The size and allocation of EU banking sector losses: looking into the Commission's toolbox and exploring its applications

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Disclaimers

- **The views expressed are those of the author and do not necessarily reflect the official view of the European Commission.**
- This presentation builds on the work of many past and present staff members of EC JRC, IPSC, Unit Financial and Economic Analysis. An incomplete list of related papers and documents is available at the end.
- In order not to err on omitting someone, I am not including specific names

Before starting: some information about the JRC

- The Joint Research Centre (JRC) is the EC's Research-Based Policy Support Centre
- It is a separate DG, now under commissioner Navracsics
- As the Commission's in-house science service, the JRC provides independent, evidence-based scientific and technical support to a wide range of EU policies
- 7 Institutes in 5 EU countries 2800 staff

The Financial and Economic Analysis Unit: main activities

- Macro-economic modeling (QUEST and extensions)
- Financial system modelling to assess policy options to strengthen financial stability (ex ante Impact Assessment of EC initiatives, e.g. for the European banking market)
- Output gap methodology of the Commission
- New items: capital markets union, (corporate) taxation, energy and the macroeconomy, social impact of financial reforms
- Within-EC cooperation with DG FISMA, ECFIN, TAXUD, COMP, ENER
- Many outside links as well

An early start: deposit guarantee schemes

- The starting point: estimation of the loss distribution of a Deposit Insurance Scheme
- The main challenge: need to simulate extreme realizations of banking system losses, at an individual bank level
  - Here extreme means the top 97, 99, 99.9 and 99.99%
  - This is much more extreme than typical stress tests
- How to describe a bank's loss distribution?
  - Idea: invert the Basel II formula of capital requirements to obtain a proxy of the average default probability of the obligor portfolio of bank j
- De Lisa et al, Journal of Fin. Serv. Research, 2011
- The model later got named as SYMBOL (SYstemic Model of Banking Originated Losses)

A major lesson: the role of correlated shocks

	Banks' correlation factor		
	0.3	0.5	0.7
No contagion			
97%	417	149	-
99%	4,072	3,397	1,513
99.9%	32,990	33,193	39,198
99.99%	47,939	76,925	117,189
Contagion			
97%	417	149	-
99%	4,213	3,427	1513
99.9%	32,990	42,241	120,780
99.99%	106,755	298,053	343,360

The crisis call

- Enormous public “bailout” of banks
- Essentially: a high tail event realized, with banks running out of their capital fully or partially
- A need to introduce measures to limit the future potential need of public finance intervention
- I.e., to create a “banking system safety net”
  - Redefined capital requirements
  - Bail-in (“forced conversion into capital”)
  - Various resolution/intervention tools
- Can you assess the potential gain? I.e., the reduction in the *potential* public finance intervention?
  - The same model is readily available, you “just” need to implement the ingredients of the safety net!

Capabilities of SYMBOL: a brief preview

Perc.	Baseline	Scen.1 (BRRD, BIII def.) (around 2019)		Scen.2 (BRRD, CRDIV, RF) (around 2023)		
	XLR	XLR	after LAC	XLR	after LAC	after SRF
97.5	108.2	108.2	32.4	36	11.1	1.1
99	164	164	52.3	75.5	23.1	3.2
99.9	386.6	386.6	137.6	260.9	86.4	29.7
99.95	475.3	475.3	173.5	343.3	116.1	56.7
99.99	697.2	697.2	291.3	548.9	219.1	157.6
(In billions of euro. 2012 EU GDP is around 12,888B)						

And now let us get down to the work...

- **Part 1: model idea, details, mechanics, the computational/data challenges**
- Part 2: applications, and the necessary modifications they initiate
  - Original safety net calibration (bail-in), Bank Resolution and Resolution Directive
  - Capital Requirements Directive IV (Basel III)
  - Financial Activities Taxes, Bank Levies and Systemic Risk
  - Debt bias in taxation and its impact on financial stability
  - Structural separation, SRISK versus symbol-based contributions
  - Debt sustainability Analysis: country-level results
  - Economic Review of the Financial Reform Agenda
  - DGS

Workplan 2

- Part 3: ongoing extensions
  - Contagion
  - Sovereign-banking loop
  - Correlation structure
  - SRM
  - Linking to macro
  - A conceptual issue: obtaining/defining the cutoffs
  - Data issues: using supervisory data for selected countries, the role of (RWA) imputation
  - Extensions to outside the EU – US, Japan?

Setting up the modeling framework: the Basel IRB formula

- There is a bank with n borrowers, each with a debt of $1/n$.
- Each borrower's asset value is subject to an $N(0,1)$ shock, having a common and an idiosyncratic component as well:

$$X_i = \sqrt{R}\beta + \sqrt{1-R}Z_i.$$

- Borrower i defaults (fully) if X_i goes below some level $\bar{X}$.
- Denote the default event by $D_i = \chi\left(X_i \leq \bar{X}\right)$ and the total realized loss of the bank is thus $RL = \sum_{i=1}^{n} D_i$.
- We need the cdf of realized losses $lim_{n\to\infty} P\left(RL \leq K_v\right)$
- Using the CLT (or citing Vasicek), and with $PD = N\left(\bar{X}\right)$:

$$N\left(\frac{1}{\sqrt{R}}\left(\sqrt{1-R}N^{-1}\left(K_v\right) - N^{-1}\left(PD\right)\right)\right)$$

The Basel formula 2

- Now, by the law of large numbers (or in other words, the fact that $n \to \infty$), the bank can safely count on (expected) losses of PD. Realized losses, however, can be larger or smaller.
- Let us define the capital requirement as the smallest necessary amount such that the probability of unexpected losses not exceeding that amount is at least α :

$$P\left(RL \leq PD + C\right) = \alpha.$$

- After some straigthforward manipulations, this yields

$$C = N\left(\frac{\sqrt{R}N^{-1}\left(\alpha\right) + N^{-1}\left(PD\right)}{\sqrt{1-R}}\right) - PD.$$

A single parameter describing a bank's loss distribution: the Implied Obligor Probability of Default

- Basel II defines the capital requirements for each asset class separately:

$$C_{ij} = LGD_{ij} \cdot \left(N\left(\sqrt{\frac{1}{1-R_i}} N^{-1}\left(PD_{ij}\right) + \sqrt{\frac{R_i}{1-R_i}} N^{-1}\left(\alpha\right) \right) - PD_{ij} \right) \cdot MATA_{ij}$$

- Here LGD_{ij} is the loss given default (in the previous formula it was set at 1), and $MATA_{ij}$ is some maturity correction
- Reliability is chosen at $\alpha = 0.999$

The IOPD 2

- Sum it up and divide by total assets to get an average percentage requirement for bank j:

$$\hat{C}_j = \frac{C_{ij} A_{ij}}{\sum_i A_{ij}}$$

- Working with a common (regularory) value of $\widehat{LGD}_j$, $\hat{R}_j$, $\widehat{MATA}_j$ (details coming), the IOPD of bank j is defined by

$$\hat{C}_j = \widehat{LGD}_j \cdot \left(N\left(\sqrt{\frac{1}{1-\hat{R}_j}} N^{-1}\left(\widehat{PD}_j\right) + \sqrt{\frac{\hat{R}_j}{1-\hat{R}_j}} N^{-1}(\alpha) \right) - \widehat{PD}_j \right) \cdot \widehat{MATA}_j$$

- In other words, it is the value $\widehat{PD}_j$ that would lead to the same capital requirement under the assumption that the bank has only a representative asset class.

The IOPD 3

- There is an extra correction coefficient of 1.06 on the RHS, aimed at “maintaining the aggregate level of minimum capital requirements”
- For the choice of the values for $\widehat{LGD}_j$, $\hat{R}_j$, $\widehat{MATA}_j$:

$$
\begin{aligned}
\widehat{LGD}_j &= 0.45 \\
\widehat{MATA}_j &= \frac{1 + (M - 2.5)\, b_j}{1 - 1.5 b_j},\ M = 2.5 \\
b_j &= 0.11852 - 0.05478 * \ln(\widehat{PD}_j)^2 \\
\hat{R}_j &= 0.12 \frac{1 - e^{-50\widehat{PD}_j}}{1 - e^{-50}} + 0.24 \left(1 - \frac{1 - e^{-50\widehat{PD}_j}}{1 - e^{-50}}\right) - 0.04 \left(1 - \frac{\hat{S}_j - 5}{45}\right) \\
\hat{S} &= 50
\end{aligned}
$$

The IOPD 4

- These values correspond to the fundamental IRB approach – risk assessment is done by the bank, but the parameters are prescribed by Basel II
- There is almost no maturity correction, and the within-bank correlations only depend on IOPD but not on obligor size
- Banks report risk weighted assets, 8% of which is then the capital requirement
- $\hat{C}_j$ is obtained by dividing this with total assets
- So one simply needs to solve a nonlinear equation to obtain $\widehat{PD}_j$

Using the IOPD to simulate losses for banks

- Consider a 2 bank example: Banks A and B, each with a unit mass of debtors, with asset values evolving as

$$X^{A,i} = \sqrt{R^A}\left(\sqrt{\rho}\beta + \sqrt{1-\rho}\beta^A\right) + \sqrt{1-R^A}Z^{A,i}$$
$$X^{B,i} = \sqrt{R^B}\left(\sqrt{\rho}\beta + \sqrt{1-\rho}\beta^B\right) + \sqrt{1-R^B}Z^{B,i}$$

- So for each bank X, there is an idiosyncratic shock Z to all of its debtors and a common shock β^X
- The common shock differs between the two banks, but it has a common component
- The parameter R^X measures the degree of commonality among debtors of bank X (defied as shown before), while ρ measure sthe strength of commonality among different banks

Using the IOPD 2

- In the simulation we thus draw $N(0,1)$ random numbers for β, β^A and β^B, and then the conditional loss (conditional on the three beta values but taking expectations w.r.t. the Z components) for bank A is

$$P_A\left(\beta,\beta^A,\beta^B\right)=N\left(\frac{N^{-1}\left(PD\right)-\left(\sqrt{\rho}\beta+\sqrt{1-\rho}\beta^A\right)\sqrt{R^A}}{\sqrt{1-R^A}}\right)$$

- Repeat this many times and get an estimation for the (joint) distribution of losses for the two banks

Using the IOPD 3

- The actual code does a slightly different (but equivalent) thing: it shocks the expression

$$N\left(\frac{N^{-1}\left(PD\right)+N^{-1}\left(\alpha_{Ah}\right)\sqrt{R^{A}}}{\sqrt{1-R^{A}}}\right)$$

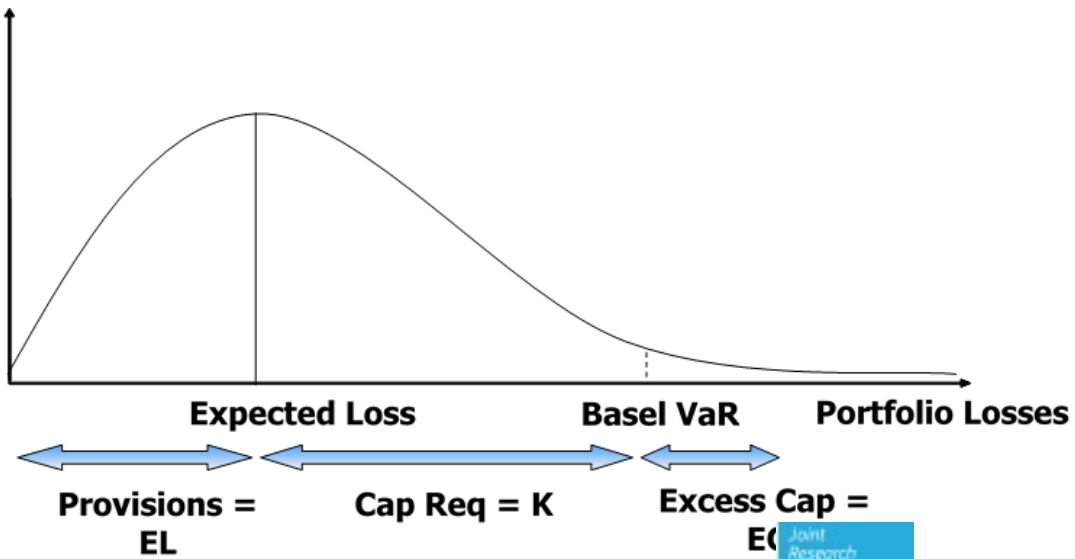
  through different values for $N^{-1}\left(\alpha_{Ah}\right)$ drawn from a correlated normal distribution
- Note the difference: $-\sqrt{\rho}\beta-\sqrt{1-\rho}\beta^{A}$ versus $N^{-1}\left(\alpha_{AH}\right)=-N^{-1}\left(1-\alpha_{Ah}\right)$
- So essentially we "change variables", between $\sqrt{\rho}\beta+\sqrt{1-\rho}\beta^{A}$ and its implied confidence level $1-\alpha$

An early discussion

- We have neglected possible differences among asset classes of the same bank
  - In principle, one could add a further factor to the fundamental process
  - A key issue is that banks do not only provide loans but they also trade – which might require a different "Vasicek model"...
- Correlations among banks
  - The value is set at $\rho = 0.5$, based on Italian evidence (Sironi and Zazzara, 2004)
  - Could again add extra layers of correlated shocks to the fundamental processes
  - We are exploring a case with a different within and between country correlation

From losses to bank insolvency

- A bank fails if its losses L are greater than provisions (expected losses) EL plus capital requirement K plus excess capital EC
- Introducing one of our key variables "excess losses":$XL = L - EL - K - EC$, a bank fails if $XL > 0$
- "Fails" – it is insolvent, but probably would be rescued



Contagion?

- SYMBOL allows for a contagion effect between banks via the interbank market
- (Very rough) assumption: in case of an insolvency, 40% of interbank debits are passed as extra losses to creditors
- The interbank network is only approximated
- The contagion phase is iterated until convergence – it stops once it no longer produces additional failures
- I will comment on this approach later – in short, now we typically do not consider this interbank contagion mechanism

Adding the “safety net” and aggregation

- We add up excess losses of failed banks to get the system-wide banking system losses
- We also define the recapitalization need of banks, which can also be aggregated
- At the same time, we look into the treatment of excess losses (and recapitalization) on a bank by bank level
- It usually revokes various resolution steps – the “safety net”
  - Bank level: recapitalization from market/parent
  - Bank level (new!): bail-in bonds
  - Systemic level: deposit guarantee schemes, resolution funds
  - Residual: potential public finance involvement

Adding the “safety net” and aggregation 2

- The main strength of the model is that it can incorporate “any” (counterfactual or planned) safety net design
  - Resolution funds might be emptied
  - Could even consider a distinction between single versus country-level resolution funds
  - One can even redefine the capital (and risk-weighted assets) of the banks – this is before the simulation
- And then assess the split between the various ingredients

Defining a crisis

- The Monte Carlo simulation gives us the distribution of system-wide excess losses (or excess losses plus recapitalization)
  - A remark on recapitalization: for technical reasons, we will be able to consider recapitalization values only when at least one bank fails in the sample!
- Which segment should we look at?
  - Basel II logic: regulatory capital should be enough against tail events up to the 99.9 percentile
  - But in reality, banks fail more often
  - This means that probabilities from the estimated distribution are not really indicative of true relative frequencies...
  - Think of a themometer in direct sunlight: its value is useful to assess the extremity of heat but it is not directly indicative

Defining a crisis 2

- Remedy: look at the percentile which leads to similar EU-wide public finance losses than the recent crisis (cumulated)
  - The 2008-11(12) DG COMP estimates for state aid are around 550 billion euros
  - This is around the 99.95 percentile of the aggregate excess loss plus recapitalization (*XLR*) distribution
  - (One reference: the Structural Reform Impact Assessment, its Annex entitled “Quantitative Estimation of a part of the Costs and Benefits of Bank Structural Separation”)
  - I.e., once every 2000 years – this is why we view it as “theoretical probability”
  - Think again of the thermometer: you can define a value which indicates an extreme heatwave

And then looking at other variables...

- We should look at the corresponding value of other variables of interest
  - For example, aggregate DGS or public finance losses
- This is far from obvious though...
  - Plainly looking at the 99.95 percentile is not what we want, because that would correspond to a different “ranking” of the outcome variables
- The solution applied up to now: rank the simulated realizations according to *XLR* and then look at the 99.95 position there
  - It might be a non-monotonic series, but it is typically only some “random spikes around a monotonic series”
  - Which can be smoothed by an H-P filter

Some important notes on this procedure

- Even when looking at different scenarios (e.g. Basel II or III), we should use the ranking by the “crisis-like” one
- Whenever one adjusts the model, the probability level should be recalibrated
  - For example, one should look at a lower percentile under contagion
- For technical reasons, simulations were initially run on a country by country basis
  - Then their percentile values were added up (which is only “approximately correct”), instead of looking at the percentiles of the EU-wide loss distribution
  - A better way we managed to implement recently: run them together, with a control over within and between country correlations

Notes on this procedure 2

- We are currently exploring two sounder approaches
  - Conditional expectation 1: Define the threshold value $\bar{X}$ for XLR, and then calculate the expected value of any variable of interest conditional on $XLR \geqq \bar{X}$
  - Conditional expectation 2: Consider an interval of length h around $\bar{X}$, calculate $E\left[Y \middle| \bar{X} - h \leqq X \leqq \bar{X} + h\right]$ and let $h \to 0$ (or at least small enough)
- The questions is always the numerical stability/reliability of the results

Computational issues

- We need a lot of realizations (very extreme events)
- Depending on country size (or EU-wide), there are 6-3000 banks
- It is computing power and storage intensive
- A useful shortcut: keep only those realizations where at least one bank fails
  - We stop when having 100,000 such realizations
  - We need 300,000-20,000,000 realizations to reach this!
- There is still some remaining “sampling uncertainty” about the very extreme tail cutoffs, but for variables “sufficiently similar to XLR”, the 100,000 failures are enough
- With an enhanced computational approach, we reduced typical running times from weeks/days to hours...

Data issues

- We start from balance sheet data (from Bankscope or SNL)
- Impute missing data (too much unfortunately...) and do some cleaning
- Change RWA and capital according to EBA QIS results
  - Essentially a detailed correction of bank reports
- Multiply all simulation results by the coverage ratio – total banking assets relative to TA in the sample
- Around 3000 EU banks, representing about 70% of EU banking assets
- High degree of concentration

Data issues 2

- Under Basel III (CRD IV), need to redefine capital
  - In many cases, we have to assume that the bank would recapitalize itself
- We need data on covered deposits, bail-inable assets etc.
  - Often difficult and can only be approximated (we are not supervisors)

A note on risk weighted asset criticism

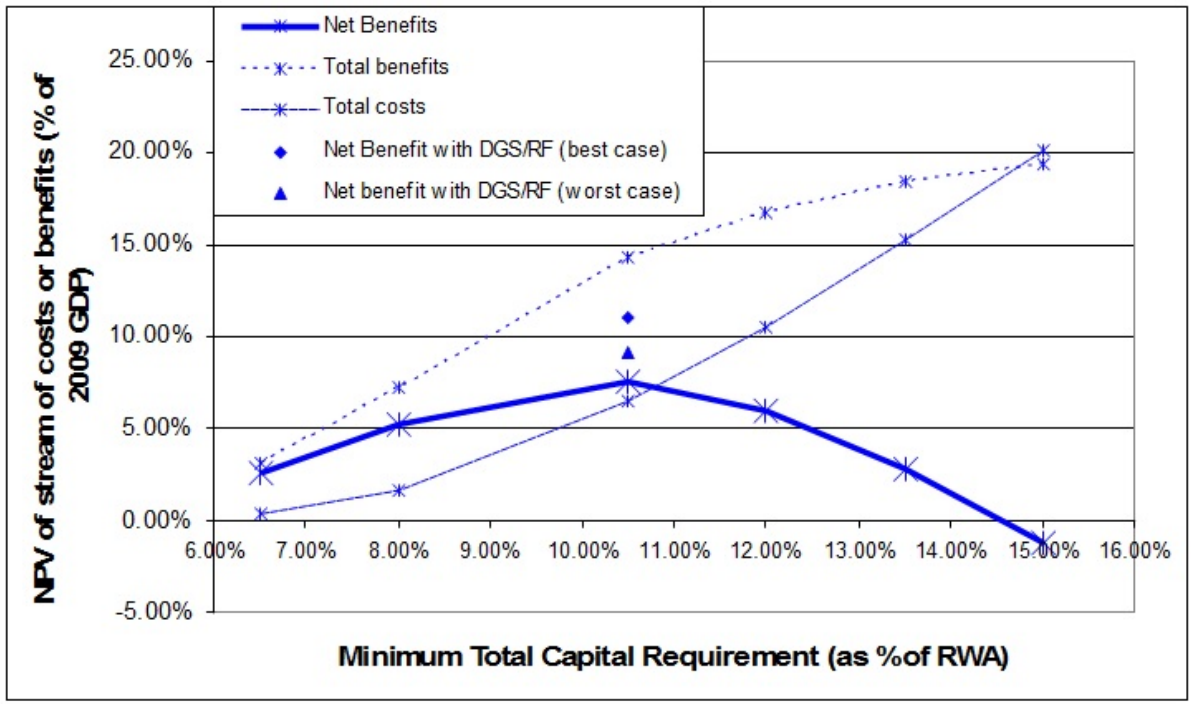
- There is an ongoing debate
  - Plus side: conceptually, they are very appealing
  - Minus side: they are clearly “manipulated” by the banks (self-reporting)
- We apply the QIS correction, which is a partial supervisory correction
- Later I will talk briefly about a comparison between a SYMBOL- (i.e., RWA-) based risk measure and SRISK
  - And they generate quite simlar rankings, which is some relief for RWA

Applications

- Original safety net calibration (bail-in), BRRD
- CRD IV
- Financial Activities Taxes, Bank Levies and Systemic Risk
- Debt bias in taxation and its impact on financial stability
- **Structural separation, SRISK versus symbol-based contributions**
- **ERFRA**
- **DSA: country-level results**
- DGS

BRRD and CRD IV

- BRRD: the impact of bail-in on potential public finance losses
  - Who bears the bail-in? It might get back to the banking sector...
- CRD IV: a “full cost-benefit analysis”, based on a BoE approach
  - Benefits: estimated GDP loss due to a systemic crisis
  - Costs: lending spreads $\uparrow \Longrightarrow$ investment $\downarrow \Longrightarrow$ GDP $\downarrow$



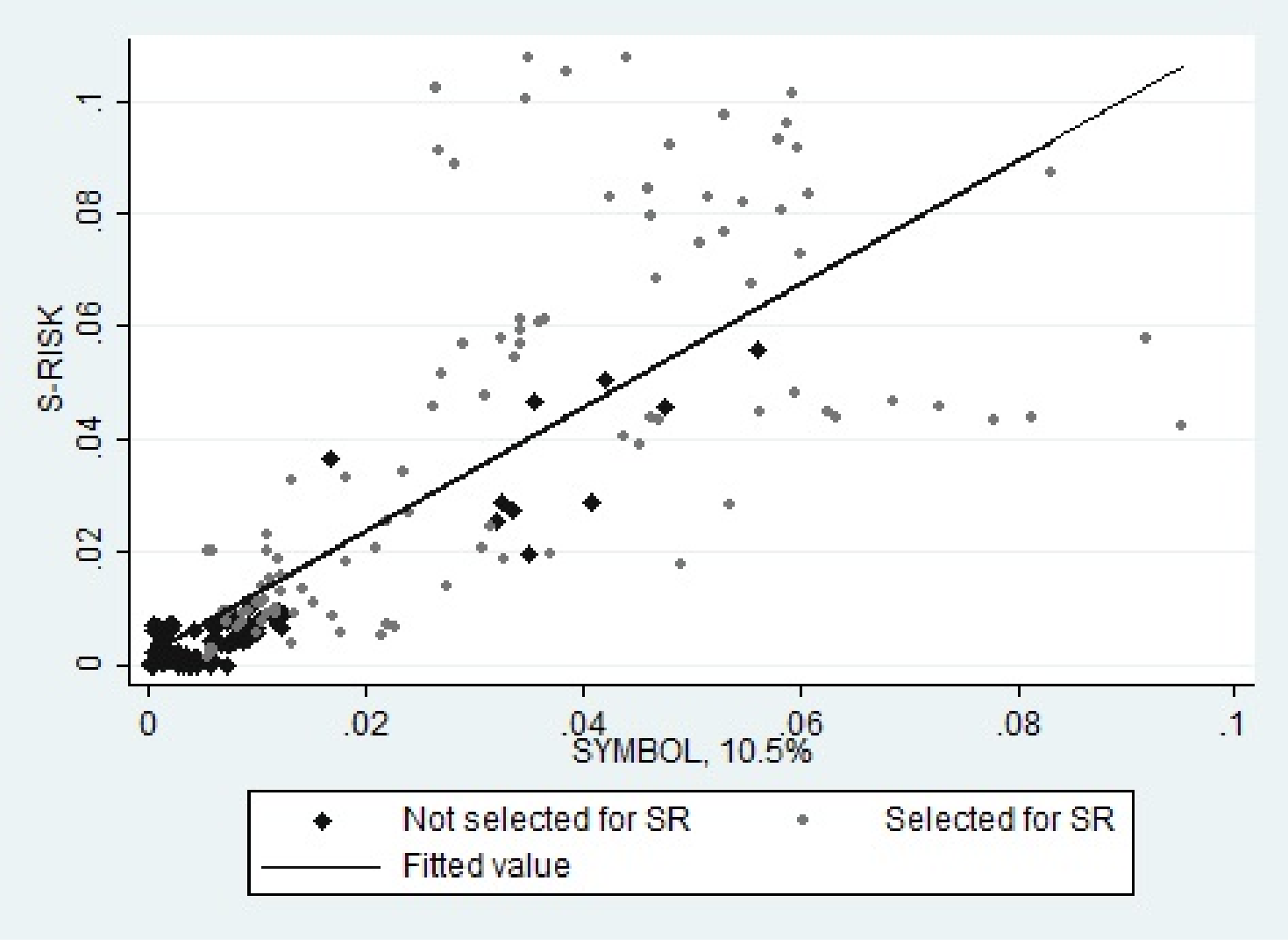
Applications to taxation

- Financial Activity Tax (FAT)
  - Estimate contributions to systemic risk of individual banks under various future regulatory scenarios
  - Compare them to their potential tax liabilities under alternative designs of FAT and Bank Levies
  - When contagion is not avoided, all taxes perform about the same way
  - When contagion is avoided, bank levies outperform FATs
- Debt bias in corporate taxation
  - Use panel regressions to find sizable long-run effects of CIT on leverage in the EU
  - Then simulate the effect of no debt bias on bank losses by changing their leverage
  - Even for conservative estimates for the leverage effect, ww wouldget reductions of public finance losses in the range of 60-90%

Structural separation

- Analyze the selection of banks as candidates for structural separation, based on their trading activities
- Estimated metrics to assess trading activity of banks (i.e. trading size, leverage etc.) based on balance sheet data
- How the selection criteria based on trading activity and the metrics relate to systemic riskiness of each bank?
- Using SYMBOL:
  - Define a bank-level (average) XLR
  - Can even perform an adjustment for trading activities
    - Split the universal bank to a trading and retail entity
    - Apply a lower α for trading – which is equivalent to a systematic increase of trading-RWA

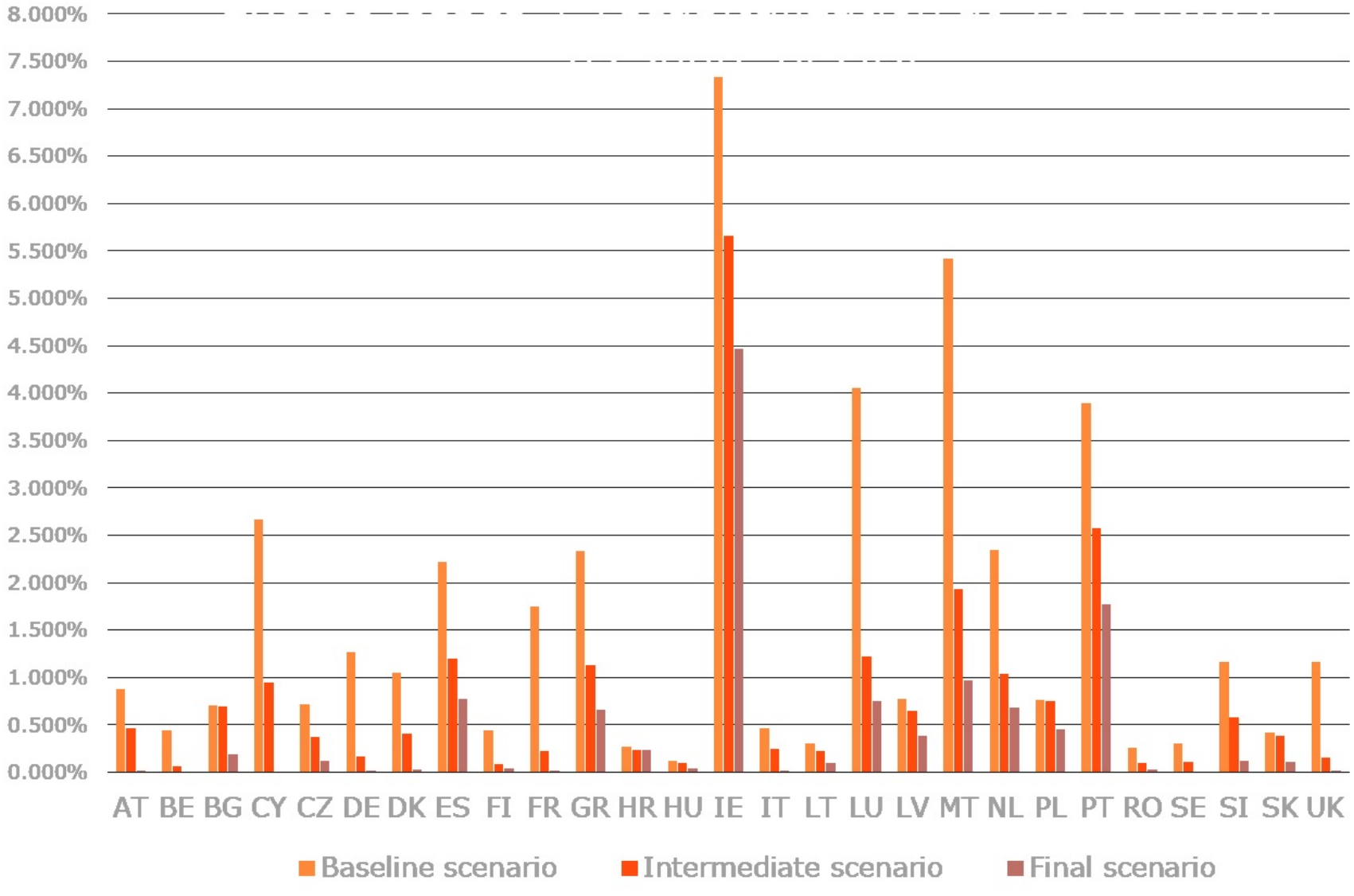
SYMBOL-based risk contributions?



ERFRA: cumulative impact assessment of (nearly) all “banking union” steps

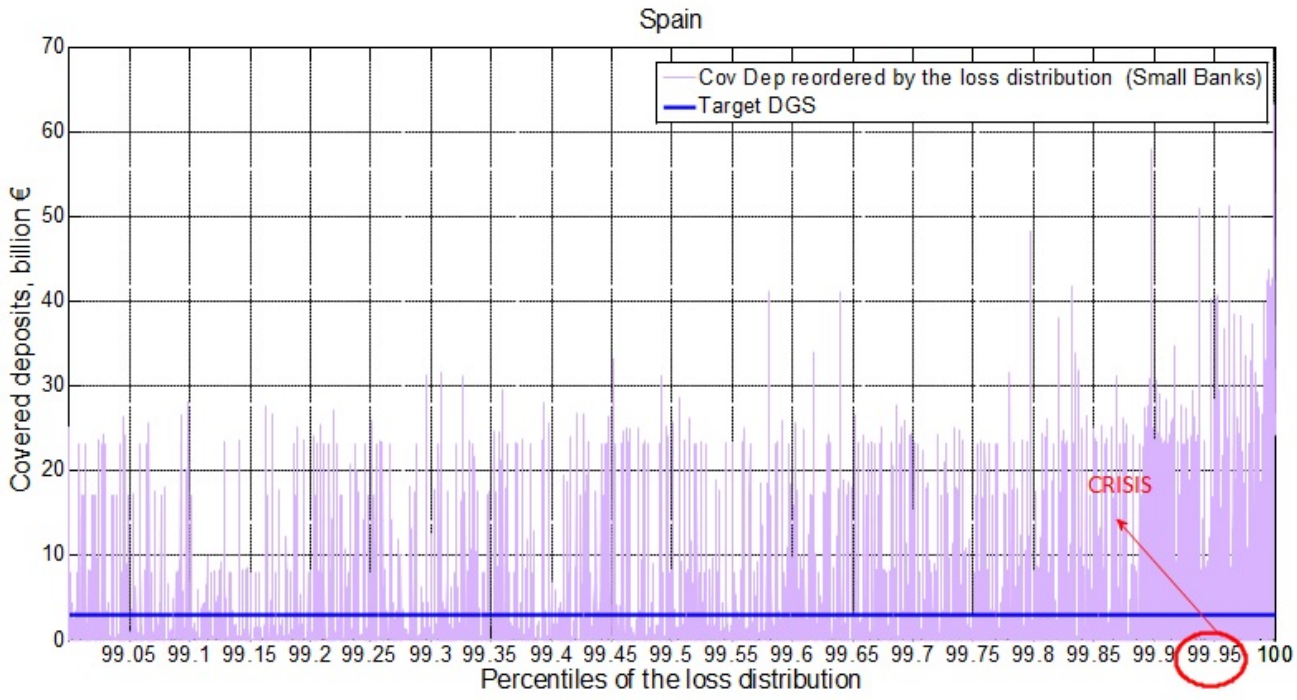
- An official EC impact assessment document of many hundred pages
- Our SYMBOL-based analysis in Annex IV
- Main idea:
  - Look at EU-wide XLR at the baseline (crisis onset) safety net scenario
  - Then look at the impact of bail-in and BIII definitions
  - And finally look at the full package – BRRD, CRD IV, SRF
- A massive reduction in the potential losses hitting public finances – as seen in the introduction
- A major caveat: this is the benefit side only!

DSA: **unofficial** country-by-country results



DGS: looking at a “very different” outcome variable...

- The issue: calibrating the target level of DGS funds by assessing tail cutoffs for DGS losses
- The main challenge: extreme realizations for XLR can be very different than for DGS losses
- The solution: “expected value 2” approach from before



Ongoing extensions

- Contagion
- **Sovereign-banking loop**
- **Correlation structure**
- SRM
- Linking to macro
- (A conceptual issue: obtaining/defining the cutoffs)
- **Data issues: using supervisory data for selected countries, the role of (RWA) imputation**
- Extensions to outside the EU – US, Japan?

Contagion

- Objective: can we do better than the contagion step we have now?
- Bring in at least country-by-country positions from the BIS
- For within-country, use similar interpolation (maximum entropy or minimum density) as at the aggregate level previously
- Indicative findings:
  - Limited scope for cross-country contagion
  - The domestic effect depends on the network structure
  - Centrality measures of individual banks are a good proxy for the final contagion effects

Sovereign-banking loop: the idea

- Simulate banking sector distress using SYMBOL
- The implied recapitalization (or loss absorption) is done by the government, financed by debt
- This raises the sovereign spread (using the model of Mody-Sandri, Economic Policy, 2012)
- This drop in bond prices causes additional losses to banks, leading to further recapitalization needs
- This loop is iterated until convergence
- What is the degree of multiplication?
- How much can a SRF help in breaking the loop?

Sovereign-banking loop: illustrative results

		First order effect				Total effect			
	XLR	Incr.	Incr.	Haircut	Losses on	Incr.	Incr.	Haircut	Losses on
		in D/Y	in spr.		sov. hold.	in D/Y	in spr.		sov. hold.
	(euro, B)		(bps)		(euro, B)		(bps)		(euro, B)
DE	44,803	1.70%	20	1.70%	22,581	4.20%	55	6.60%	68,168
FR	78,921	3.90%	64	5.20%	18,435	6.00%	105	10.50%	43,100
NL	22,661	3.80%	55	4.60%	7,128	6.90%	119	11.50%	18,492
IE	12,929	7.90%	171	12.50%	6,179	16.20%	391	27.70%	13,667
IT	**70,271**	**4.50%**	**91**	**6.70%**	**29,466**	**9.20%**	**206**	**16.90%**	**73,907**
PT	13,085	7.90%	242	15.80%	8,109	18.60%	556	33.60%	17,556
SP	70,401	6.80%	235	16.30%	39,953	15.80%	605	37.40%	92,413

Correlation structure

- Until recently:
  - EU-wide simulation (for a subset of banks): 0.5 correlation among all banks
  - Country-by-country simulation: 0.5 among banks of the same country, 0 if banks from different country
    - Moreover, we were adding up the country-specific percentile values to get the aggregate cutoffs
- Now: we can manage a more complex correlation structure
  - ρ_1 among banks of the same country, ρ_2 for banks of different countries
  - Varying these values can yield a meaningful interpretation of different degrees of contagion (commonality)

SRF

- Main question: what is the differential impact of a country-by-country or a single resolution fund?
- An SRF might have allowed a lower percentage of bail-in (loss absorbing capacity) requirement
- A pooled country simulation can handle the comparison of the two different schemes
- The correlation structure is likely to be important

Linking to macro

- How would a counterfactual macro scenario affect the tail cutoffs of the banking loss distribution?
- Regress some function of bank-specific IOPD on macro variables and (fixed) bank characteristics
  - It might include some adjustment from the bank already...
  - Use the EBA 2011 macro stress test variables
- Form predicted values under a counterfactual scenario
- Recalculate the loss distribution for these new IOPD values
- Some preliminary results but not yet perfect

Data issues

- Consolidated versus unconsolidated data
- Using other data sources to reduce the need for imputation
  - From the top 20 banks, the majority has incomplete information on RWA
- Country-specific QIS coefficients
- Using supervisory data for a “volunteering country” (with WB)

Extensions to non-EU

- Repeating similar exercises to the US, Japan etc. (with OECD)
- Two data challenges
  - RWA and capital adjustment (QIS) for non-EU countries?
  - Crisis level calibration – we need cumulative banking (or public finance) losses

Wrapup

- A versatile model capable of addressing many relevant issues
- Sounds simple but its details are very rich and occasionally complicated
  - A mixture of economics, finance, probability, statistics and computational expertise
- Served as an important tool to almost all of the banking sector reform agenda

Incomplete list of references

- Deposit Guarantee Schemes Directive Proposal July 2010
- Capital Requirement Directive Proposal July 2011
- Financial Transaction Tax Proposal Sept 2011
- Public Finances in EMU Sept 2011
- EU framework for Bank recovery and resolution June 2012
- Fiscal Sustainability Report 2012 Dec 2012
- BRRD Negotiations June 2013
- Banking Sector Structural Reform, IA Jan 2014
- Cumulative Impact Study First quarter 2014
- Assessing Public Debt Sustainability in EU Member States: A Guide, Summer 2014