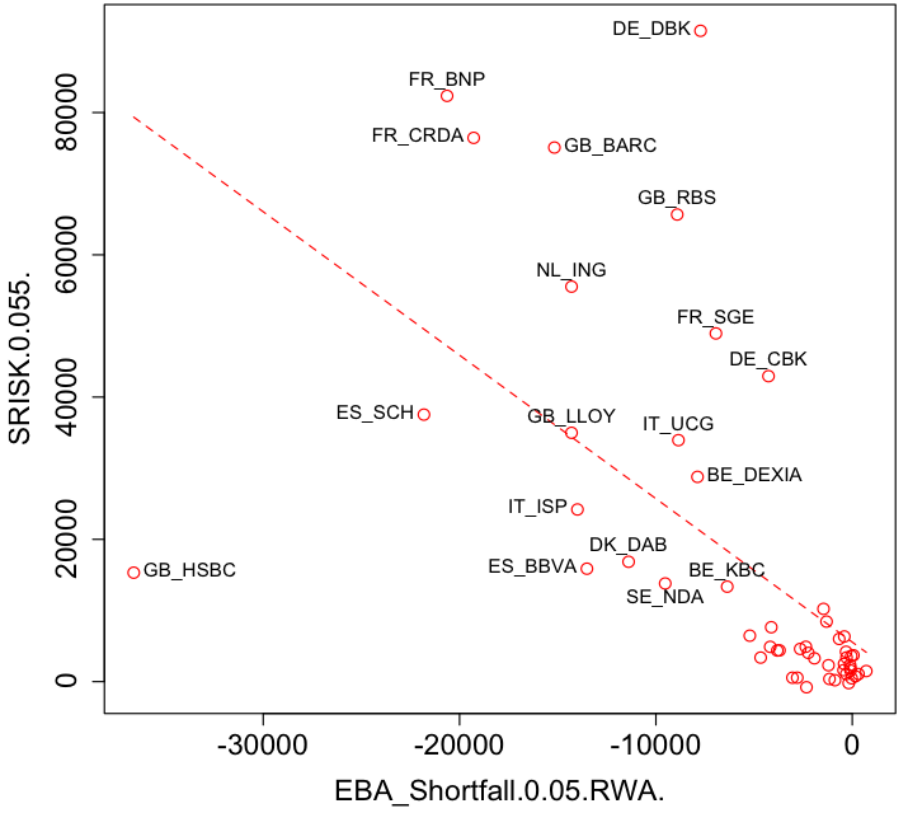
EBA Overall capital shortfall $= \max(0, [k' * RWA - T1C]) + BuffSOV$
(k=0.055, k'=0.09, rank correlation: 0.163)

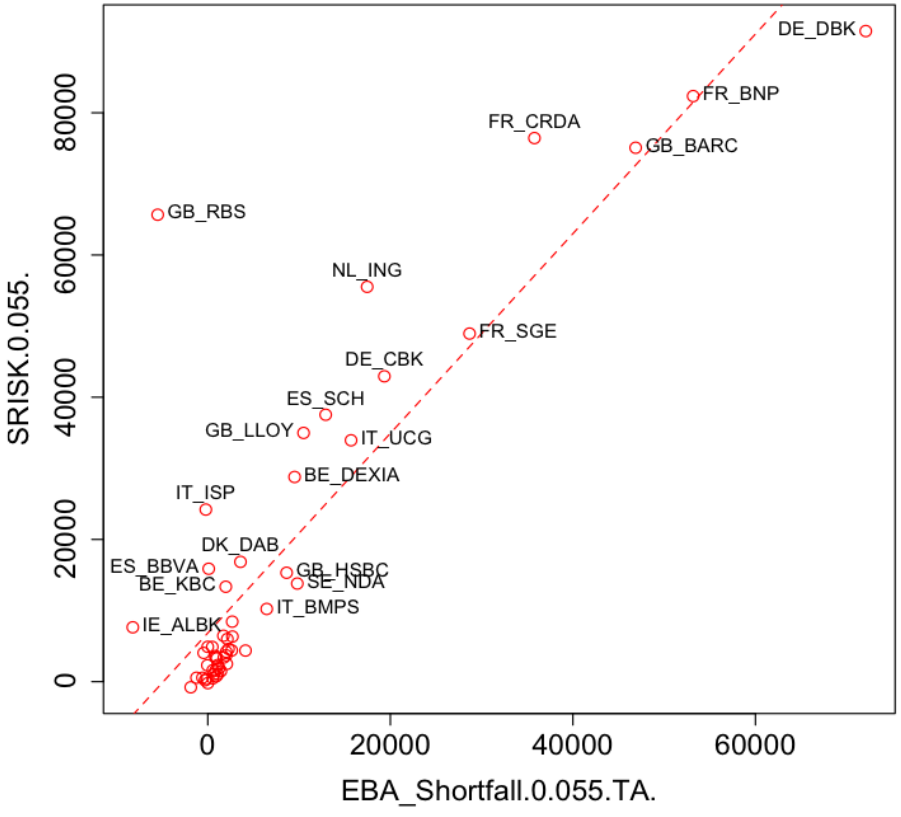


Risk-based capital vs. leverage-based capital shortfall (EBA 2011)

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





Outline

Threshold severity

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

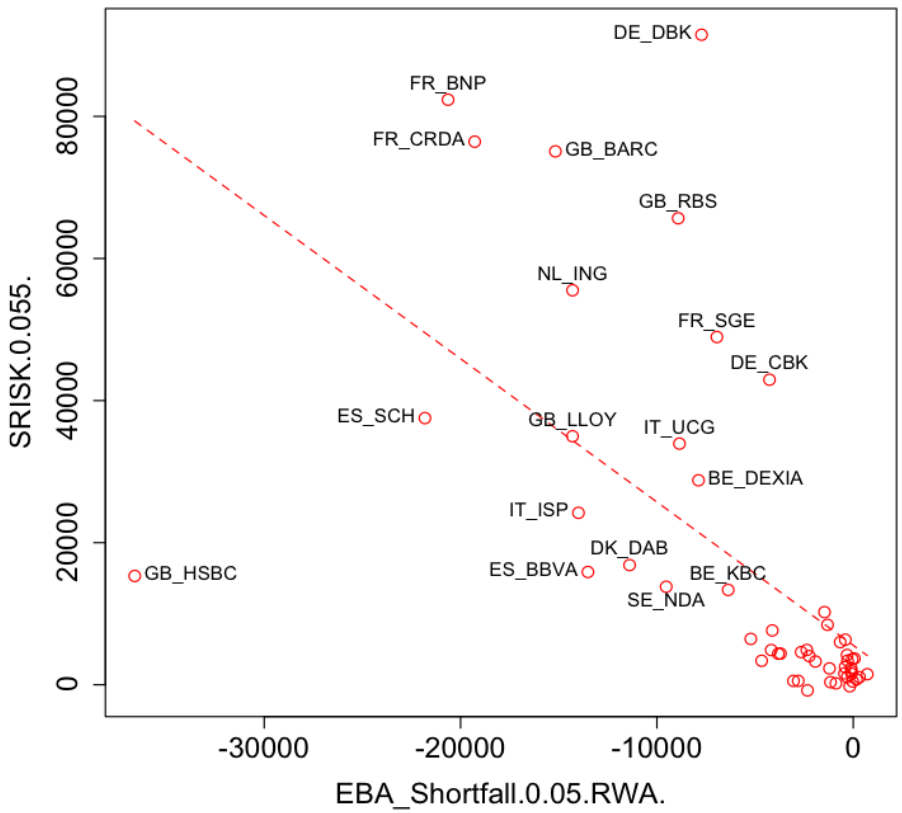
Leverage-based capital shortfall (TA) $= k * TA_S - Capital_S$
Risk-based capital shortfall (RWA) $= k' * RWA_S - Capital_S$
By definition: RWA $\leq$ TA, so $k \leq k'$ for comparable severity levels

- Values for k:
  - Vlab uses $k = 5.5\%$ (of quasi-mkt assets)
  - CCAR uses $k = 3 - 4\%$
  - Basel III: $k = 3\%$
  - Dodd-Frank Act: $k = 4\%$ ('adequately' capitalized), $k = 5\%$ ('well' capitalized)
- Values for k':
  - EBA and CCAR: $k' = 5\%$ when $Capital_S$ = Tier 1 Common Capital under stress (US) or Core Tier 1 Capital under stress (EU).
  - EBA Capital Exercise used $k' = 9\%$

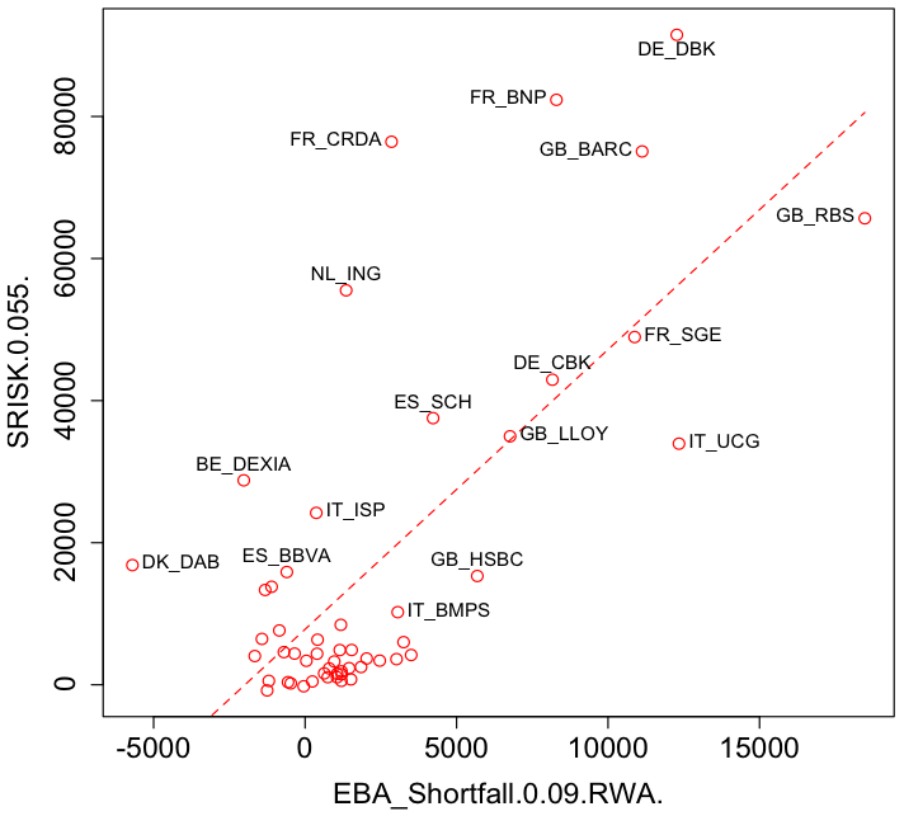
In the next slides, we vary k and k' for the EBA stress test shortfalls and compare them with SRISK where an adequate threshold for SRISK is 5.5%.

Higher threshold for the risk-based capital shortfall (EBA 2011)

Risk-based shortfall
$5\% * RWA_S - Capital_S$
(correlation with SRISK: -0.790)
Total shortfall (53 banks): 1.2 EUR bn

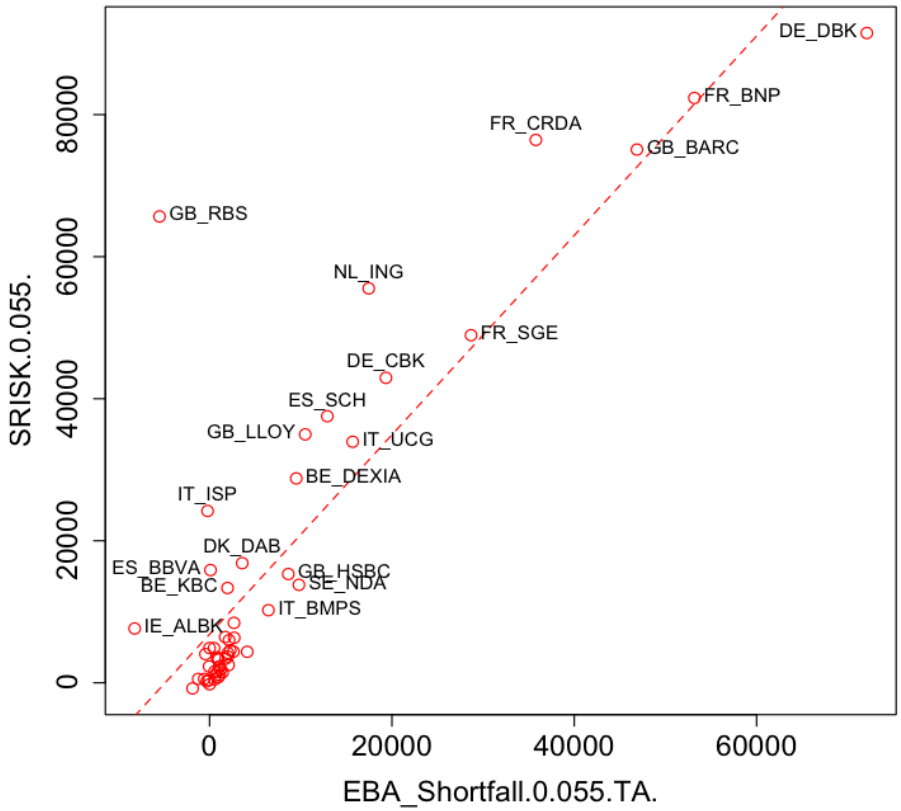


Risk-based shortfall
$9\% * RWA_S - Capital_S$
(correlation with SRISK: 0.418)
Total shortfall: 139 EUR bn

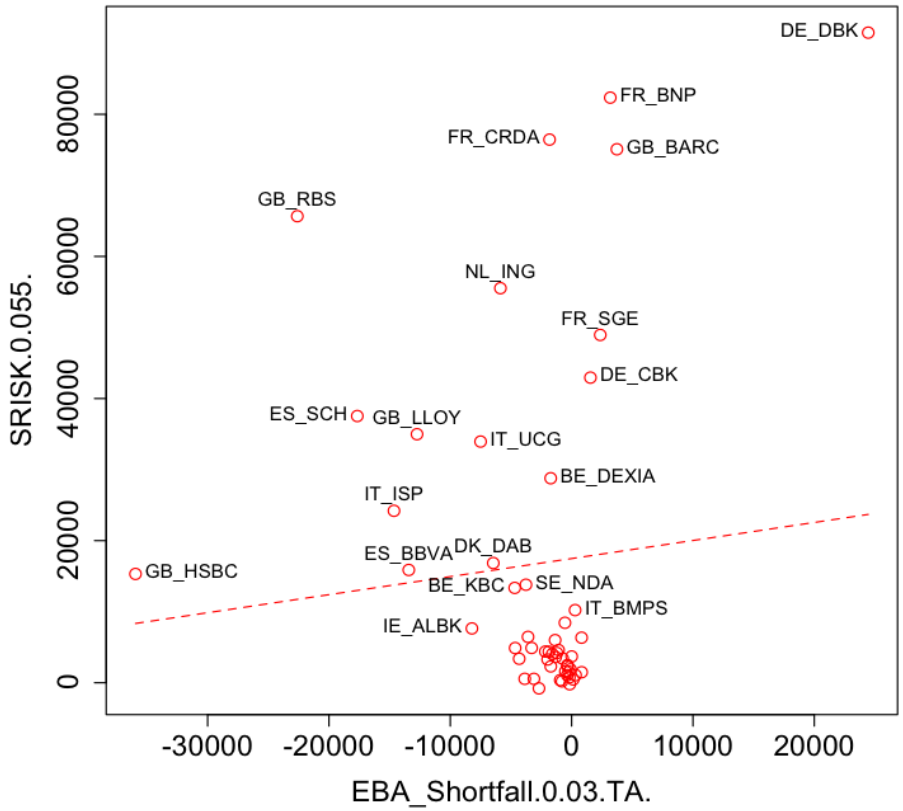


Lower threshold for the leverage-based capital shortfall (EBA 2011)

Leverage-based shortfall
$5.5\% * TA_S - Capital_S$
(correlation with SRISK: 0.679)
Total shortfall (53 banks): 390 EUR bn



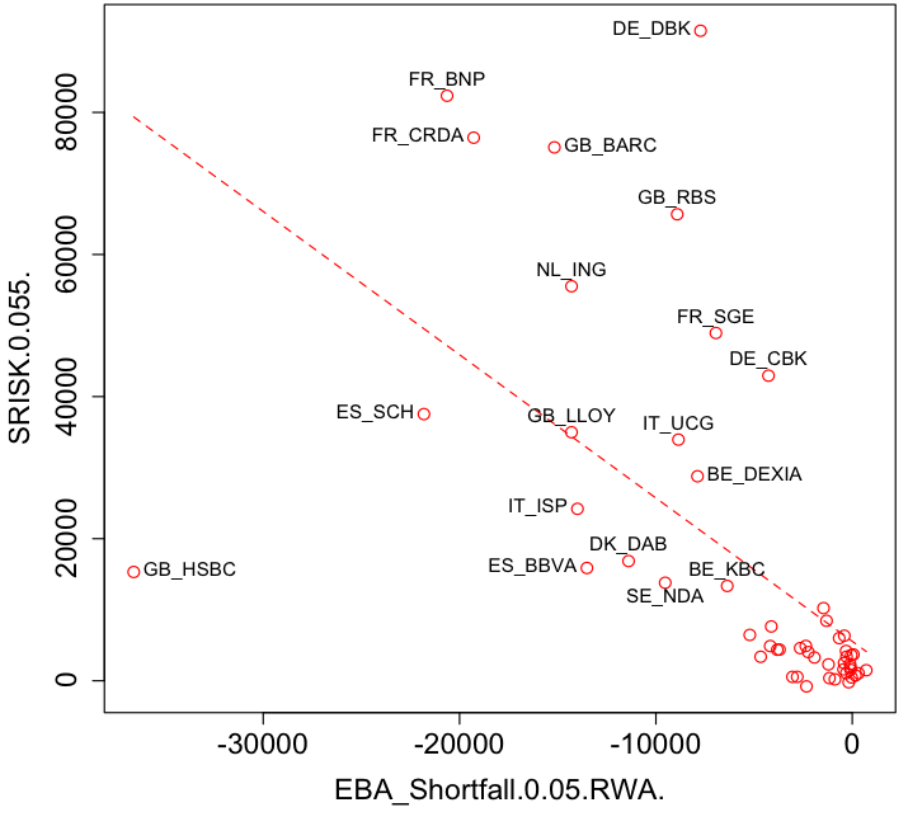
Leverage-based shortfall
$3\% * TA_S - Capital_S$
(correlation with SRISK: -0.218)
Total shortfall: 38 EUR bn

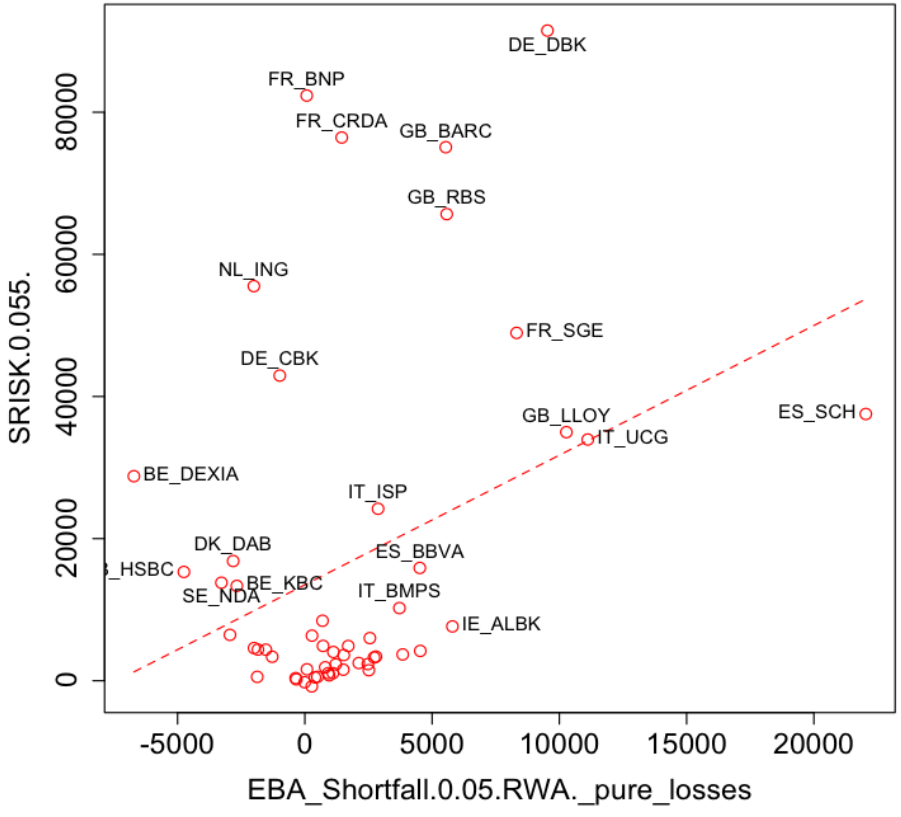


The impact of projected revenues in the RB capital shortfall (EBA 2011)

Risk-based shortfall
$5\% * RWA_S - Capital_S$
(correlation with SRISK: -0.790)
Total shortfall (53 banks): 1.2 EUR bn

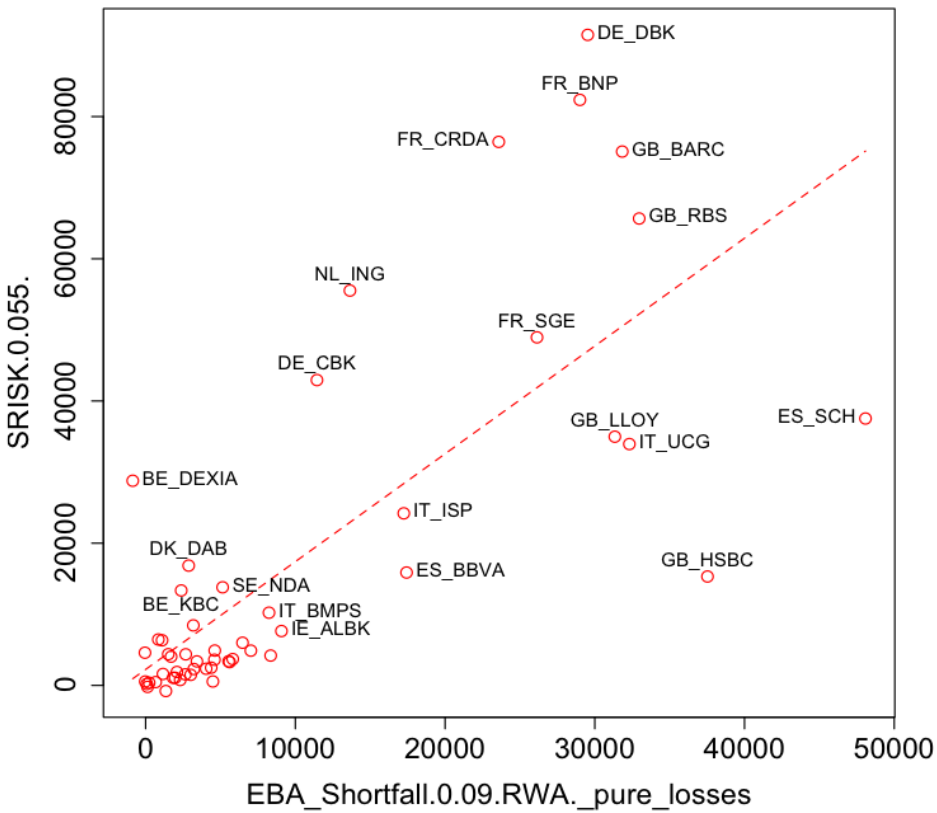
Leverage-based shortfall
$5\% * RWA_S - (Capital_0 - '\,pure'\ losses)$
(correlation with SRISK: 0.214)
Total shortfall: 128 EUR bn



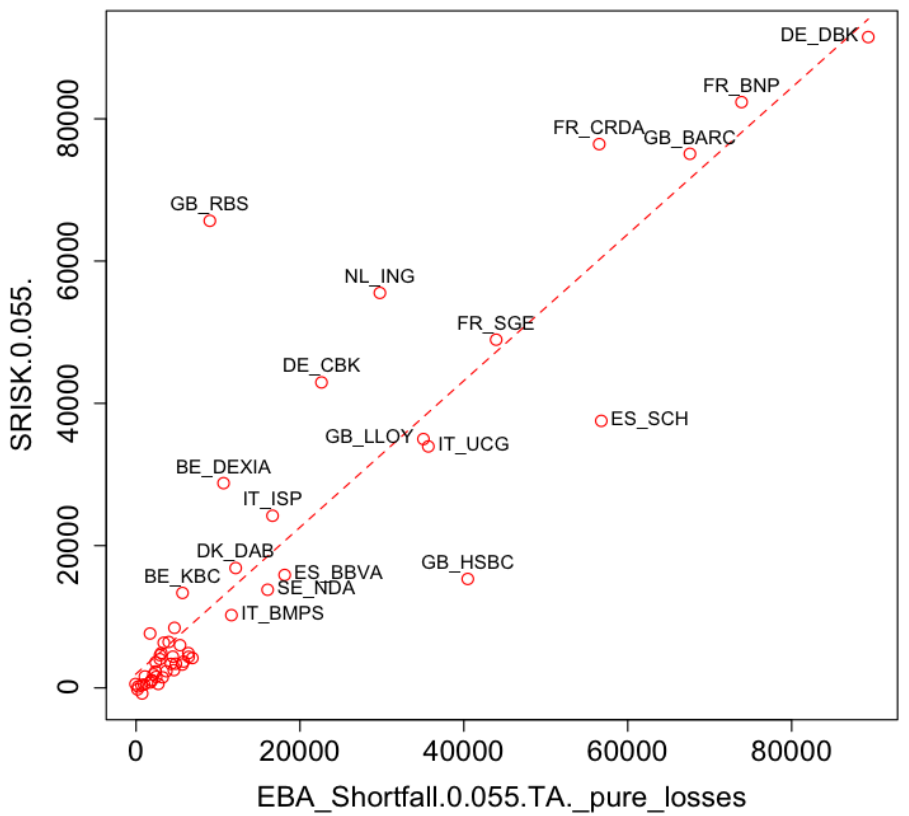


Highest correlations with SRISK (EBA 2011)

Risk-based shortfall
$9\% * RWA_S - (Capital_0 - '\, pure' \, losses)$
(correlation with SRISK: 0.710)
Total shortfall (53 banks): 506 EUR bn



Leverage-based shortfall
$5.5\% * TA_S - (Capital_0 - '\, pure' \, losses)$
(correlation with SRISK: 0.901)
Total shortfall: 757 EUR bn



Outline

Regulatory capital ratios

Numerator: different qualities of capital based on Basel requirements

- **Tier 1 Common (Core) Capital** (T1C)
- **Tier 1 Capital** (T1)
- **Total Capital** = T1 + T2 + (additional T3 for market risk)

Denominator: **Total Assets** or **Risk-Weighted Assets** (RWA)

Regulatory ratios in the US:

- Tier 1 Common Capital ratio = $T1C/RWA$ (5%)
- Tier 1 Capital ratio = $T1/RWA$ (4%)
- Total risk-based capital ratio = $Total\,Capital/RWA$ (8%)
- Tier 1 Leverage ratio = $T1/Total\,assets$ (3-4%)

Regulatory ratio in the EU: Core Tier 1 capital ratio = $T1C/RWA$ (5%)

Stress tests vs. Vlab ratio

Vlab market leverage ratio under stress

$$M - LVGR_s = \frac{MV(1 - LRMES)}{MV(1 - LRMES) + D}$$

Cross-sectional average ratios (average change with the stress scenario in parentheses):

		Stress tests estimates	**Vlab estimates**
US	Sample	Ratio	M-LVGR$_s$
CCAR 2012	18 US BHCs	7.55% T1CR	3.54%
		(-3.34%)	(-4.54%)
CCAR 2013	17 US BHCs	8.37% T1CR	5.48%
		(-2.68%)	(-5.36%)
EU	Sample	Ratio	M-LVGR$_s$
CEBS 2010	50 EU banks	8.98% T1R	2.6%
		(-1.38%)	(-2.01%)
EBA 2011	53 EU banks	7.98% T1CR	2.26%
		(-1.02%)	(-1.73%)

Risk-based vs. leverage ratio

Tier 1 Leverage ratio (T1 LVGR = T1 Capital/Total Assets) recommended under Basel III to supplement the risk-based regime.

Rank correlations with Vlab market leverage ratio ($M-LVGR_s$) increase considerably when RWA are replaced by Total Assets.

Vlab market leverage ratio under stress

$$M-LVGR_s = \frac{MV(1-LRMES)}{MV(1-LRMES)+D}$$

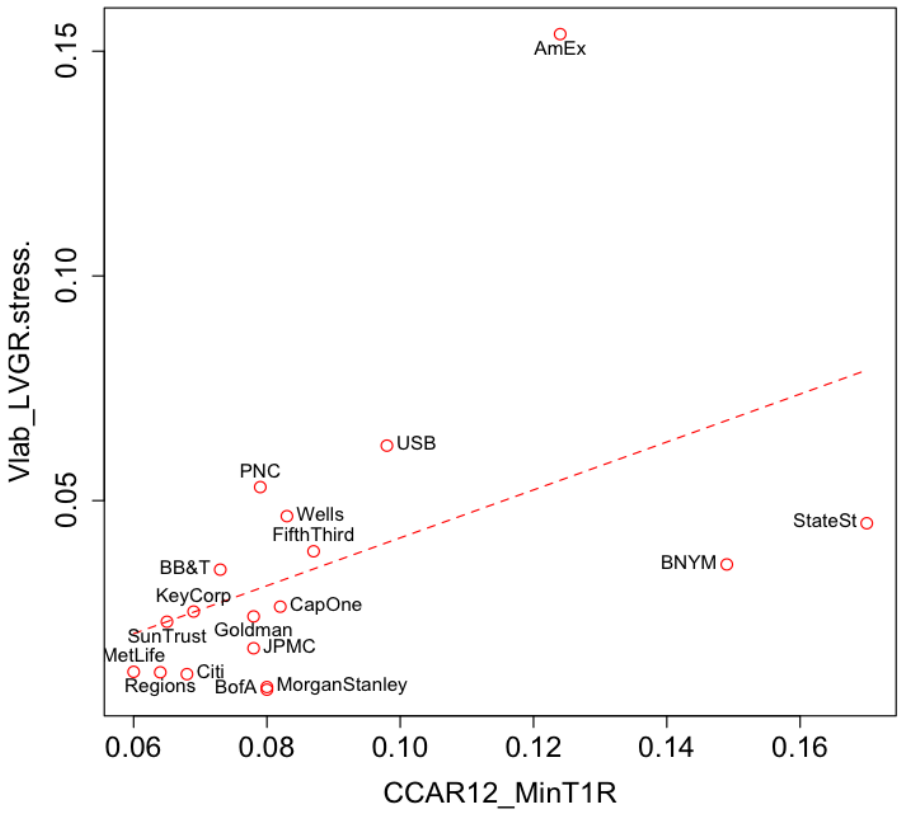
Panel C: Rank correlations with Vlab M-LVGR$_s$

Stress tests projected ratios	CCAR 2012	CCAR 2013	EBA 2011
T1CR, scenario end	0.242		0.282*
T1 LVGR, scenario end	0.576*		0.570**
min T1CR	0.797**	0.581*	
min T1 LVGR	0.846**	0.877**	

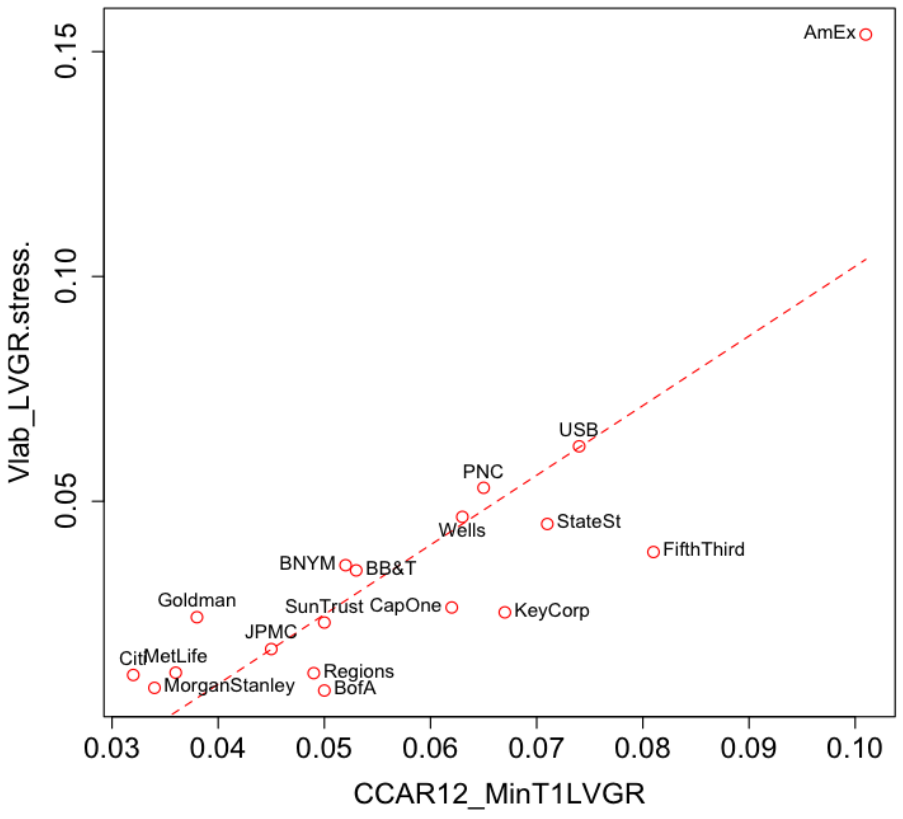
* Significant parameters at 5%; ** at 1%.

Risk-based vs. leverage ratio (CCAR 2012)

T1 Risk-based ratio:
$T1\,Capital_S / RWA_S$
(correlation with M-LVGR$_s$: 0.648)

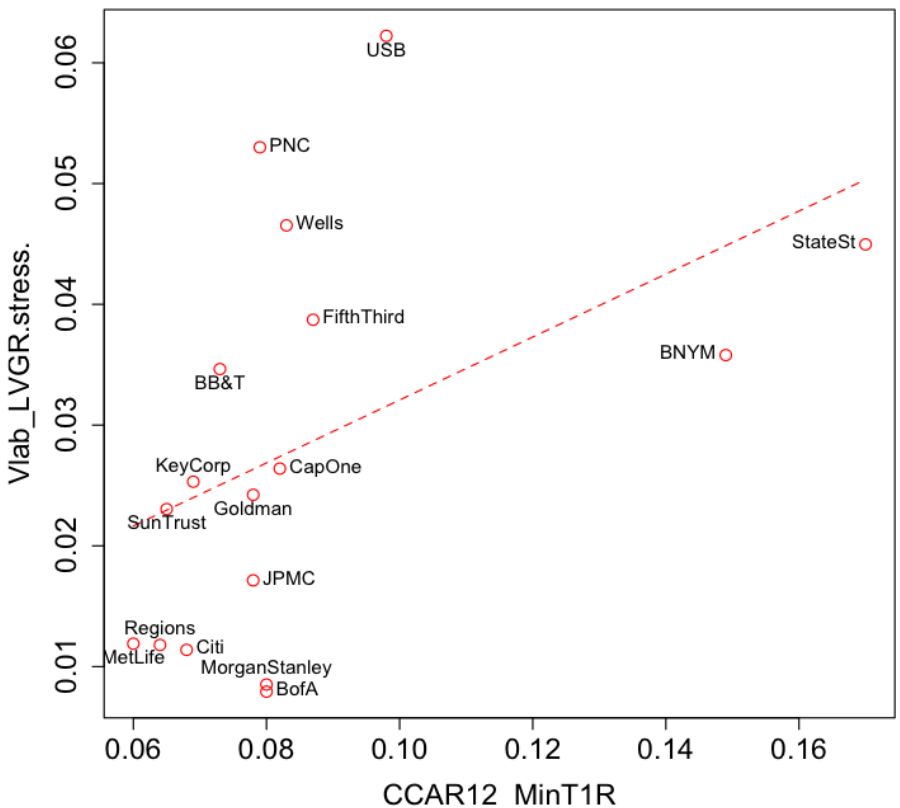


T1 Leverage ratio:
$T1\,Capital_S / TA_S$
(correlation with M-LVGR$_s$: 0.846)

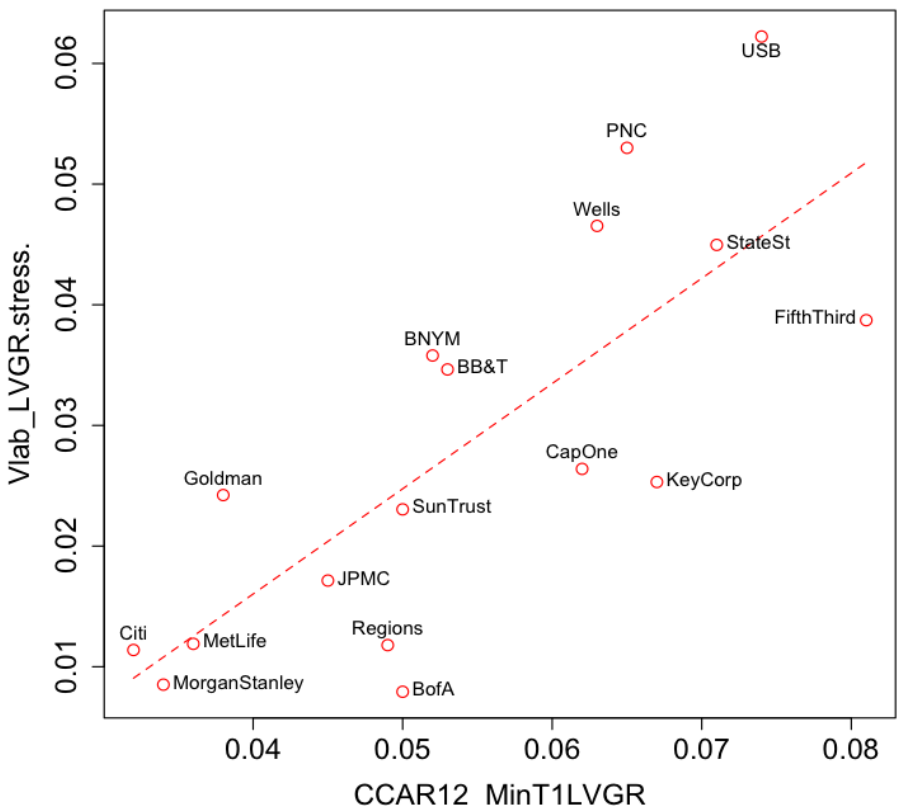


Risk-based vs. leverage ratio (CCAR 2012 w/o AmEx)

T1 Risk-based ratio:
$T1\,Capital_S / RWA_S$
(correlation with M-LVGR$_s$: 0.607)

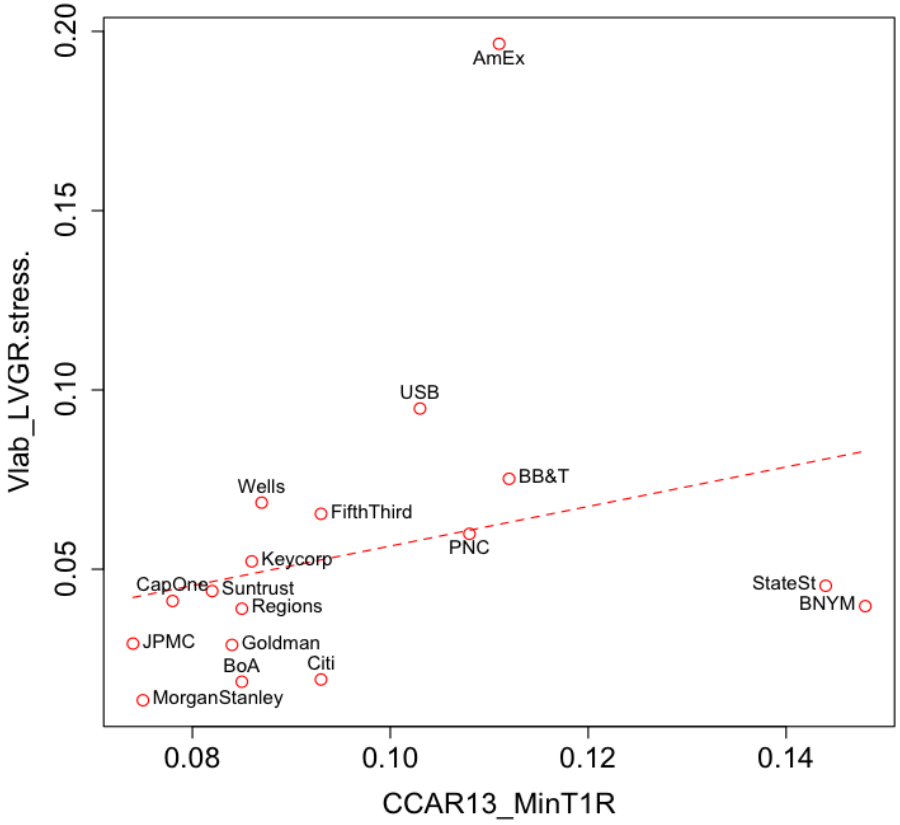


T1 Leverage ratio:
$T1\,Capital_S / TA_S$
(correlation with M-LVGR$_s$: 0.816)

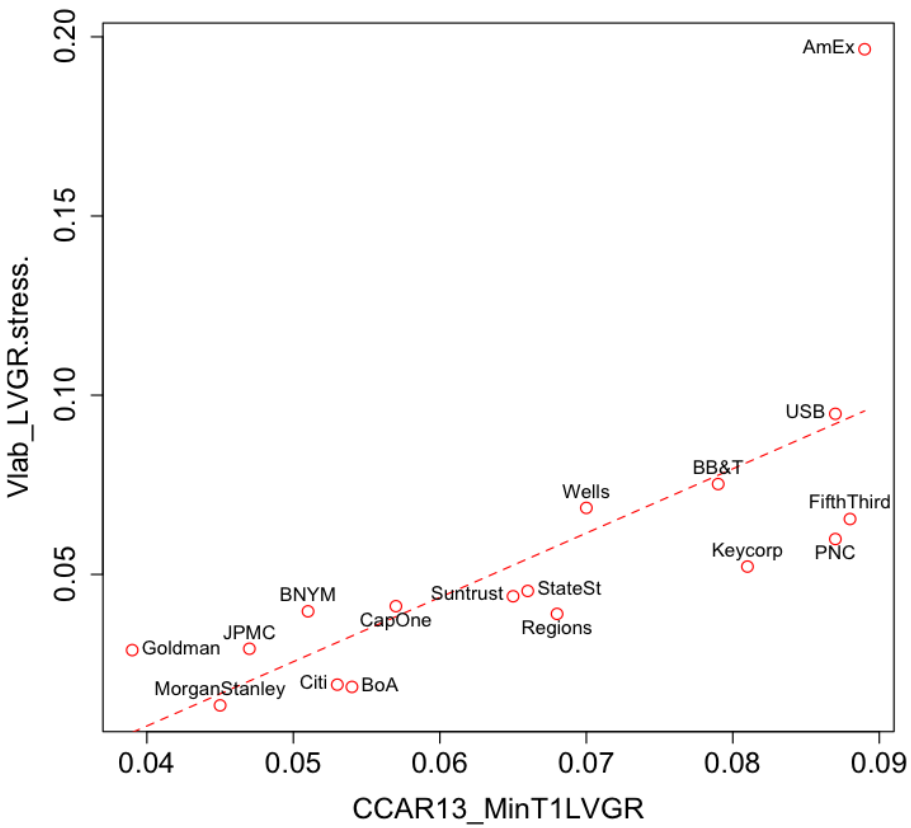


Risk-based vs. leverage ratio (CCAR 2013)

T1 Risk-based ratio:
$T1\,Capital_S / RWA_S$
(correlation with M-LVGR$_s$: 0.554)

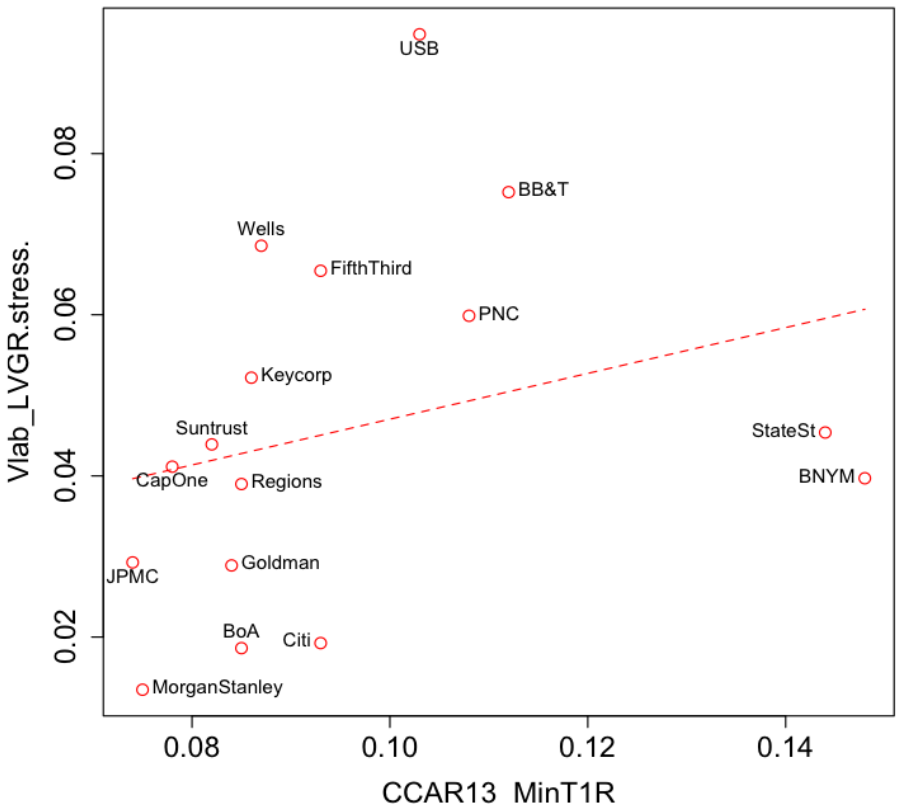


T1 Leverage ratio:
$T1\,Capital_S / TA_S$
(correlation with M-LVGR$_s$: 0.877)

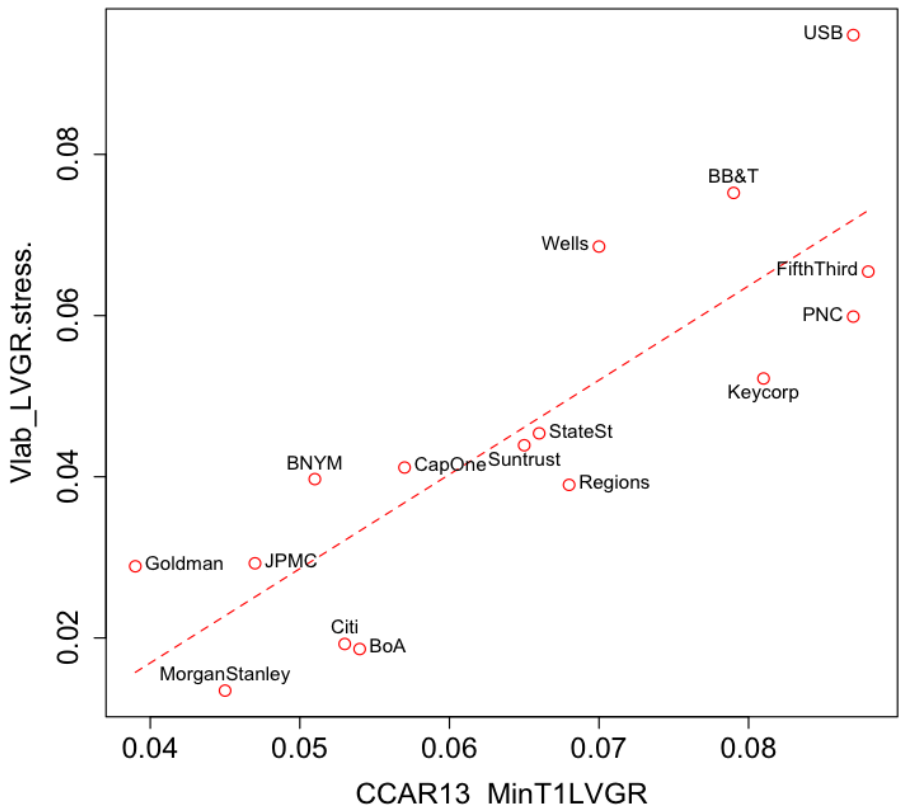


Risk-based vs. leverage ratio (CCAR 2013 w/o AmEx)

T1 Risk-based ratio:
$T1\,Capital_S / RWA_S$
(correlation with M-LVGR$_s$: 0.527)



T1 Leverage ratio:
$T1\,Capital_S / TA_S$
(correlation with M-LVGR$_s$: 0.854)



Outline

Impact of the stress scenario

Impact of the stress scenario: lower ratios

- US: capital decrease due to stressed losses
- EU: RWA increase due to stressed risk weights

	Measure	Before scenario	After scenario
CCAR 2012	T1CR	10.1%	6.6% min
	T1C	741 $ bn	438 $ bn
	RWA	7356 $ bn	6904 $ bn
EBA 2011	T1CR	8.9%	7.7%
	T1C	1006 EUR bn	1001 EUR bn
	RWA	11.37 EUR tn	13 EUR tn

Risk-weighted assets (RWA)

RWA under Basel I (US, before 2013)

$$RWA = \sum_j w_j A_j$$

with $w_j = 0\%, 20\%, 50\%, 100\%$.

RWA under Basel II (EU)

$$RWA = \frac{1}{k} \left[C_{cdt} + C_{op} + C_{mkt} \right]$$

where k is the prudential capital ratio (8%) and C_{cdt}, C_{op}, C_{mkt} are the capital requirements to respectively support credit, operational, and market risks.

Basel II risk weights: IRB approach

Credit component ($\simeq 80\%$ of RWA): $C_{cdt} = \sum_j w_j * EAD_j$

The weight w_j is a function of risk parameters: probability of default (PD) and loss given default (LGD).

Banks derive the stressed PDs, LGDs using their own risk models under the IRB (Internal-Rating-Based) approach.

- Lower capital requirements
- Inconsistency (Basel Committe on Banking Supervision RCAP (2013))
- Opacity: Internal models are black boxes that investors do not understand or trust (Haldane (2012))

EBA stress test: 59 of the 90 participating banks are IRB banks.

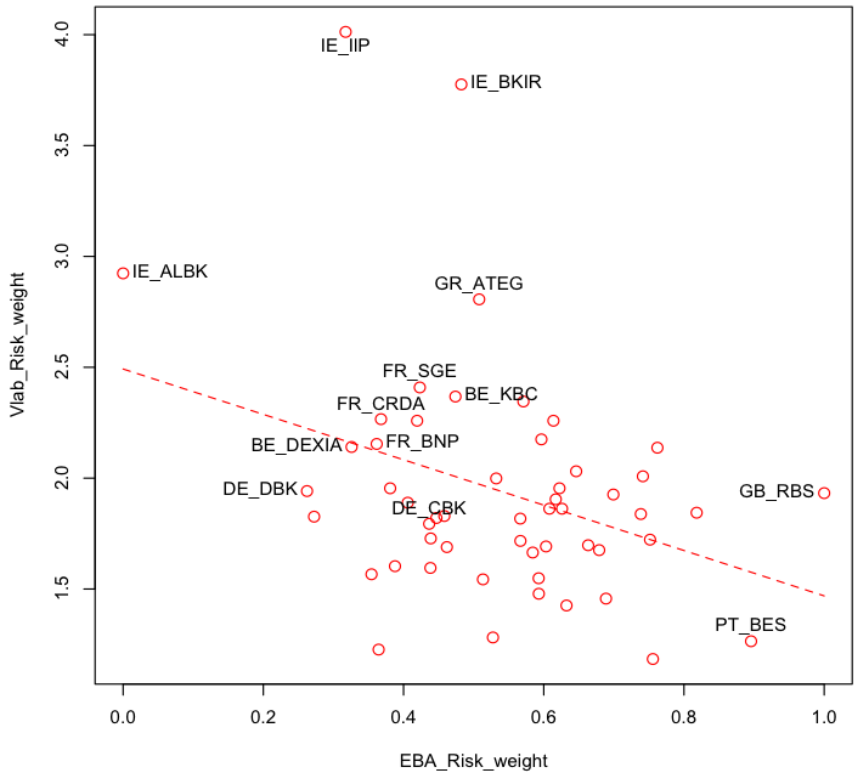
Regulatory risk weight vs. market risk weight (EBA 2011)

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 Crédit Agricole: below 25% quantile of RWA_S / TA_S, above the 75% quantile of Vlab risk weight distribution



Stress to sovereign exposures (EBA 2011): impact on RWA?

Sovereign exposures in the **banking book** $\rightarrow$ **higher provisions**

- No market risk haircut but fundamental credit analysis based on movements in PDs and LGDs
- Consistent approach:
  - downgrades applied to sovereign credit ratings
  - "For simplicity this approach could focus purely on determining appropriate provisions (EL) for both IRB and TSA banks. No changes would be made to RWA from the existing submission." (EBA additional guidance to the methodological note, June 2011)

Sovereign exposures in the **trading book** $\rightarrow$ **lower net trading income**

- 2 main factors influencing valuation haircuts:
  - widening of sovereign credit spreads
  - higher risk-free rate
- Updated haircuts on June 9, 2011 to "more fully reflect the impact of the current conjuncture"

Forecasting risk: realized volatility regression (EBA 2011)

Regression #	1	2	3	4	5	6	7
Constant	4.39**	-0.44	6.25**	5.02**	5.95**	3.35**	1.46
	(0.27)	(1.84)	(0.83)	(0.47)	(0.94)	(1.41)	(1.52)
Book-to-market	0.03**					0.031**	0.04**
	(0.001)					(0.001)	(0.002)
Vlab risk weight		2.76**				2.901**	3.45**
		(0.99)				(0.68)	(0.71)
EBA T1 LVGR			-34.47*			-134.98**	-177.7**
			(16.26)			(24.24)	(16.38)
EBA T1 LVGR^2				-167.78		867.27**	997.99**
				(126.03)		(172.2)	(108.3)
EBA risk weight					-2.58		4.84**
					(1.59)		(1.37)
F-test	11.48**	7.63**	5.92*	1.76	2.5	15.77**	17.47**
Adj. R^2 (%)	16.78	11.31	8.65	1.45	2.8	53.18	61.29

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

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 rather low, and 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
- if not, a capital requirement based on the size and leverage of banks delivers more consistent results (Basel III T1 leverage ratio)

Portfolio choice under regulatory risk weights (1/2)

- The total assets TA are allocated between cash C, and other risky assets
- N risky assets with conditional expected returns m, and conditional covariance matrix H
- Each of these assets has a risk weight $w_j \in [0,1]$
- The solution is a $(N \times 1)$ vector of dollars to be invested in each asset, q
- The risk budget requires that $C \geq kw'q$, where k is the prudential capital ratio and $C = TA - \iota'q$, where ι is a $(N \times 1)$ vector of ones.

To maximize assets returns subject to these constraints the firm must solve

$$\max_{q} \; q'm$$
$$\text{s.t. } TA - \iota'q \geq kw'q, \;\; q \geq 0$$

Portfolio choice under regulatory risk weights (2/2)

Solution:

$$q_j = \frac{TA}{1 + kw_j}$$

The maximum will occur if the entire portfolio of the bank is invested in the asset with the greatest value of the ratio $m_j(1 + kw_j)^{-1}$.

Observations:

- RWA ignore the subbadditivity feature of portfolio risk and consequently, there is no incentive to diversify.
- The underestimation of risk weights automatically leads to excess leverage: $C/TA = 1 - (1 + kw_j)^{-1}$.
- This result explains the portfolio decisions of Eurozone banks during the European sovereign debt crisis (see Acharya and Steffen (2013) for empirical evidence).