Pitfalls in the use of systemic risk measures*

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The views herein do not necessarily reflect those of the Deutsche Bundesbank.
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 (SRM)** we talk about try to

  − Quantify how much an entity contributes to the vulnerability of the financial system

  − Are based on **equity (or asset) returns.**
Return-based SRM 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

**\( \Delta \text{CoVaR} \) (Adrian, Brunnermeier, Oct 2011):**

- *Change of the system's VaR through bank \( i \) moving from a normal to a very bad state; formally: \( Q_{\alpha}(...) \) … \( \alpha \)-quantile*

- \( \Delta \text{CoVaR}^{S|i}_{\alpha} \equiv Q_{\alpha}(-R_S | R_i = Q_{\alpha}(R_i)) - Q_{\alpha}(-R_S | R_i = Q_{0.5}(R_i)) \)

**Exposure \( \Delta \text{CoVaR} \):**

- *Change of bank \( i \) ‘s VaR through the system moving from a normal to a very bad state; formally:*

- \( \Delta \text{CoVaR}^{i|S}_{\alpha} \equiv Q_{\alpha}(-R_i | R_S = Q_{\alpha}(R_S)) - Q_{\alpha}(-R_i | R_S = Q_{0.5}(R_S)) \)
Marginal expected shortfall (MES)

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

\[
MES^i_\alpha \equiv \mathbb{E}\left[ -R_i \mid R_s < Q_\alpha (R_s) \right]
\]

Beta

- Regression: 
  \[
  R_{i,t} = \alpha_i + beta_i R_{s,t} + u_{i,t}
  \]
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:

\[
\begin{align*}
\Delta \text{CoVaR}_{\alpha}^{S|i} &= \frac{\text{cov}(R_S, R_i)}{\sigma(R_i)} \Phi^{-1}(1 - \alpha) \\
M_{\alpha} &= -\beta_i \mu + \frac{\text{cov}(R_S, R_i)}{\sigma(R_S)} \frac{\phi(\Phi^{-1}(\alpha))}{\alpha} \\
\Delta \text{CoVaR}_{\alpha}^{i|S} &= \frac{\text{cov}(R_S, R_i)}{\sigma(R_S)} \Phi^{-1}(1 - \alpha) \\
\beta_{\alpha} &= \frac{\text{cov}(R_S, R_i)}{\sigma^2(R_S)}
\end{align*}
\]
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>ΔCoVaR (Bank i stressed)</th>
<th>Exposure ΔCoVaR (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
- **Blue fields** SRM and overall systemic risk can have opposite sensitivities
Do SRM set the right incentives?
Example: sensitivity of $\Delta$CoVaR to idiosyncratic risk $\sigma_i$

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

$$\Delta CoVaR_{\alpha}^{S|i} = \frac{\text{cov}(R_S, R_i)}{\sigma(R_i)} \Phi^{-1}(1 - \alpha)$$
Do SRM set the right incentives?
Example: sensitivity of $\Delta \text{CoVaR}$ to systematic risk $\beta_i$

$$\sigma_i = 0.4; \sigma_j = 0.1; \sigma_F = 0.1$$
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 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>( \Delta \text{CoVaR} )</th>
<th>Exposure ( \Delta \text{CoVaR} )</th>
<th>MES</th>
<th>Beta</th>
</tr>
</thead>
<tbody>
<tr>
<td>Idiosyncratic risk ( \sigma_i )</td>
<td>direct</td>
<td>assets</td>
<td>–</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td></td>
<td>equity</td>
<td>–</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>relative</td>
<td>assets</td>
<td>–</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td></td>
<td>equity</td>
<td>–</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Systematic risk direct ( \mu_i )</td>
<td>direct</td>
<td>assets</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td></td>
<td>equity</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>relative</td>
<td>assets</td>
<td>+/-</td>
<td>+/-</td>
<td>+/-</td>
<td>+/-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>equity</td>
<td>+/-</td>
<td>+/-</td>
<td>+/-</td>
<td>+/-</td>
</tr>
<tr>
<td>Size ( w_i )</td>
<td>direct</td>
<td>assets</td>
<td>+</td>
<td>+</td>
<td>+/-</td>
<td>+/-</td>
</tr>
<tr>
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<tr>
<td></td>
<td>relative</td>
<td>assets</td>
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<td>+</td>
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<td>+</td>
</tr>
<tr>
<td></td>
<td></td>
<td>equity</td>
<td>+/-</td>
<td>+/-</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

\( \Sigma \): New negative effects, only for equity ➔ tail thickness matters.

Previous negative effects confirmed.

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: $R_j = \beta_j F + \varepsilon_j \times \left( I_{\{\varepsilon_1 \geq \kappa\}} + mI_{\{\varepsilon_1 < \kappa\}} \right)$

- 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.