Testing Macroprudential Stress Tests

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Macroprudential Regulation

Macroprudential stress testing is one of the tools of the macroprudential toolkit (Greenlaw et al. (2012))

Macroprudential regulation seeks to reduce the probability and the cost of a financial crisis by forcing financial institutions to internalize their contribution to systemic risk.

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))

Testing Macro Stress Tests

We provide a test of regulatory macro stress tests by comparing their risk assessments and outcomes to those from a simple methodology (Vlab) that relies on publicly available market data and forecasts the capital shortfall of financial firms in severe market-wide downturns.

Stress tests question: which bank fails the regulatory capital ratios under stress scenario? Based on extended supervisory data.

Vlab question: how much capital the bank will have to raise if there is another financial crisis? Based on publicly available market data.

Testing Macro Stress Tests: Findings

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.

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

Outline

1. Stress tests and Vlab
2. Testing stressed losses
   - Stress tests vs. Vlab losses
   - Predicting banks real losses during the European sovereign debt crisis
3. Testing stressed capital ratios and shortfalls
4. Testing the efficacy of regulatory risk weights
   - Forecasting risk
   - Portfolio choice under regulatory risk weights

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

An alternative to stress tests: 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))

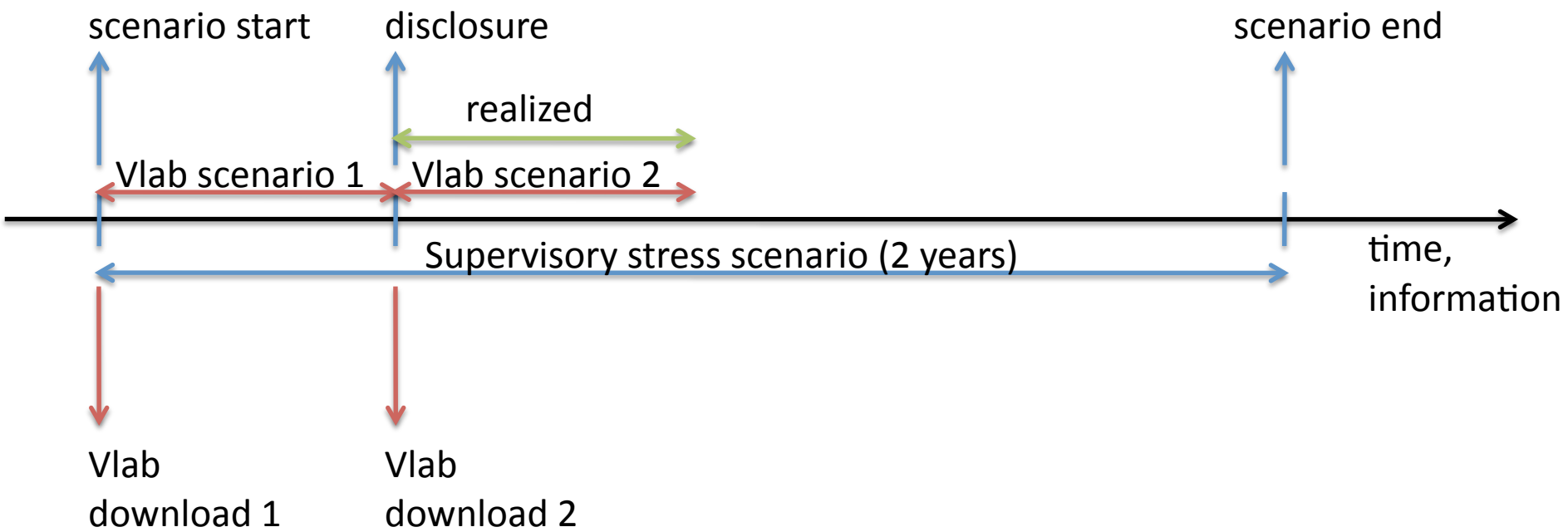
$$\begin{aligned} SRISK &= \mathrm{E}\left[k(Debt + MV) - MV | crisis\right] \\ &= kDebt – (1-k)(1-LRMES) * MV \end{aligned}$$

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.

Outline

Stress test timeline

1. Compare Vlab & stress tests results
2. Compare Vlab & stress tests performance to predict real outcomes



Outline

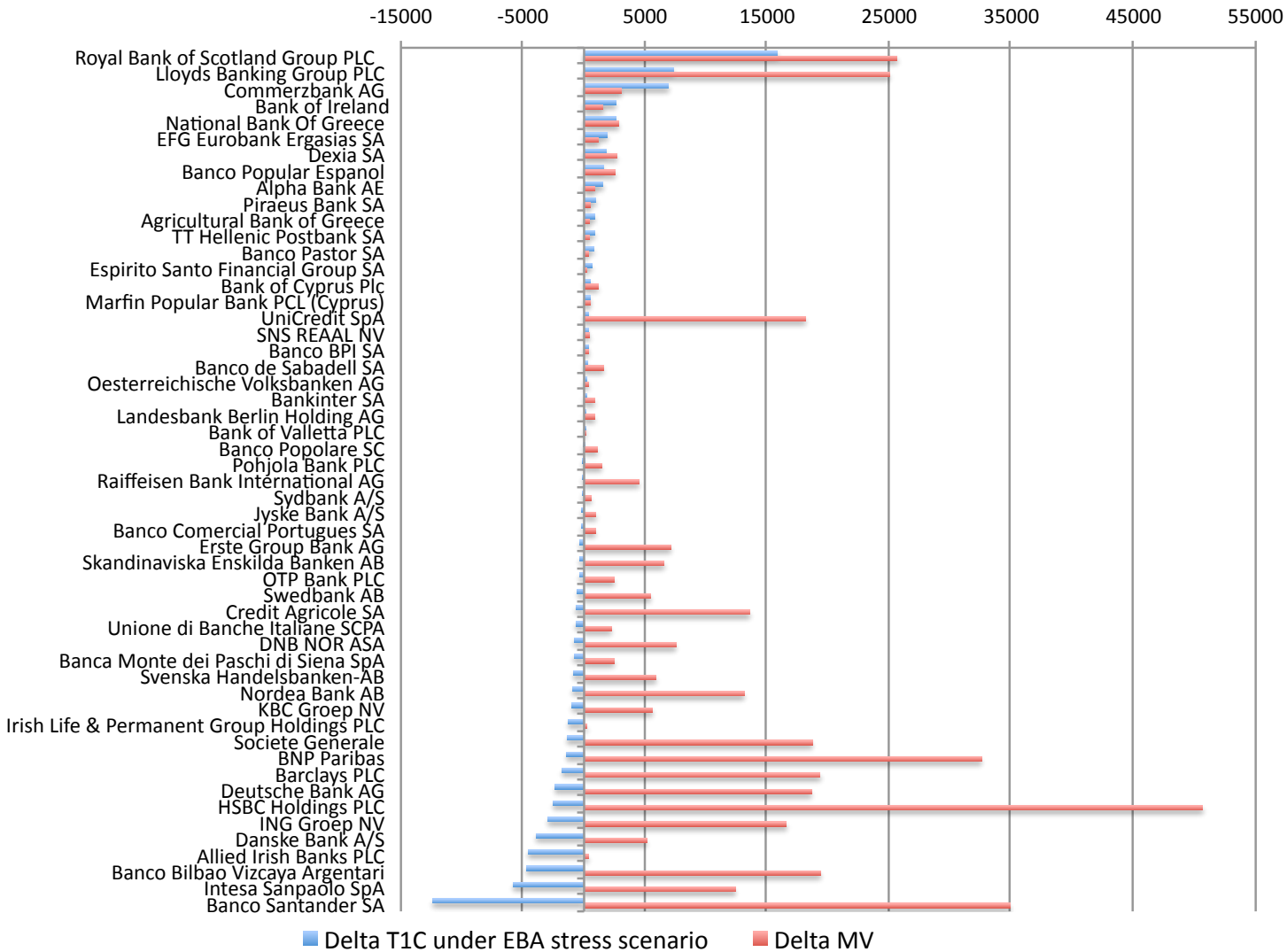
Stress tests vs. Vlab losses

- 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

EBA change in capital

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



Rank correlations

- Vlab MV loss = $LRMES * MV$
- Stress test "Total Loss" is the projected loss over the stress scenario horizon (including loan and trading losses)
- 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
Total Net Loss	0.280	0.604**	0.507*	-0.296*	-0.476**
Total Loss	**0.682****	**0.851****	**0.842****	0.830**	**0.760****
Loan losses	0.580*	0.555*	0.662**	**0.837****	0.751**
Trading losses	0.477*	0.660**	0.589*	0.731**	0.694**

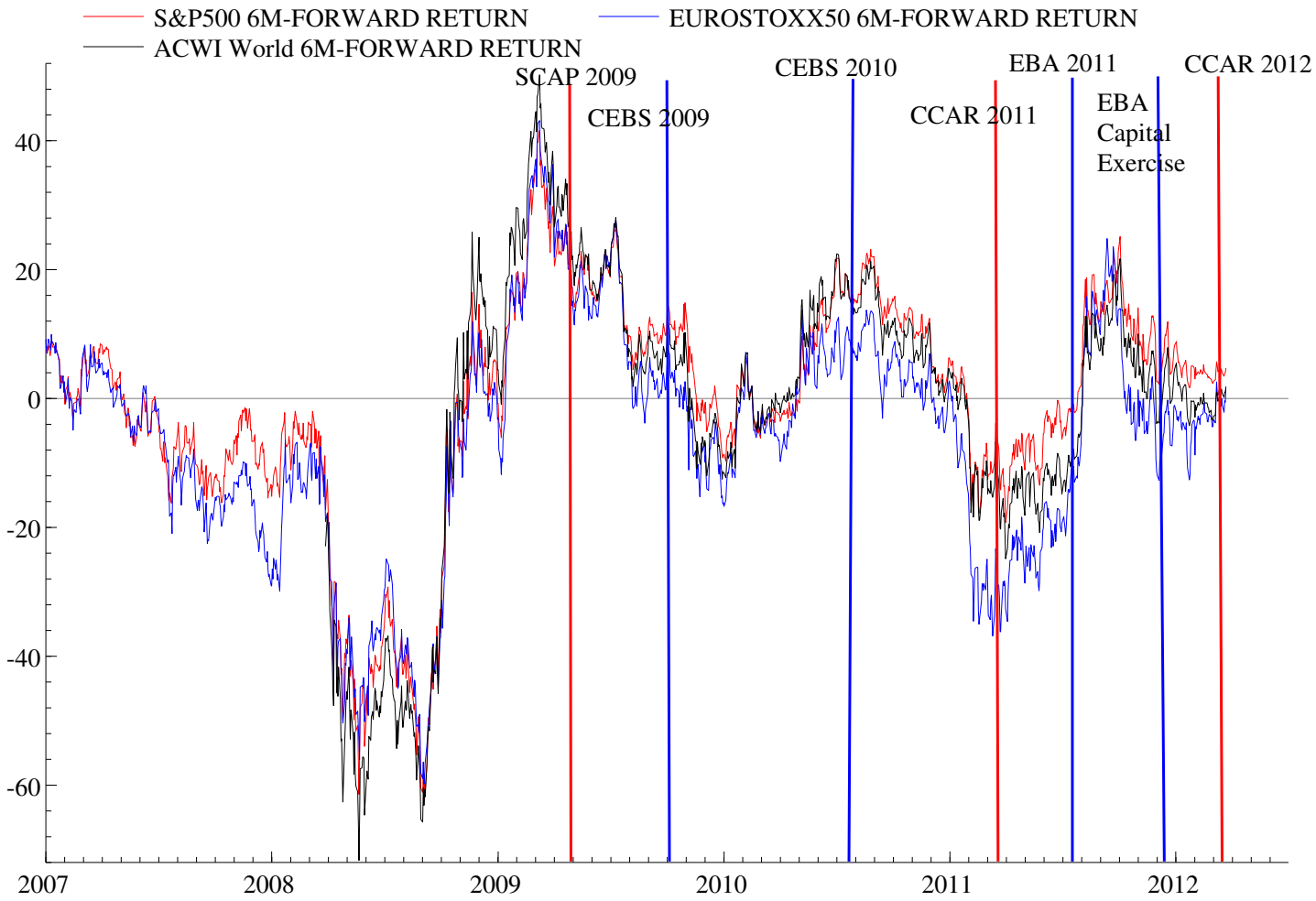
* Significant parameter at 5%; ** at 1%.

Outline

The context of 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%



Forecasting losses

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

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 Net Loss	0.329	-0.100	-0.272	11202
		(0.232)	(0.549)	(0.048)	
EBA	Total Loss	**0.557**	0.527	0.803	**4945**
		(0.000)	(0.000)	(0.000)	

P-values in parentheses.

Testing stressed losses: findings

- Important gap between the losses and the *net* losses in stress tests due to the effect of projected revenues
- Severity: Vlab six-month MV loss amplitude is similar to the 2-year 'pure' losses of stress tests
- Rank correlations between Vlab and stress tests losses are very high for all stress tests (but decrease with the effect of projected revenues)

Predicting realized losses:

- Size (rank correlation with MV is 0.813)
- Similar performance of Vlab and stress tests total losses
- Predicting realized returns: EBA T1C return is a better predictor of the ranking, but LRMES predicts better the amplitude of returns

Outline

Regulatory capital ratios

Numerator: different qualities of capital based on Basel requirements

- **Tier 1 Common (Core) Capital** (T1C) $\approx$ Shareholders' Equity
- **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

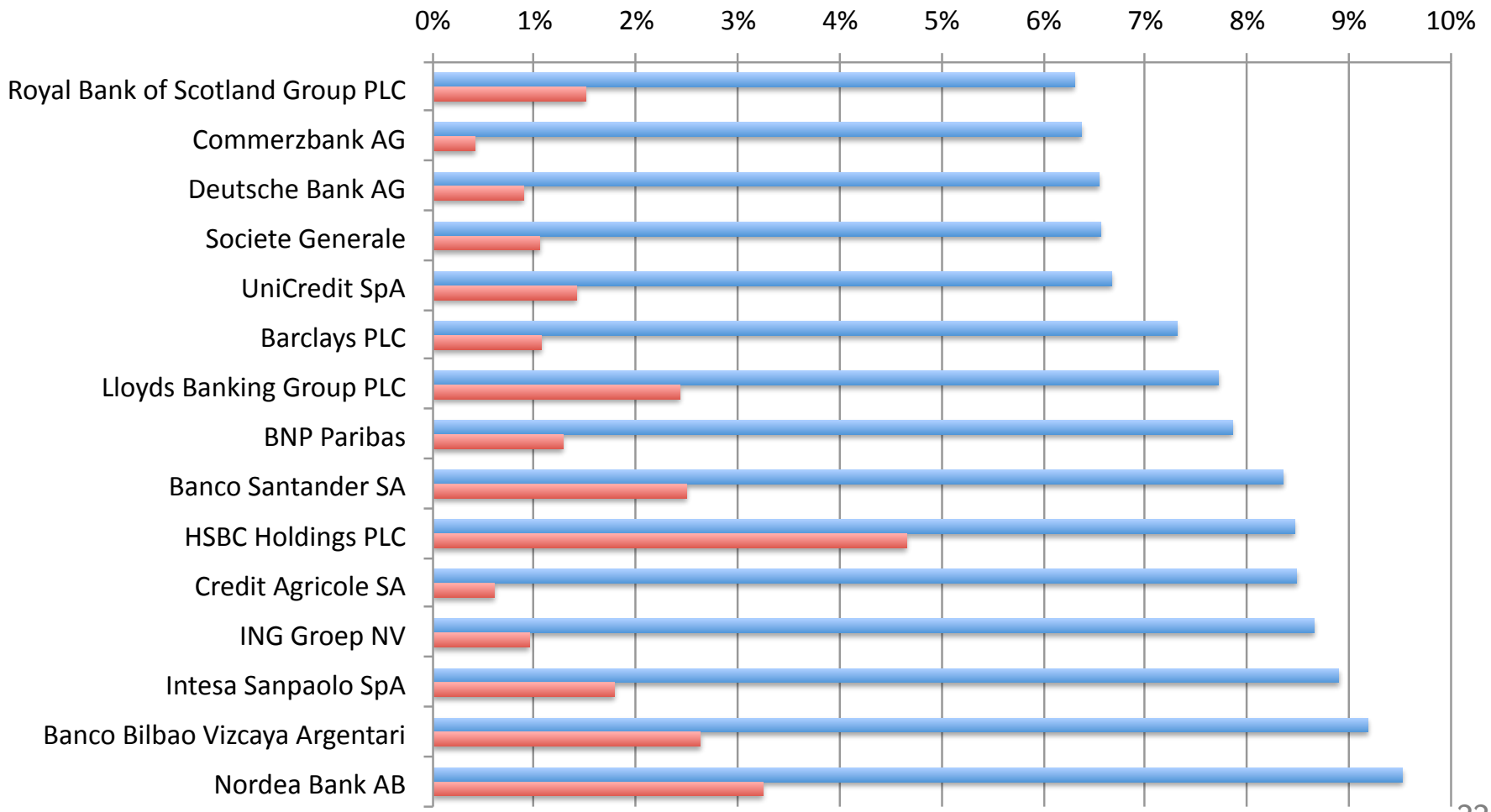
$$M - LVGR_s = \frac{MV(1 - LRMES)}{MV(1 - LRMES) + D}$$

Cross-sectional average ratios:

		Stress tests estimates	Vlab estimates
US	Sample	Ratio	M-LVGR$_s$
CCAR 2012	18 US BHCs	7.55% T1CR	3.54%
CCAR 2013	17 US BHCs	8.37% T1CR	5.48%
EU	Sample	Ratio	M-LVGR$_s$
CEBS 2010	50 EU banks	8.98% T1R	2.6%
EBA 2011	53 EU banks	7.98% T1CR	2.26%

EU Core T1 ratio of large banks: no one fails! (EBA 2011)

EBA Core T1 ratio = T1C/RWA
Correlation with Vlab M-LVGR under stress: 0.496 (large), 0.297 (small), 0.282 (all)
Threshold: 5%



Stress tests capital shortfalls vs. SRISK

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

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

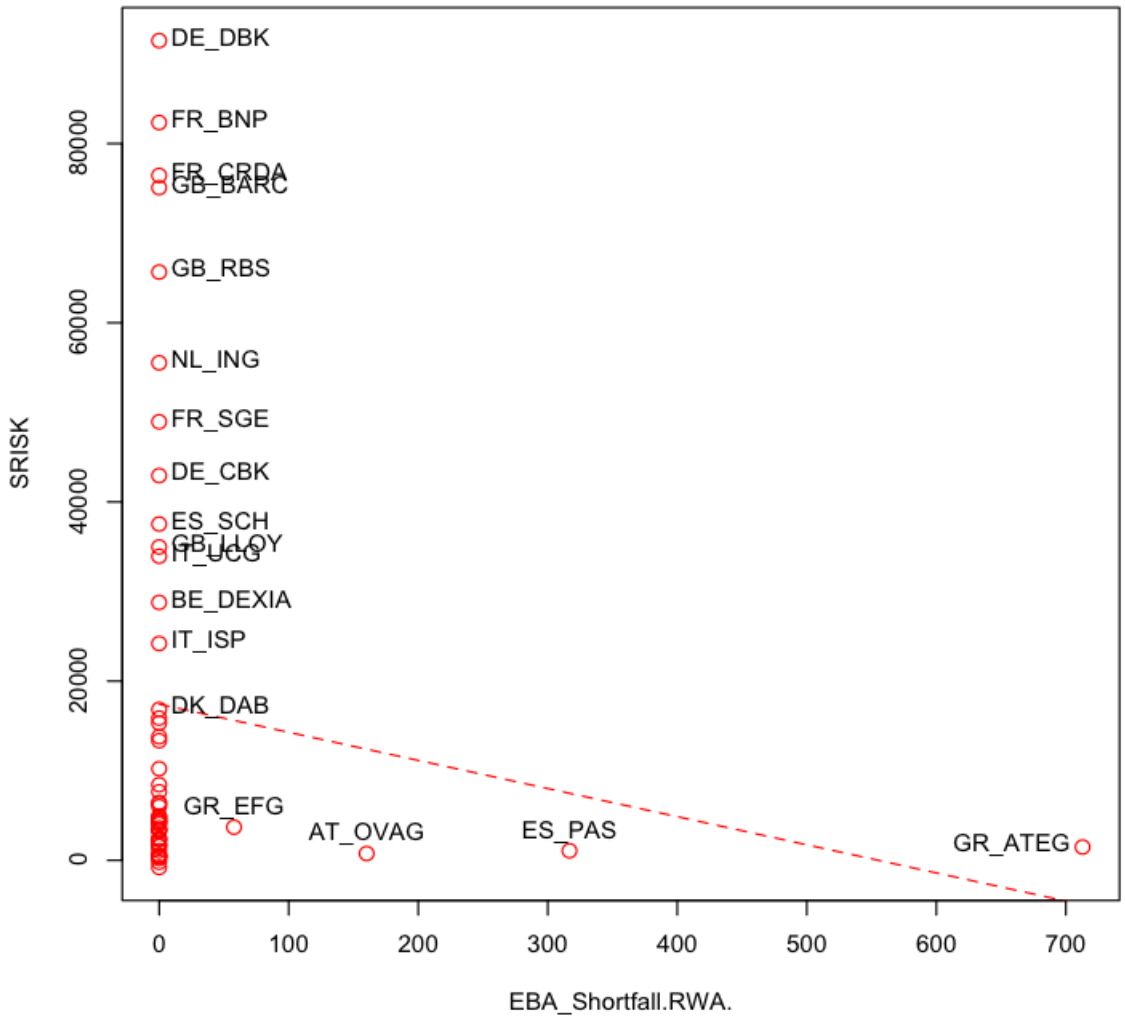
		Stress tests estimates	Vlab estimates
US	Sample	Shortfall	SRISK
SCAP 2009	18 US BHCs	63.1 $ bn (9)	674 $ bn (18)
EU	Sample	Shortfall	SRISK
CEBS 2010	50 EU banks	0.2 EUR bn (1)	796 EUR bn (48)
EBA 2011	53 EU banks	1.2 EUR bn (4)	886 EUR bn (51)
EBA Capital Exercise	44 EU banks	72 EUR bn (22)	1059 EUR bn (42)

In parentheses: number of banks with capital shortfall > 0 under stress.

EBA capital shortfall vs. SRISK

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

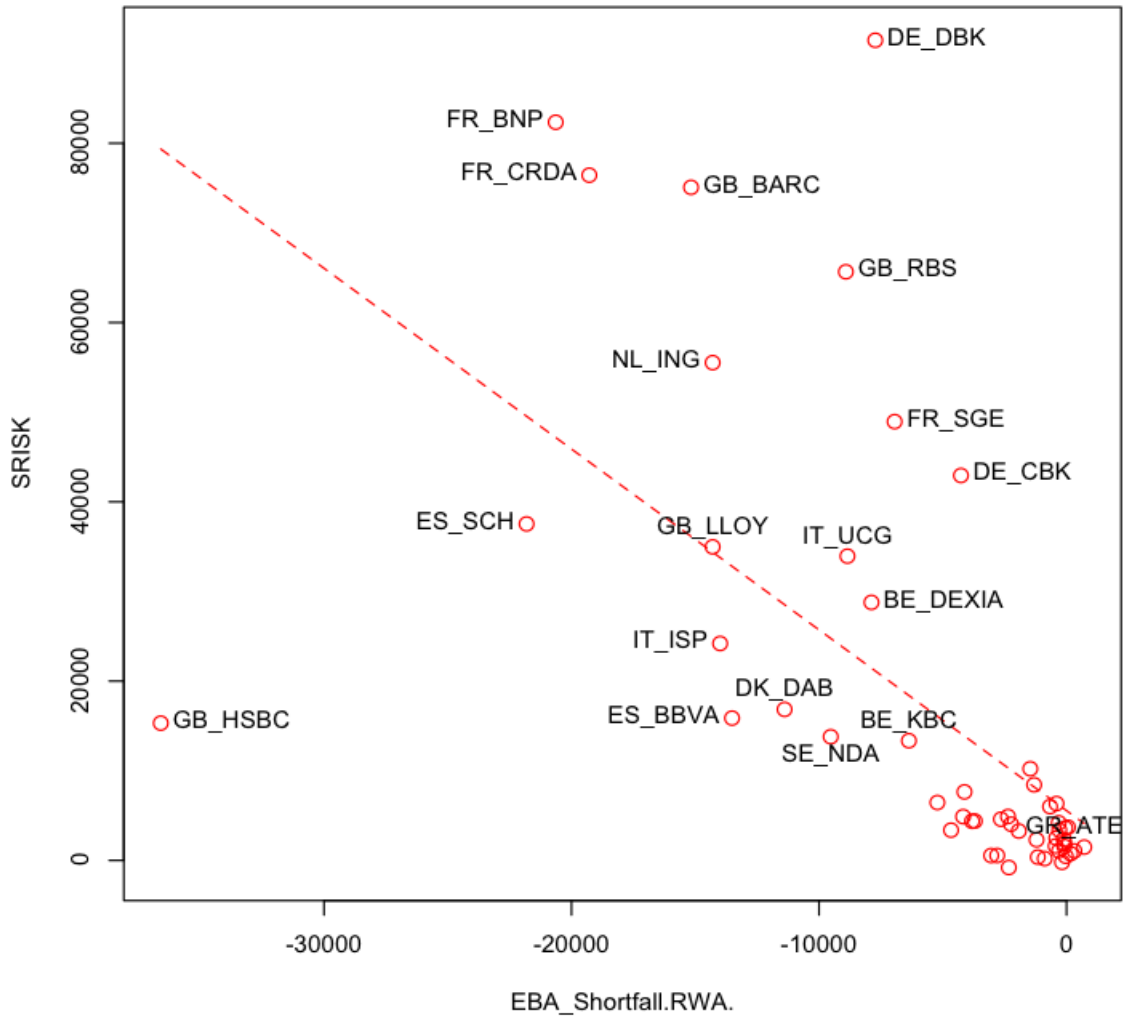
EBA disclosed capital shortfall $= \max(0, [k' * RWA_S - Capital_S])$
(rank correlation: -0.273)



EBA capital excess vs. SRISK

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

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



Evidence of the EBA failure

Dexia's bail-out 3 months after the disclosure of the EBA stress test: EBA capital excess of Dexia was 7.9 EUR bn vs. 26 EUR bn SRISK.

5 months after the disclosure of the stress test, 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

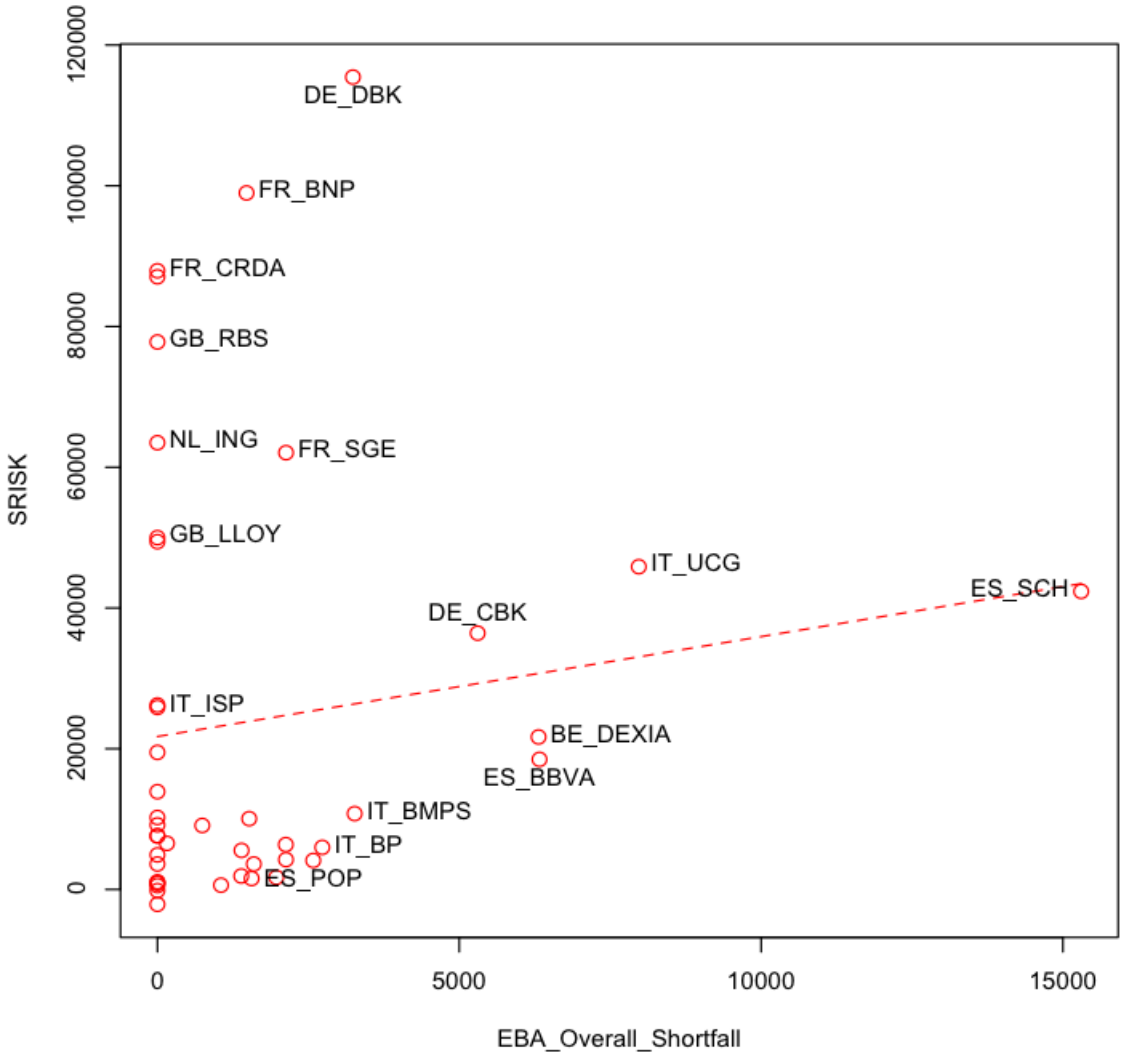
EBA Overall Shortfall, still too low?

- Dexia, with 6.3 EUR bn shortfall in the exercise and 21.7 EUR bn SRISK, was bailed out a second time for 5.5 EUR bn in November 2012 and reported a net loss of 2.9 EUR bn for 2012.
- Crédit Agricole, with no capital shortfall in the exercise but a 88 EUR bn SRISK, announced a net loss of 6.5 EUR bn for 2012.

EBA "Overall shortfall" vs. SRISK

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

EBA Overall Shortfall $= \max(0, [0.09 * RWA - T1C]) + BuffSOV$
(rank correlation: 0.163)



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 TA.

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

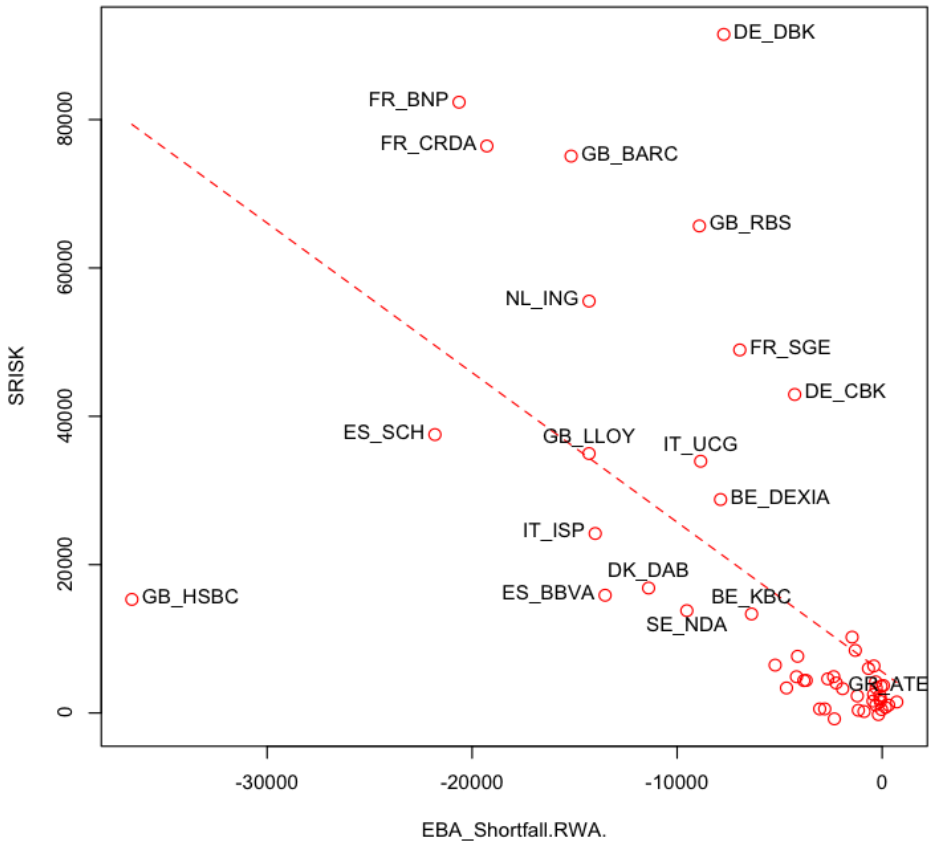
Stress tests projected ratios	CCAR 2012	CCAR 2013	EBA 2011
T1R, scenario end	0.204		0.280*
T1CR, scenario end	0.242		0.282*
T1 LVGR, scenario end	0.576*		**0.570****
min T1CR	0.797**	0.581*	
min T1 LVGR	**0.846****	**0.877****	

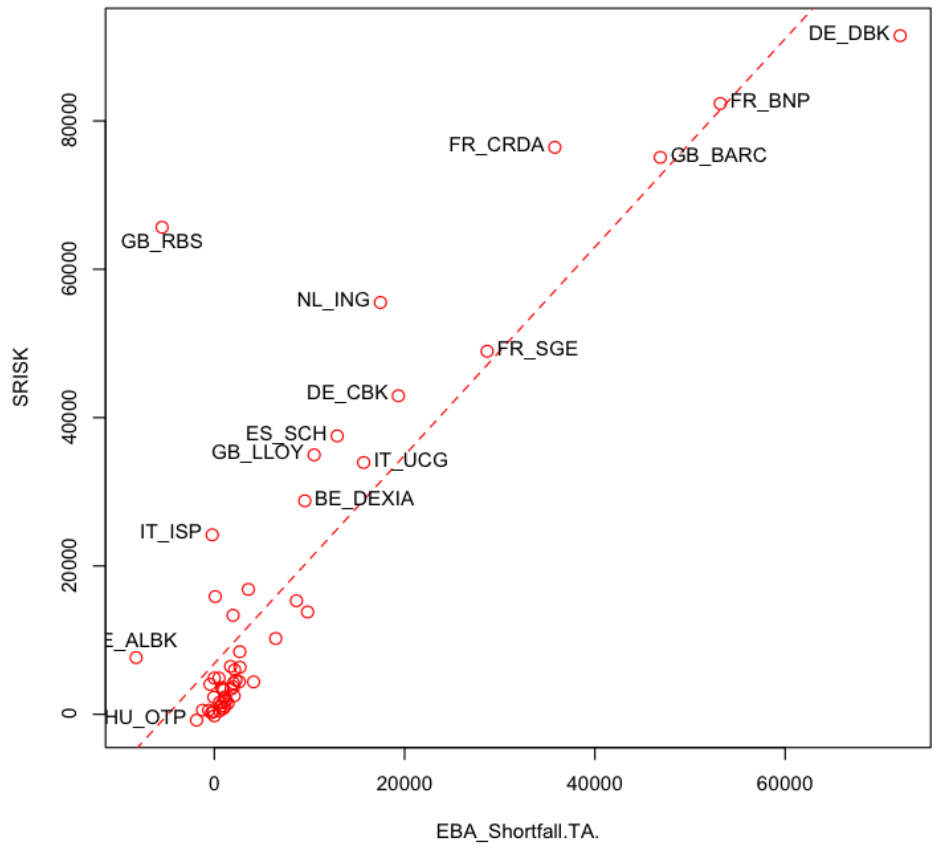
* Significant parameters at 5%; ** at 1%.

Risk-based capital vs. leverage-based capital shortfall

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: 372 EUR bn





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 $\geq$ 5%	10.1%	6.6% min (3)
	T1C	741 $ bn	438 $ bn
	RWA	7356 $ bn	6904 $ bn
EBA 2011	T1CR $\geq$ 5%	8.9% (3)	7.7% (8)
	T1C	1006 EUR bn	1001 EUR bn
	RWA	11.37 EUR tn	13 EUR tn

US-EU differences:

- scenario paths: reversion to a 'normal state' at the end of the US scenario
- heterogeneity of EU banks (size and business models)
- balance sheet evolution assumptions: static (EU) vs. dynamic in the CCAR
- implementation: bottom-up (EU) vs. top-down (US)
- RWA definitions

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.

Credit component ($\simeq 80\%$ of RWA): $C_{cdt} = \sum_j w_j * EAD_j$ and the weight w_j represents an unexpected loss in % of EAD, uncovered by provisions or revenues.

Basel II risk weights: IRB approach

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: the IRB approach allows to derive lower risk weights to incite banks to update their risk management practices
- Inconsistency: differences in risk weights across banks reflect modeling choices and supervisory decisions (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.

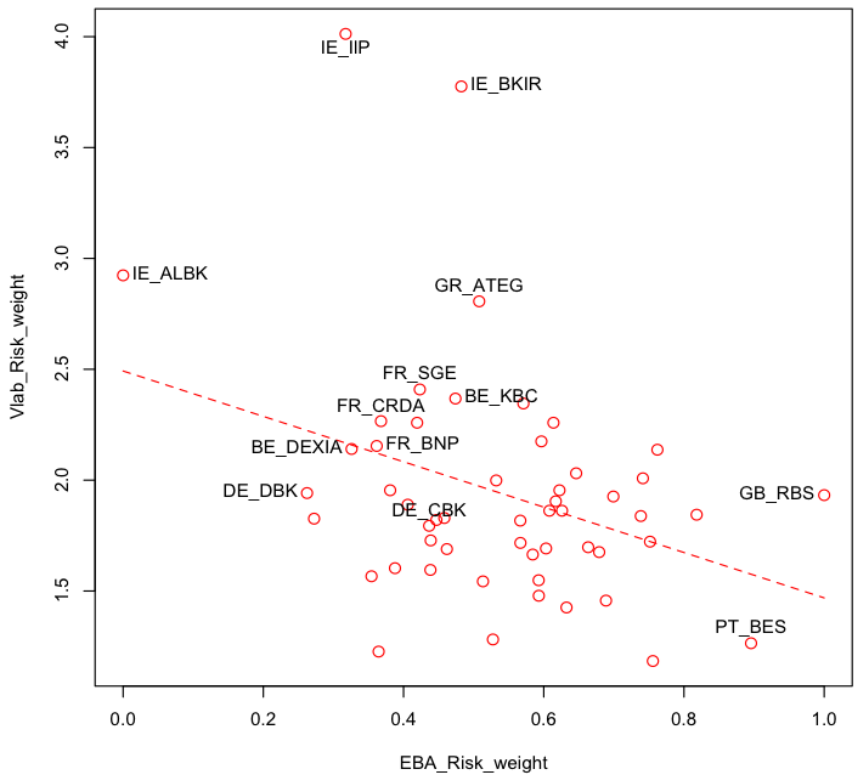
Regulatory risk weight vs. market risk weight

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



Outline

Forecasting risk

Realized measure of risk:

$$\text{Realized volatility}_{i,t,W} = \sqrt{\frac{1}{W}\sum_{t+1}^{t+1+W}(r_{it} - \bar{r}_{it,W})^2}$$

Predictor of realized risk ranking: Vlab risk weight

Panel C: Rank correlations with the 6-month realized volatility

	Estimated risk	Large	Small	All	RMSE
Vlab	risk weight	**0.554**	**0.561**	**0.535**	**3.395**
		(0.032)	(0.000)	(0.000)	
EBA	risk weight	-0.111	-0.055	-0.140	4.539
		(0.694)	(0.742)	(0.318)	

P-values in parentheses.

Forecasting risk: realized volatility regression

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

Forecasting risk change

The change in RWA under the stress scenario comes from the credit risk component: $C_{cdt} = \sum_j w_j * EAD_j$

Risk weight change $\simeq \sum_j w_{j,t|stress} - \sum_j w_{j0} > 0$ due to stressed PDs and stressed LGDs

Realized risk change = $RV_{i,t,W}$ - $RV_{i,t-W,W}$

Findings:

- Regulatory risk weights are wrong, but the stress model is right
- Vlab risk weight $((1-(1-k)LRMES)^{-1})$ also reflects investors expectations on banks' risk evolution

Panel D: Rank correlations with the 6-month realized volatility change

	Estimated risk changes	Large	Small	All	RMSE
Vlab	risk weight	**0.521**	0.395	**0.434**	**1.305**
		(0.046)	(0.014)	(0.001)	
EBA	risk weight change	0.061	**0.397**	0.341	2.400
		(0.830)	(0.014)	(0.012)	

P-values in parentheses.

Outline

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:
Supposing that each asset has a different value of the ratio $m_j(1+kw_j)^{-1}$, then the maximum will occur if the entire portfolio of the bank $\iota' q$ is invested in the asset with the greatest value of this ratio. The amount invested in this asset will be

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

Observations:

- The use of RWA ignores the subbadditivity feature of portfolio risk and consequently, there is no incentive from the regulatory perspective 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, giving incentives to build up exposures to risky sovereign debt (with a zero risk weight, see Acharya and Steffen (2013) for empirical evidence).

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.

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)