

Testing Macroprudential Stress Tests: The Risk of Regulatory Risk Weights Supplementary Material

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Appendix A includes two tables that summarize the results of regulatory stress tests implemented in the U.S. (Table 1) and in the EU (Table 2).

Appendix B covers the comparison of the projected losses in regulatory stress tests with V-Lab market cap losses.

Appendix C presents a resource allocation problem of a bank that invests in a portfolio of assets subject to a risk budget constraint based on risk-weighted assets.

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A. US and EU stress tests results

Table 1: U.S. stress tests results. This table presents the aggregate outcome of U.S. stress tests for which a bank-level outcome is publicly available. $T1$ is the Tier 1 capital, $T1C$ is the Tier 1 Common capital, and RWA are the risk-weighted assets. $T1CR$ is the Tier Common Capital Ratio ($T1CR = T1C/RWA$); $T1R$ is the Tier 1 Capital Ratio ($T1R = T1/RWA$); $TotalCR$ is the Total Risk-based Capital Ratio ($TotalCR = TotalCapital/RWA$); $T1LVGR$ is the Tier 1 leverage Ratio ($T1LVGR = T1/TotalAssets$). In parentheses: number of banks failing the regulatory criterion. “min” stands for the cross-sectional average (unweighted) of banks minimum ratios over the nine quarters of the CCAR scenario. The different minimum ratios may not happen on the same quarter. The column “After scenario*” presents the aggregate results of stress tests without the effect of BHCs planned capital actions (results disclosed in the Dodd-Frank Act stress test 2013 for the CCAR 2013).

	Disclosure	Sample	Scenario horizon	Measure and threshold	Before scenario	After scenario	After scenario*
SCAP 2009	05/07/2009	19 U.S. banks (19 BHCs)	2009 - 2010 (2 years)	T1	837 \$ bn	540 \$ bn	185 \$ bn (10)
				T1C	413 \$ bn	438 \$ bn	
				RWA	7815 \$ bn	6904 \$ bn	
				T1CR \geq 4%	6.7% (2)	7.3% min (1)	
				T1R \geq 6%	11.5%	8.0% min (0)	8.7% min (0)
				T1C shortfall \leq 0		10.8% min (2)	11.5% min (2)
CCAR 2012	03/13/2012	19 U.S. banks (19 BHCs)	Q4 2011 - Q4 2013 (9 quarters)	T1	907 \$ bn	74.6 \$ bn (10)	74.6 \$ bn (10)
				T1C	741 \$ bn	540 \$ bn	
				RWA	7356 \$ bn	6904 \$ bn	
				T1CR \geq 5%	10.1%	6.6% min (3)	7.3% min (1)
				T1R \geq 4%	12.3%	8.0% min (0)	8.7% min (0)
				Total CR \geq 8%	15.5%	10.8% min (2)	11.5% min (2)
				T1 LVGR \geq 3-4%	7.4%	5.2% min (2)	5.7% min (1)
CCAR 2013	03/14/2013	18 U.S. banks (18 BHCs)	Q4 2012 - Q4 2014 (9 quarters)	T1C	792 \$ bn	6.9% min (1)	8.0% min (1)
				T1CR \geq 5%	11.3%	8.3% min (0)	9.8% min (0)
				T1R \geq 4%	13.1%	10.7% min (0)	12.1% min (0)
				Total CR \geq 8%	15.6%	5.7% min (2)	6.8% min (0)
				T1 LVGR \geq 3-4%	8.8%		

Table 2: EU stress tests results. This table presents the aggregate outcome of EU-wide stress tests for which a bank-level outcome is publicly available. $T1$ is the Tier 1 capital, $T1C$ is the Tier 1 Core capital, and RWA are the risk-weighted assets. $T1CR$ is the Core Tier 1 Capital Ratio ($T1CR = T1C/RWA$); $T1R$ is the Tier 1 Capital Ratio ($T1R = T1/RWA$). In parentheses: number of banks failing the regulatory criterion. Ratios are cross-sectional average ratios at a specific date (scenario start or scenario end). The column “After scenario*” presents the aggregate results of stress tests without the effect of capital actions and restructuring plans.

	Disclosure	Sample	Scenario horizon	Measure and threshold	Before scenario	After scenario	After scenario*
CEBS 2010	07/23/2010	91 banks,	2010 - 2011	T1	1162 EUR bn	1118 EUR bn	
		65% of	(2 years)	RWA	11.29 EUR tn	12.15 EUR tn	
		EU-27 assets		T1R \geq 6%	10.3%	9.2% (7)	
				T1 shortfall \leq 0		3.5 EUR bn	
EBA 2011	07/15/2011	90 banks,	2011 - 2012	T1	1218 EUR bn	1199 EUR bn	
		65% of	(2 years)	T1C	1006 EUR bn	1001 EUR bn	954 EUR bn
		EU-27 assets		RWA	11.37 EUR tn	13 EUR tn	13.12 EUR tn
				T1CR \geq 5%	8.9% (3)	7.7% (8)	7% (20)
				T1C shortfall \leq 0		2.5 EUR bn	25 EUR bn
EBA Capital Exercise	12/08/2011	65 banks		T1	1190 EUR bn		
		(excluding		T1C	987 EUR bn		
		Greek banks)		RWA	10.55 EUR tn		
				T1CR \geq 9%	10.2% (27)		
		Sovereign buffer			39 EUR bn		
		Overall shortfall \leq 0			85 EUR bn (31)		

B. Evaluating stressed losses

Stress test models can be used to translate the stress scenario into losses to assets on banks' balance sheets. The net loss (difference of projected losses and projected revenues) is the main driver of capital diminution under stress.

The rank correlations of the V-Lab loss with the projected total losses of stress tests are very high and significant in all stress tests (see Table 3).¹ The correlations of the V-Lab loss with the total *net* loss (including stressed revenues) are smaller for all stress tests and negative in Europe; banks with larger profits under European stress scenarios are predicted to have larger losses in V-Lab. Some banks actually report positive profits under the stress scenario of stress tests where stressed revenues cover stressed losses.² The profits are then reported in the balance sheet so that the divergence with V-Lab is also visible in capital changes. We show in Figure 1 that the projected profits under the EBA stress scenario lead to increasing capital levels for many banks with the largest V-Lab losses. Controlling for the size effect, the correlation between the V-Lab market cap return (*LRMES*) and the return on Core Tier 1 capital over the EBA stress scenario is less important (-0.133) and not significant at the 5% level.

Second, we compare in Table 4 the performance of V-Lab and the EBA 2011 stress test in predicting the actual ranking of banks' realized six-month losses and six-month returns after disclosure of the EBA stress test (i.e., the last two quarters of 2011). The six-month realized return is $-\sum_{t+1}^{t+131} \ln(p_{it}/p_{it-1})$, where p_{it} is the daily stock price of the bank, and the six-month realized loss is the product of the six-month realized return with the market cap of the bank.

For predicting realized losses (Panel A), the V-Lab market cap loss has the highest rank correlation (0.832) with the six-month realized loss. The correlation of the realized loss with the EBA projected net loss is negative (except for large banks) since many banks with positive projected profits in the stress test actually endured the highest losses during the sovereign debt crisis.

For predicting realized returns (Panel B), V-Lab long-run marginal expected shortfall (*LRMES*) is a better predictor of the *size* of realized returns according to the root mean square error (RMSE). However, the estimated Core Tier 1 capital return over the EBA stress scenario better predicts the *ranking* of realized six-month returns than V-Lab *LRMES*, suggesting that the ranking of stressed returns in the EBA stress test was correct, only the stress applied to banks was too mild compared to what happened during the following six months.

¹We also report the correlations of the V-Lab loss with the stress test loan losses and trading losses since they are the most important sources of losses (85%) according to CCAR 2012. The correlations of the V-Lab loss with the loan and trading losses are also very high and significant, making V-Lab's ranking and the ranking of losses under supervisory stress scenarios very consistent.

²First, the stress scenario is not an absolute scenario as in V-Lab but is defined as a deviation from a baseline scenario. If some banks are projected to make large profits in the baseline scenario, they will make lower but still positive profits under the adverse scenario. Second, the EBA explains that the stress scenario may lead to a higher net interest income where some banks assume that the impact of higher interest rates will be passed onto customers without a corresponding increase in the cost of funding for the bank. Then, the EBA considers a directional market risk stress test; depending on the direction of their exposures, banks can realize trading gains on certain portfolios.

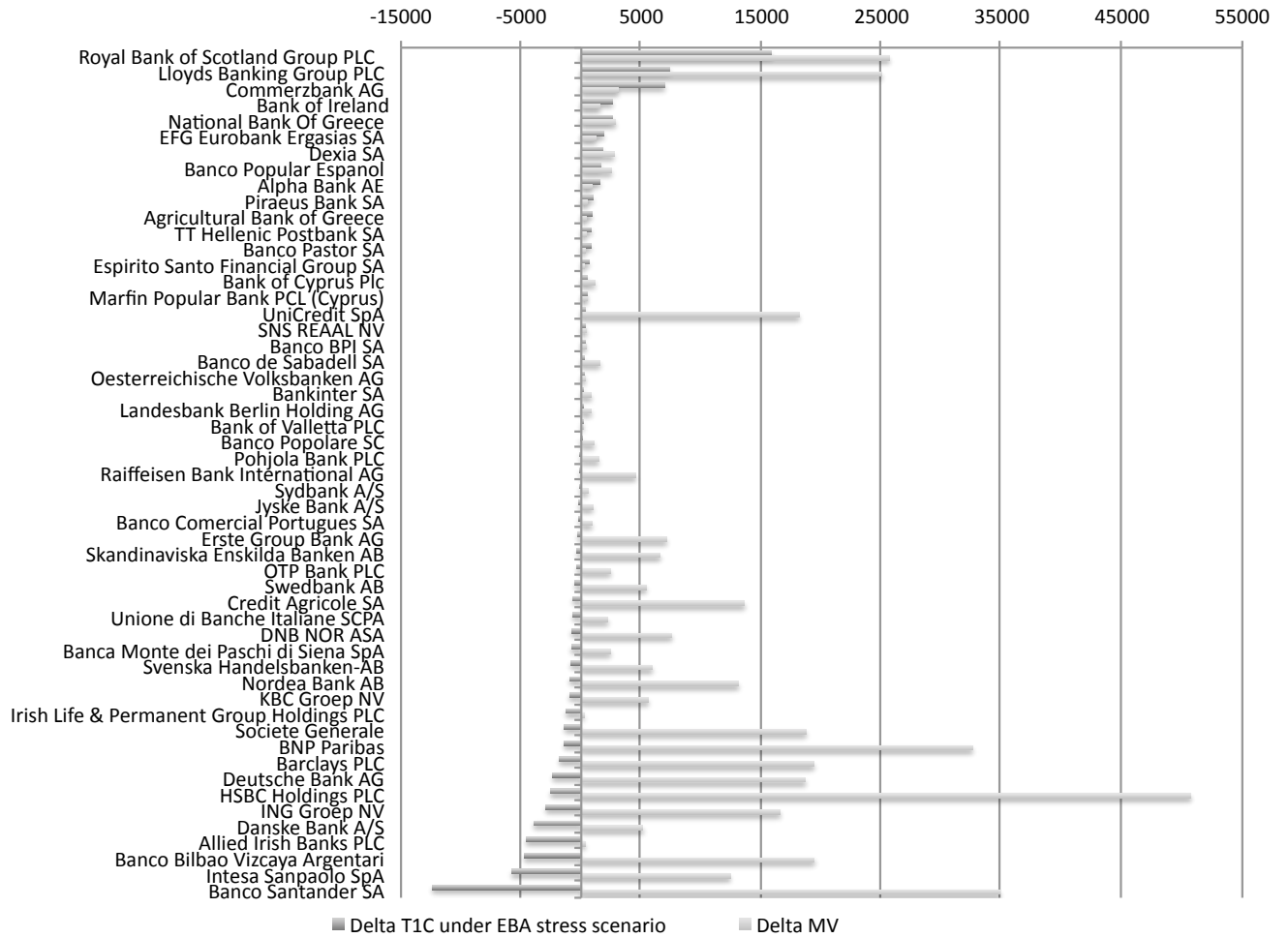
Table 3: **V-Lab vs. stress tests losses: rank correlations.** Rank correlations of stress tests losses with V-Lab’s MV loss ($LRMES * MV$). “Loss” (SCAP) = *Total Loss estimates*, “Loss” (CCAR) = *Loan Losses + Trading and Counterparty Losses + Realized Losses on Securities + Other Losses*, “Loss” (CEBS & EBA) = *Impairment losses + Trading losses*. “Net Loss” (SCAP) = *Total Loss estimates - Resources Other Than Capital to Absorb Losses in the More Adverse Scenario*, “Net Loss” (CCAR) = *- Projected Net Income before Taxes*, “Net Loss” (CEBS) = *Loss - pre-impairment income after the adverse scenario*, “Net Loss” (EBA) = *- Net profit after tax*. V-Lab download date: 12/31/2008 (SCAP), 09/30/2011 (CCAR 2012), 09/28/2012 (CCAR 2013), 12/31/2009 (CEBS), 12/31/2010 (EBA), 09/30/2011 (EBA Capital exercise). * indicates statistical significance at the 5% level; ** at the 1% level. Sample size: 18 (SCAP and CCAR 2012), 17 (CCAR 2013), 50 (CEBS), 53 (EBA).

Rank correlations with V-Lab MV loss					
Stress tests projected 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**

Table 4: **Forecasting losses during the European sovereign debt crisis.** This table presents the rank correlations and root mean square errors (RMSE) of the EBA and V-Lab outcomes with the realized outcomes of banks after disclosure of the EBA stress test in July 2011 (p-values in parentheses). Panel A: rank correlations and RMSE with the 6-month realized loss ($-MV_{it} * \sum_{t+1}^{t+131} \ln(p_{it}/p_{it-1})$). Panel B: rank correlations and RMSE with the 6-month realized return ($-\sum_{t+1}^{t+131} \ln(p_{it}/p_{it-1})$). EBA T1C return is the percentage return on Core Tier 1 capital during the EBA 2011 stress scenario. V-Lab output was downloaded before the disclosure date of the EBA stress test: 06/30/2011. Sample size: 15 (large), 38 (small), 53 (all).

Panel A: 6-month realized EUR loss		Rank correlations			RMSE
Estimated losses		Large	Small	All	All
V-Lab	MV loss	0.293 (0.289)	0.610 (0.000)	0.832 (0.000)	5086
EBA	Total Net Loss	0.329 (0.232)	-0.100 (0.549)	-0.272 (0.048)	11202
EBA	Total Loss	0.557 (0.000)	0.527 (0.000)	0.803 (0.000)	4945
Panel B: 6-month realized return		Rank correlations			RMSE
Estimated returns		Large	Small	All	All
V-Lab	$LRMES$	0.350 (0.201)	0.314 (0.055)	0.299 (0.029)	0.553
EBA	T1C return	0.546 (0.035)	0.339 (0.038)	0.354 (0.009)	0.767

Figure 1: **EBA stress test change in capital vs. V-Lab market cap loss (EUR millions)**. Change in Core Tier 1 capital (Delta T1C) under the EBA 2011 stress scenario (dark grey) against V-Lab’s market capitalization loss (Delta MV) (light grey). Negative changes represent a capital increase. Banks are ranked according to their changes in Core Tier 1 capital under the EBA stress scenario. V-Lab download date: 12/31/2010.



C. Portfolio choice under regulatory risk weights

We demonstrate in this section the weakness of Basel regulatory risk weights as an aggregate measure of bank risk where the bank is seen as a portfolio of assets. The bank chooses its resources allocations to maximize its return subject to a tolerable level of risk. Regulators implement several standards of prudent risk but these may sometimes be misguided. Here we consider the allocation of a fixed investment budget to asset categories subject to the regulatory requirement implemented in a stylized version of Basel standards.

Let TA be the total assets to be allocated between cash, C (equivalent to the capital requirement for credit risk in Basel II), and other risky assets. Let there be N risky assets with conditional expected returns given by the $(N \times 1)$ vector m , and conditional covariance matrix given by the $(N \times N)$ matrix H . According to Basel rules, each of these assets has a risk weight w_j between zero and one that we assemble in a $(N \times 1)$ vector w . The solution is a $(N \times 1)$ vector of dollars to be invested in each asset, q . The vector q will also determine the optimal exposures at default under Basel II and the optimal RWA, $w'q$. 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 asset returns subject to these constraints, the bank must solve:

$$\begin{aligned} & \max_q q'm \\ \text{s.t. } & TA - \iota'q \geq kw'q, \quad q \geq 0. \end{aligned} \quad (1)$$

The Lagrangian of this maximization problem is:

$$L(q, \lambda, \mu) = m'q - \lambda(TA - \iota'q - kw'q) - \mu'q, \quad (2)$$

where the scalar λ and the $(N \times 1)$ vector μ are Lagrange multipliers. The first order condition of equation (2) with respect to q is given by:

$$m' + \lambda(\iota' + kw') - \mu' = 0. \quad (3)$$

Multiplying equation (3) by q and recognizing that either q or μ will be zero for each asset (from the first-order condition of (2) w.r.t. to μ), then:

$$\begin{aligned} m'q + \lambda(\iota'q + kw'q) &= 0 \\ m'q &= -\lambda TA \\ \lambda &= \frac{-m'q}{TA}. \end{aligned} \quad (4)$$

Replacing λ in (3), we obtain:

$$m' - \left(\frac{m'q}{TA}\right)(\iota' + kw') - \mu' = 0. \quad (5)$$

Hence all non-zero allocations, q_j , must satisfy:

$$m_j - \left(\frac{m'q}{TA}\right)(1 + kw_j) = 0 \quad (6)$$

$$\frac{m_j}{1 + kw_j} = \frac{m'q}{TA}.$$

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

$$q_j = \frac{TA}{1 + kw_j} \quad (7)$$

If there are multiple assets with the same value of this ratio, the performance will be the same for any feasible allocation to these assets.

The main observation is that the risk of a portfolio is always less than or equal to the sum of the risks of its components. The use of risk-weighted assets ignores this portfolio feature of risk and consequently there is no incentive from the regulatory perspective to diversify. The only case where this measure is appropriate is when all assets are perfectly correlated.

For banks with risk aversion, risk weights act as an additional cost on assets.³ Glasserman and Kang (2013) show that risk weights that are optimal from both banking and regulatory perspectives have nothing to do with risk but are instead proportional to the asset returns m . These optimal risk weights do not distort the portfolio a bank would choose without the risk-based capital constraint and satisfy the regulator's objective to limit the bank's portfolio riskiness.⁴

Then, if some risk weights are underestimated or are not adjusted to reflect increased risk during a crisis, a bank will choose its optimal asset with the most underestimated risk weight, which will automatically lead to excessive leverage. If w_j is the risk weight of the optimal asset and since $q_j = l'q = TA - C$, the leverage ratio C/TA from (7) is $1 - (1 + kw_j)^{-1}$. Consequently, banks will take excessive leverage if their risk weights are not adequately adjusted to more severe economic conditions.

References

Glasserman, P., Kang, W., 2013. Design of risk weights, Columbia Business School Research Paper No. 13-39.

³It can be shown that the additional cost will be greater if the threshold k is large and for a bank with low risk aversion and low capital.

⁴Also note that the portfolio distortion problem does not exist for banks that are only leverage-constrained since the additional charges are the same for all assets.