

Back-Testing European Stress Tests

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October 2016, Boston Fed

Stress Tests

- Major tool of banking supervision
- Time consuming, labor intensive, expensive
- Existing research
 - Market reaction to results: U.S. (Morgan et al. 2014, Bird et al. 2015, Fernandes, Igan & Pinheiro 2015, Flannery, Hirtle & Kovner 2016), E.U. (Petrella & Resti 2013, Candelon & Sy 2015).
 - Design & Governance: Schuermann (2012, 2016)
- But data produced by/during stress tests have not been exploited
- No test of reliability of stress tests

Notations

- EBA 2014 Stress Tests
 - unit of observation is (i, j, p, s, t)
- Name of the bank $i \in [1 : 122]$
- Country of operation $j \in [1 : 28]$
- Portfolio $p \in \{\text{retail, corporate}\}$
- Scenario $s \in \{\text{baseline, adverse}\}$ and projection year $t = \{2014, 2015, 2016\}$

Definitions

- A **scenario** s is a sequence of vectors $y_{j,t}^s$, representing the macroeconomic factors in country j at time t .
- The **results** of the stress tests is a set of loss rates $l_{i,j,t}^{s,p}$ representing the losses for portfolio p of bank i in country j at time t under scenario s .
- A **model** of portfolio losses is a mapping from scenarios $y_{j,t}^s$ to results $l_{i,j,t}^{s,p}$

$$l_{i,j,t}^{s,p} = F_{i,j}^p(y_{j,t}^s)$$

Stress Test Data

	Loss rate		g		pi		u	
	baseline	adverse	baseline	adverse	baseline	adverse	baseline	adverse
N	2,954	2,954	84	84	84	84	84	84
Min (%)	0.00	0.00	-4.80	-6.30	-0.60	-2.50	4.70	5.00
Median (%)	0.33	0.60	1.80	-0.80	1.60	0.70	9.45	11.55
Max (%)	7.45	8.87	4.30	2.10	3.40	2.50	26.00	27.10
Mean (%)	0.59	1.00	1.92	-0.92	1.56	0.49	10.64	12.64
StD (%)	0.76	1.20	1.16	1.40	0.64	1.05	5.09	5.26

Model

- Principal Component Macro Factor

$$y_{j,t}^s = [c_1^g \quad c_1^\pi \quad c_1^{\Delta u}] \cdot \begin{bmatrix} g_{j,t}^s \\ \pi_{j,t}^s \\ \Delta u_{j,t}^s \end{bmatrix}$$

- Loss Rate Model

$$\log \frac{l_{i,j,t}^{s,p}}{1 - l_{i,j,t}^{s,p}} = \alpha_i^p + \beta_i^p \times \theta_j^p \times y_{j,t}^s + \varepsilon_{i,j,t}^{s,p}$$

- Country-specific sensitivity θ_j^p .
- Bank-specific elasticities β_i^p . Also estimate model with $\beta_i^p = 1$
- note on slopes: $\beta_i^p \times \theta_j^p$: $28 + 122 = 150 < 28 * 122 = 3,416$
- note on PCA: $153 + 3 - 1 = 152 < 3,416 * 3 - 122 = 10,126$

PCA

	1 st component	2 nd	3 rd
g loading	0.64	-0.18	0.74
π loading	0.48	0.86	-0.20
Δu loading	-0.60	0.49	0.64
Eigenvalue	1.88	0.76	0.35
Prop. variance	62.75%	25.50%	11.76%
Observations	168		

Summary of Estimation

	Country Sensitivity θ_j^P		Bank Elasticity β_i^P	
	Corporate	Retail	Corporate	Retail
<i># of α</i>	122	117	122	117
<i># of θ</i>	28	28		
<i># of β</i>			122	117
R^2	.53	.48	.54	.50
Obs.	3,148	2,760	3,148	2,760

Country Sensitivities θ_j^p

Country	Corporate	Retail
...		
Cyprus	0.15	0.19
Czech Republic	0.41	0.70
Denmark	0.95	0.85
Estonia	0.98	1.09
Finland	0.68	0.61
France	1	1
Germany	0.90	0.90
...		

Bank Elasticities β_i^P

Distribution of $\hat{\beta}_i$	Min	Median	Max	Mean	StD
Corporate (N = 122)	-1.25	-0.43	0.05	-0.44	0.22
Retail (N = 117)	-1.46	-0.44	0.44	-0.44	0.27

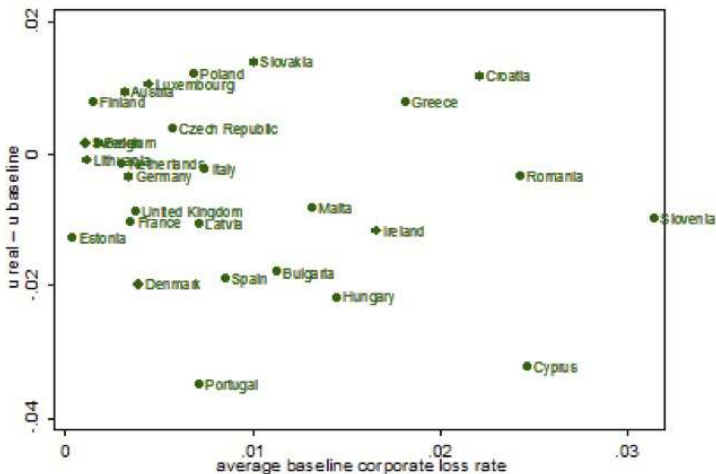
Realized Macro vs Baseline

Realized minus Baseline	g	π	u
N	56	56	56
Min (%)	-3.23	-4.00	-4.07
Median (%)	0.24	-1.22	-0.48
Max (%)	4.93	-0.33	2.15
Mean (%)	0.36	-1.38	0.52
StD (%)	1.53	0.83	1.36

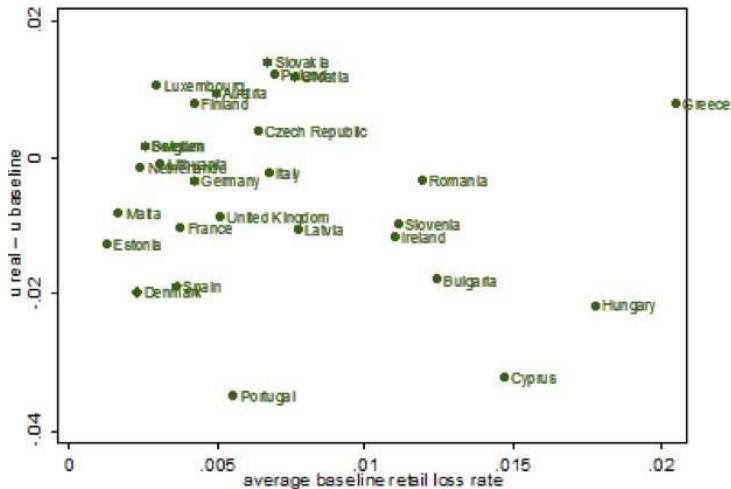
Biased Scenarios?

	$g^{real} - g^{base}$	$g^{real} - g^{adv}$	g^{adv}	$g^{base} - g^{adv}$	$loss_j^{base,corp}$
$g^{real} - g^{base}$	1				
$g^{real} - g^{adv}$	0.67*	1			
g^{adv}	-0.01	-0.38*	1		
$g^{base} - g^{adv}$	-0.23	0.57*	-0.66*	1	
$loss_j^{base,corp}$	0.27*	0.24	-0.23*	0.07	1
$loss_j^{base,retail}$	0.13	0.01	-0.12	-0.00	0.70*

Biased Scenarios? Corp. Losses



Biased Scenarios? Ret. Losses



Predicted Outcomes

- Let $Y_t \equiv \{y_{j,t}\}_{j=1..28}$ be the actual realization of the macro variables
- Predict consolidated loss

$$\mathbb{E} \left[L_{i,t}^P \mid Y_t \right] = \sum_{j=1}^{21} \frac{\exp \left(\hat{\alpha}_i^P + \hat{\beta}_i^P \hat{\theta}_j^P y_{j,t} \right)}{1 + \exp \left(\hat{\alpha}_i^P + \hat{\beta}_i^P \hat{\theta}_j^P y_{j,t} \right)} \times EXP_{i,j}^P$$

Predicted vs Realized Losses, from Baseline

	<i>Provisions / Loans</i>				<i>Provisions / Loans - Baseline ST loss Exposure</i>		
	All	All	2014	2015	All	2014	2015
$L^{Base}/Expo$	0.982*** (0.115)	-0.017 (0.127)	-0.134 (0.161)	0.160 (0.192)			
$\mathbb{E}(L)/Expo$		1.539*** (0.139)	1.879*** (0.175)	1.074*** (0.214)			
$\frac{\mathbb{E}(L) - L^{Base}}{Expo}$					1.192*** (0.131)	1.403*** (0.180)	0.911*** (0.188)
Constant	0.001 (0.001)	-0.002 (0.001)	-0.002 (0.001)	-0.000 (0.001)	0.002 (0.001)	0.003*** (0.001)	0.001 (0.001)
Year Dum.	Y	Y			Y		
Adj. R ²	0.29	0.58	0.69	0.43	0.31	0.40	0.20
Obs.	180	180	91	89	180	91	89

Macro News and Stock Returns

- Change in expected loss upon news

$$\Delta_{\tau} \mathbb{E}[L_{i,\tau}] = \sum_{j=1}^{28} EXP_{i,j} \times \left(\frac{\exp(\hat{\alpha}_i^p + \hat{\beta}_i^p \hat{\theta}_j^p \cdot y_{j,\tau^+})}{1 + \exp(\hat{\alpha}_i^p + \hat{\beta}_i^p \hat{\theta}_j^p \cdot y_{j,\tau^+})} \dots \right. \\ \left. \dots - \frac{\exp(\hat{\alpha}_i^p + \hat{\beta}_i^p \hat{\theta}_j^p \cdot y_{j,\tau^-})}{1 + \exp(\hat{\alpha}_i^p + \hat{\beta}_i^p \hat{\theta}_j^p \cdot y_{j,\tau^-})} \right)$$

- Compare to stock returns

$$r_{i,\tau} = \alpha_0 + \gamma \frac{\Delta_{\tau} \mathbb{E}[L_{i,\tau}]}{CET1_i} + \vartheta_{\tau} + \varepsilon_{i,\tau}$$

Macro News and Stock Returns

Bank equity daily return

	(1)	(2)	(3)	(4)
Δ EL/ CET1	-0.317*** (0.063)	-0.270*** (0.079)	-0.265*** (0.072)	-0.272*** (0.074)
Market return	1.143*** (0.097)			
Constant	-0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Adjusted R ²	0.16	0.24	0.25	0.24
Observations	5,079	5,079	5,079	5,079
Date FE	N	Y	Y	Y
Coun of origin FE	N	N	Y	N
Bank FE	N	N	N	Y

Stress-Test Implied Market Factor

	<i>Bank equity daily return</i>						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Market factor	1.162*** (0.078)						
X-W factor		1.193*** (0.084)		-0.365 (0.430)	-0.328 (0.422)	-0.317 (0.412)	-0.318 (0.412)
ST-W factor			1.281*** (0.056)	1.659*** (0.441)	1.593*** (0.436)	1.580*** (0.425)	1.581*** (0.426)
Constant	0.000	0.000	0.000	0.000	0.000	-0.000***	-0.000***
Adj. R ²	0.15	0.30	0.32	0.32	0.35	0.35	0.35
Obs	22,294	22,294	22,294	22,294	22,294	22,294	22,294
Date FE	N	N	N	N	Y	Y	Y
Co of origin	N	N	N	N	N	Y	N
Bank FE	N	N	N	N	N	N	Y

Bias: Bank Size?

Error Rank	2014		2015	
	Pred. – Real. (%)	Size Decile	Pred. – Real. (%)	Size Decile
1	0.01	8	0.17*	8
2	-0.05	10 (large)	0.09	2
3	-0.13	9	0.02	1 (small)
4	-0.17	6	-0.02	9
5	-0.20	5	-0.02	10 (large)
6	-0.31	2	-0.10	7
7	-0.32	1 (small)	-0.16	6
8	-0.51	4	-0.26	5
9	-0.65	3	-0.42	4
10	-0.68	7	-0.79	3

Bias: Government Ownership?

Error Rank	2014		2015	
	Pred. – Real. (%)	Govt	Pred. – Real. (%)	Govt
1	0.09	Yes	-0.09	Yes
2	-0.34*	No	-0.16	No

Bias: Country of Origin?

Error	2014		2015	
Rank	Pred.–Real.(%)	Country	Pred.–Real.(%)	Country
...				
8	0.08	Poland	0.16	France
9	0.07	Germany	0.16	Sweden
10	0.02	Portugal	0.14	Netherlands
11	0.01	Netherlands	0.13	Belgium
12	0.00	France	0.12	Luxembourg
13	-0.05	Luxembourg	0.08	Austria
14	-0.13	Denmark	0.04	Germany
15	-0.24	Malta	-0.37	Spain
16	-0.55*	Austria	-0.38	Latvia
17	-0.70*	Spain	-0.64	Malta
18	-1.10*	Italy	-1.00*	Italy
19	-2.15	Cyprus	-1.14	Cyprus
20	-5.20	Hungary	-3.81	Hungary

Comparison with 2011 ST

	2011-2012	2011	2012	2011-2012	2011	2012
	(1)	(2)	(3)	(4)	(5)	(6)
Exp. Loss/Exposure	2.352*** (0.500)	3.137** (1.376)	2.017*** (0.307)	0.615 (0.585)	0.735 (1.671)	0.580 (0.470)
Baseline ST loss/Exposure				1.672*** (0.385)	1.669** (0.654)	1.656*** (0.376)
(Exp. – Baseline)/Exposure						
Constant	-0.002 (0.003)	-0.007 (0.008)	-0.001 (0.003)	-0.005* (0.003)	-0.006 (0.008)	-0.000 (0.004)
Year dummy	Y			Y		
Adjusted R ²	0.210	0.210	0.206	0.420	0.425	0.384
Observations	123	61	62	122	60	62

Comparison with 2011 ST

2011			2012		
Rank	Real.-Pred (%)	Country	Rank	Real.-Pred (%)	Country
1	-0.48	Norway	1	-0.73	Sweden
2	-0.46	Sweden	2	-0.52	Luxembourg
3	-0.21	Germany	3	-0.50	Norway
4	-0.09	Netherlands	4	-0.39	Germany
5	0.00	France	5	-0.24	Finland
6	0.02	Malta	6	-0.23	Netherlands
7	0.04	Spain	7	-0.21	Belgium
8	0.07	Finland	8	-0.15	France
9	0.15	Belgium	9	0.11	Malta
10	0.17	Luxembourg	10	0.37	United Kingdom
11	0.37	Italy	11	0.50	Portugal
12	0.48	Cyprus	12	0.67	Italy
13	0.50	Denmark	13	0.77	Denmark
14	0.50	Portugal	14	1.08	Poland
15	0.88	Austria	15	1.74	Greece
16	0.89	United Kingdom	16	1.97	Ireland
17	1.05	Poland	17	2.07	Spain
18	2.77	Slovenia	18	2.20	Austria
19	3.17	Hungary	19	3.12	Hungary
20	3.45	Greece	20	3.67	Cyprus
21	5.23	Ireland	21	5.25	Slovenia

Comparison with 2011 ST

