Pitfalls in the use of systemic risk measures*

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The views herein do not necessarily reflect those of the Deutsche Bundesbank.
Traditional bank regulation

Bank-level Value at Risk

Micro-prudential

Post-crisis bank regulation

Bank-level Value at Risk + Measure of systemic relevance

Macro-prudential
Definitions

We favor an inclusive definition:

**Systemic risk** is the risk of a breakdown or severe dysfunction of the financial system - no matter what the source of it is.

The **systemic risk measures** we talk about try to

Quantify how much an entity contributes to the vulnerability of the financial system.
Possible approaches to measuring systemic risk

- Indicator-based approach

<table>
<thead>
<tr>
<th>Indicators and their weights</th>
<th>Table 1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Category</strong></td>
<td><strong>Indicator</strong></td>
</tr>
<tr>
<td>Size</td>
<td>Total exposures(^1)</td>
</tr>
<tr>
<td>Interconnectedness</td>
<td>Intra-financial system assets</td>
</tr>
<tr>
<td></td>
<td>Intra-financial system liabilities</td>
</tr>
<tr>
<td></td>
<td>Securities outstanding</td>
</tr>
<tr>
<td>Substitutability/financial institution infrastructure</td>
<td>Payment activity</td>
</tr>
<tr>
<td></td>
<td>Assets under custody</td>
</tr>
<tr>
<td></td>
<td>Underwritten transactions in debt and equity markets</td>
</tr>
<tr>
<td>Complexity</td>
<td>Notional amount of OTC derivatives</td>
</tr>
<tr>
<td></td>
<td>Trading and AFS securities</td>
</tr>
<tr>
<td></td>
<td>Level 3 assets</td>
</tr>
<tr>
<td>Cross-jurisdictional activity</td>
<td>Cross-jurisdictional claims</td>
</tr>
<tr>
<td></td>
<td>Cross-jurisdictional liabilities</td>
</tr>
</tbody>
</table>

Why use return-based measures?

- Data are easily available
- Timely identification of risk build-ups and in-crisis dynamics
- Market prices may reflect risks that are overlooked in holdings-based risk analysis or network analysis
- Equity prices: liquid and hit first by losses of a bank
Return-based risk measures can be relevant even if they are not used by supervisors

- Internal risk management
  - Systemic risk of counterparties
  - Macro risk analysis and stress testing

- Cost of capital: Market may use information from market prices even though regulators do not
Possible pitfalls in using systemic risk measures

- Estimation error
- Conceptual misunderstandings, e.g. systemic vs systematic
- Misaligned incentives
  - A bank wishing to lower its systemic risk may take an action that actually increases system risk
- Wrong diagnosis
  - Counterparty A appears to be more dangerous for system stability than B but the reverse is true
Systemic risk measures 1

- $R_i$ … return of bank $i$
- $R_S$ … market return, or „system“ return

$\Delta$CoVaR (Adrian, Brunnermeier, Oct 2011):
- Change of the system's VaR through bank $i$ moving from a normal to a very bad state; formally: $Q_\alpha (...) \ldots \alpha$-quantile
- $\Delta \text{CoVaR}^S_{\alpha|i} \equiv Q_\alpha (-R_S | R_i = Q_\alpha (R_i)) - Q_\alpha (-R_S | R_i = Q_{0.5} (R_i))$

Exposure $\Delta$CoVaR:
- Change of bank $i$ 's VaR through the system moving from a normal to a very bad state; formally:
- $\Delta \text{CoVaR}^i_S \equiv Q_\alpha (-R_i | R_S = Q_\alpha (R_S)) - Q_\alpha (-R_i | R_S = Q_{0.5} (R_S))$
Marginal expected shortfall (MES)

- (Acharya, Pedersen, Philippon, Richardson, 2010)

\[ MES^i_\alpha = \mathbb{E} \left[ -R_i \bigg| R_S < Q_\alpha \left( R_s \right) \right] \]

Beta

- Regression: \( R_{i,t} = \alpha_i + \beta_{i,t} R_{S,t} + u_{i,t} \)
Do SRM set the right incentives?
Sensitivities in a linear normal model

- **Classic market model**: $N$ banks, returns:
  \[ R_i = \beta_i F + \varepsilon_i ; \quad (F \sim N(\mu, \sigma_F^2), \varepsilon_i \sim N(0, \sigma_i^2), \text{independent}) \]

- Bank sector index $R_S = \sum_{j=1}^{N} w_j R_j$ represents „the system“

- Very simple representation of the SRM:
  \[
  \Delta \text{CoVaR}_{i|S} = \frac{\text{cov}(R_S, R_i)}{\sigma(R_i)} \Phi^{-1}(1 - \alpha) \\
  \Delta \text{CoVaR}_{\alpha}^S = \frac{\text{cov}(R_S, R_i)}{\sigma(R_S)} \Phi^{-1}(1 - \alpha) \\
  M\text{ES} = -\beta_i \mu + \frac{\text{cov}(R_S, R_i)}{\sigma(R_S)} \frac{\phi(\Phi^{-1}(\alpha))}{\alpha} \\
  \beta_i = \frac{\text{cov}(R_S, R_i)}{\sigma^2(R_S)}
  \]
Do SRMs set the right incentives?
Sensitivities to risk parameters in a linear normal model

- **Assumptions**
  - Banks can steer their idiosyncratic risk ($\sigma_i$), systematic risk ($\beta_i$) and relative size ($w_i$).
  - Banks strive for low SRMs (e.g., in presence of SRM-based risk charges)

- **Direct effect**: on the own SRM:
  $$\frac{\partial}{\partial p_i} [SRM_i], \quad p_i \in \{\sigma_i, \beta_i, w_i\}$$

- **Relative effect**: compared to another bank’s SRM:
  $$\frac{\partial}{\partial p_i} \left[ \frac{SRM_i}{SRM_j} \right], \quad p_i \in \{\sigma_i, \beta_i, w_i\}$$
## Do SRM set the right incentives?

### Linear model; sensitivity to risk parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Effect type</th>
<th>$\Delta$CoVaR (Bank $i$ stressed)</th>
<th>Exposure $\Delta$CoVaR (System stressed)</th>
<th>MES</th>
<th>Beta</th>
</tr>
</thead>
<tbody>
<tr>
<td>idiosyncratic risk $\sigma_i$</td>
<td>direct</td>
<td>+/−</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>relative</td>
<td>+/−</td>
<td>+</td>
<td>$+^{n}$</td>
<td>+</td>
</tr>
<tr>
<td>systematic risk $\beta_i$</td>
<td>direct</td>
<td>+</td>
<td>+</td>
<td>$+^{n}$</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>relative</td>
<td>+/−</td>
<td>+/−</td>
<td>+/−</td>
<td>+/−</td>
</tr>
<tr>
<td>size $w_i$</td>
<td>direct</td>
<td>+/−</td>
<td>+</td>
<td>+</td>
<td>+/−</td>
</tr>
<tr>
<td></td>
<td>relative</td>
<td>$+^{n}$</td>
<td>$+^{n}$</td>
<td>$+^{n}$</td>
<td>$+^{n}$</td>
</tr>
</tbody>
</table>

**Legend:**

- $+$: SRM rises with risk parameter
- $+/−$: SRM rises / falls, depending on other parameters
- $+^{n}$: SRM rises under non-exotic conditions
Do SRM set the right incentives?

Sensitivity of $\Delta \text{CoVaR}$ to idiosyncratic risk $\sigma_i$

$(\sigma_j = 0.2, \sigma_F = 0.2)$

$$\Delta \text{CoVaR}_{\alpha}^{S|i} = \frac{\text{cov} \left( R_S, R_i \right)}{\sigma(R_i)} \Phi^{-1}(1 - \alpha)$$
Sensitivity of $\Delta \text{CoVaR}$ to idiosyncratic risk $\sigma_i$

$$R_i = \beta_i F + \varepsilon_i, \quad R_S = \sum_i w_i R_i \text{ with } F \sim N(\mu, \sigma^2_F), \quad \varepsilon_i \sim N(0, \sigma^2_i)$$

- $\sigma_i = 20\%$
- $\sigma_i = 40\%$
- $\sigma_i = 60\%$
Do SRM set the right incentives?

Sensitivity of $\Delta \text{CoVaR}$ to systematic risk $\beta_i$

Direct effect

Similar graphs for the other SRMs

(Side effect)

Relative effect

$\sigma_i = 0.4; \sigma_j = 0.1; \sigma_F = 0.1$
Do SRM set the right incentives?

**Sensitivity of beta to size**

- **Direct effect**
- **(Side effect)**
- **Relative effect**

Weight of bank $i$ in the system

- $\beta_i = 0.5$
- $\beta_i = 1$
- $\beta_i = 2$
- $\beta_i = 3$

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Slide 16
Do SRM set the right incentives? Robustness to distributional assumptions

- **Multivariate $t$-distributed returns**, increasing tail thickness
- **Dynamic structural model; multivariate extension of Collin-Dufresne / Goldstein (2001)**
  - Lognormal asset returns, 1 systematic factor
  - Stationary leverage
  - Stationary equity returns with **thicker-than-normal tails**
Do SRM set the right incentives?
dynamic structural model; sensitivity to risk parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Effect type</th>
<th>Return type</th>
<th>ΔCoVaR</th>
<th>Exposure ΔCoVaR</th>
<th>MES</th>
<th>Beta</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idiosyncratic risk $\sigma_i$</td>
<td>direct assets</td>
<td>–</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
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<tr>
<td></td>
<td>equity</td>
<td>–</td>
<td>+</td>
<td>+/–</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>relative assets</td>
<td>–</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>equity</td>
<td>–</td>
<td>+</td>
<td>+/–</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

$\Sigma$: New negative effects, only for equity $\Rightarrow$ tail thickness matters.
Previous negative effects confirmed.

<table>
<thead>
<tr>
<th>Size $w_i$</th>
<th>Effect type</th>
<th>Return type</th>
<th>ΔCoVaR</th>
<th>Exposure ΔCoVaR</th>
<th>MES</th>
<th>Beta</th>
</tr>
</thead>
<tbody>
<tr>
<td>direct assets</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+/–</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>equity</td>
<td>+</td>
<td>+/–</td>
<td>+</td>
<td>+/–</td>
<td>+</td>
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<tr>
<td>relative assets</td>
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<td>equity</td>
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<td>+/–</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

negative sensitivities that did not appear in the linear normal model
Can SRM identify an “infectious” bank?

Model setup

• A single infectious bank: \( R_1 = \beta_1 F + \varepsilon_1 \)

• Infected banks: \( R_j = \beta_j F + \varepsilon_j + \gamma_1 I_{\{\varepsilon_1 < \kappa\}} \varepsilon_1, \quad j = 2, \ldots, N \)

• Bank sector index \( R_S = \frac{1}{N} \sum_j R_j \)

• Same beta and idiosyncratic risk for all banks

• Monte Carlo simulation

  • varying impact parameter \( \gamma_1 \) and
  • „infection threshold“ \( \kappa \)

• \( N = 50 \)
Can SRM identify an "infectious" bank? Varying the impact parameter $\gamma_1$
Can SRM identify an “infectious” bank?  
Robustness

Tests
- Calibrating volatility and expectation of infected banks to that of the infectious bank
- Varying the contagion threshold $\kappa$ (quantiles at 1%, 0.1%)
- Making the infectious bank big (25% weight in the index return)
- Raising the loading to systematic risk $\beta_1$ to 1.25
- Five infectious banks
- Systematic factor as GARCH(1,1), same unconditional volatility as before
- All factors $t$-distributed, 4 degrees of freedom
- Volatility spillover:  
  \[ R_j = \beta_j F + \varepsilon_j \times \left( I_{\{\varepsilon_i \geq \kappa\}} + mI_{\{\varepsilon_i < \kappa\}} \right) \]
- Time delay in the spillover:  
  \[ R_{jt} = \beta_j F_t + \varepsilon_{1t} + 0.5\gamma_1 I_{\{\varepsilon_{1t} < \kappa\}} \varepsilon_{1t} + 0.5\gamma_1 I_{\{\varepsilon_{1t-1} < \kappa\}} \varepsilon_{1t-1} \]

Result
- Base case confirmed in all cases, except for delayed spillover
Conclusion

- If banks benefit from low SRMs, some SRMs set strange incentives w.r.t. idiosyncratic risk, systematic risk and size, even in a plain linear well-behaved model with normal returns.

- Contagion model: no clear picture whether, when and by which SRM an infectious banks would be identified.

- Results are robust to various changes in the model.

➤ A direct application of the proposed measures to regulatory capital surcharges for systemic risk could create a lot of noise and wrong incentives to banks.