Pitfalls in the use of systemic risk measures*

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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.

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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

ΔCoVaR (Adrian, Brunnermeier, Oct 2011):

- *Change of the system‘s VaR through bank i moving from a normal to a very bad state*; formally: $Q_\alpha(...)$ … α-quantile
- $\Delta CoVaR_\alpha^{S|i} \equiv Q_\alpha\left(-R_S \mid R_i = Q_\alpha(R_i)\right) - Q_\alpha\left(-R_S \mid R_i = Q_{0.5}(R_i)\right)$

Exposure ΔCoVaR:

- *Change of bank i‘s VaR through the system moving from a normal to a very bad state*; formally:
- $\Delta CoVaR_\alpha^{i|S} \equiv Q_\alpha\left(-R_i \mid R_S = Q_\alpha(R_S)\right) - Q_\alpha\left(-R_i \mid R_S = Q_{0.5}(R_S)\right)$

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Systemic risk measures 2

Marginal expected shortfall (MES)

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

$$MES_{\alpha}^{i} \equiv \mathbf{E}\left[-R_i \middle| R_S < Q_{\alpha}\left(R_S\right)\right]$$

Beta

- Regression: $R_{i,t} = \alpha_i + beta_i R_{S,t} + u_{i,t}$

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Do SRM set the right incentives?
Sensitivities in a linear normal model

- Classic market model: N banks, returns:

  $R_i = \beta_i F + \varepsilon_i$; ($F \sim N\left(\mu, \sigma_F^2\right)$, $\varepsilon_i \sim N\left(0, \sigma_i^2\right)$, independent)

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

- Very simple representation of the SRM:

$$\Delta CoVaR_\alpha^{S|i} = \frac{\operatorname{cov}\left(R_S, R_i\right)}{\sigma\left(R_i\right)} \Phi^{-1}(1-\alpha) \qquad \Delta CoVaR_\alpha^{i|S} = \frac{\operatorname{cov}\left(R_S, R_i\right)}{\sigma\left(R_S\right)} \Phi^{-1}(1-\alpha)$$

$$MES = -\beta_i \mu + \frac{\operatorname{cov}\left(R_S, R_i\right)}{\sigma\left(R_S\right)} \frac{\phi\left(\Phi^{-1}(\alpha)\right)}{\alpha} \qquad beta_i = \frac{\operatorname{cov}\left(R_S, R_i\right)}{\sigma^2\left(R_S\right)}$$

Do SRMs set the right incentives? Sensitivities to risk parameters in a linear normal model

- Assumptions
  - Banks can steer their idiosyncratic risk (σ_i), systematic risk (β_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:

$$\frac{\partial}{\partial p_i}\left[SRM_i\right], \quad p_i \in \{\sigma_i, \beta_i, w_i\}$$

- Relative effect: compared to another bank's SRM:

$$\frac{\partial}{\partial p_i}\left[\frac{SRM_i}{SRM_j}\right], \quad p_i \in \{\sigma_i, \beta_i, w_i\}$$

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Do SRM set the right incentives?
Linear model; sensitivity to risk parameters

Parameter	Effect type	ΔCoVaR (Bank *i* stressed)	Exposure ΔCoVaR (System stressed)	MES	Beta
idiosyncratic risk σ_i	direct	+/–	+	+	+
	relative	+/–	+	$+^n$	+
systematic risk β_i	direct	+	+	$+^n$	+
	relative	+/–	+/–	+/–	+/–
size w_i	direct	+/–	+	+	+/–
	relative	$+^n$	$+^n$	$+^n$	$+^n$

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

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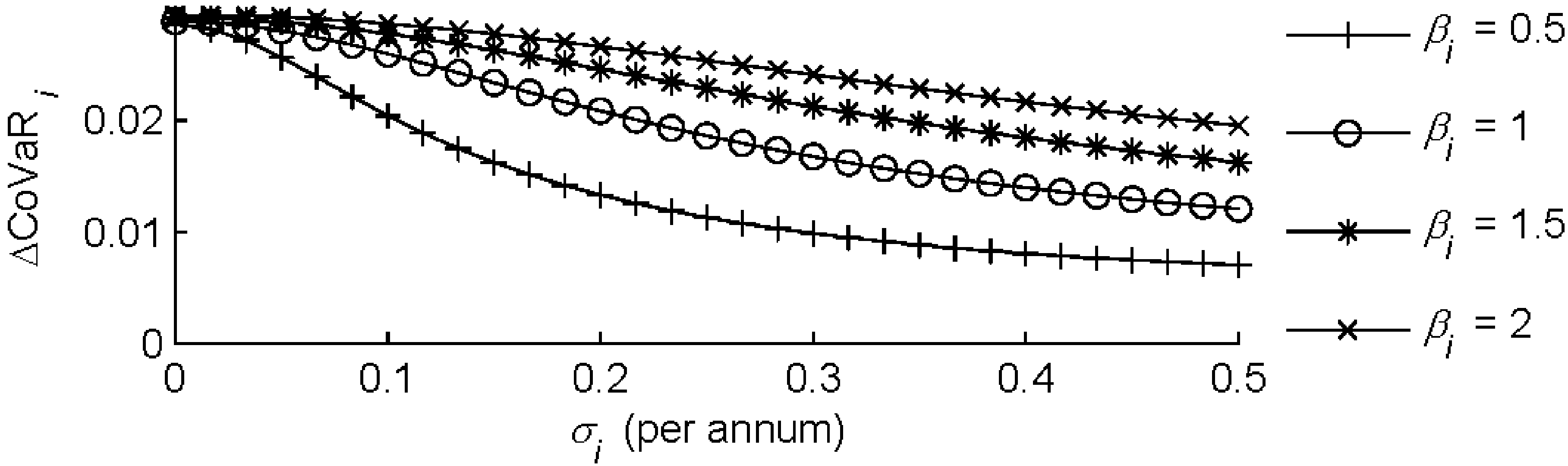
Do SRM set the right incentives?
Example: sensitivity of ΔCoVaR to idiosyncratic risk σ_i



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

$$\Delta CoVaR_{\alpha}^{S|i} = \frac{\operatorname{cov}\left(R_S, R_i\right)}{\sigma\left(R_i\right)} \Phi^{-1}(1-\alpha)$$

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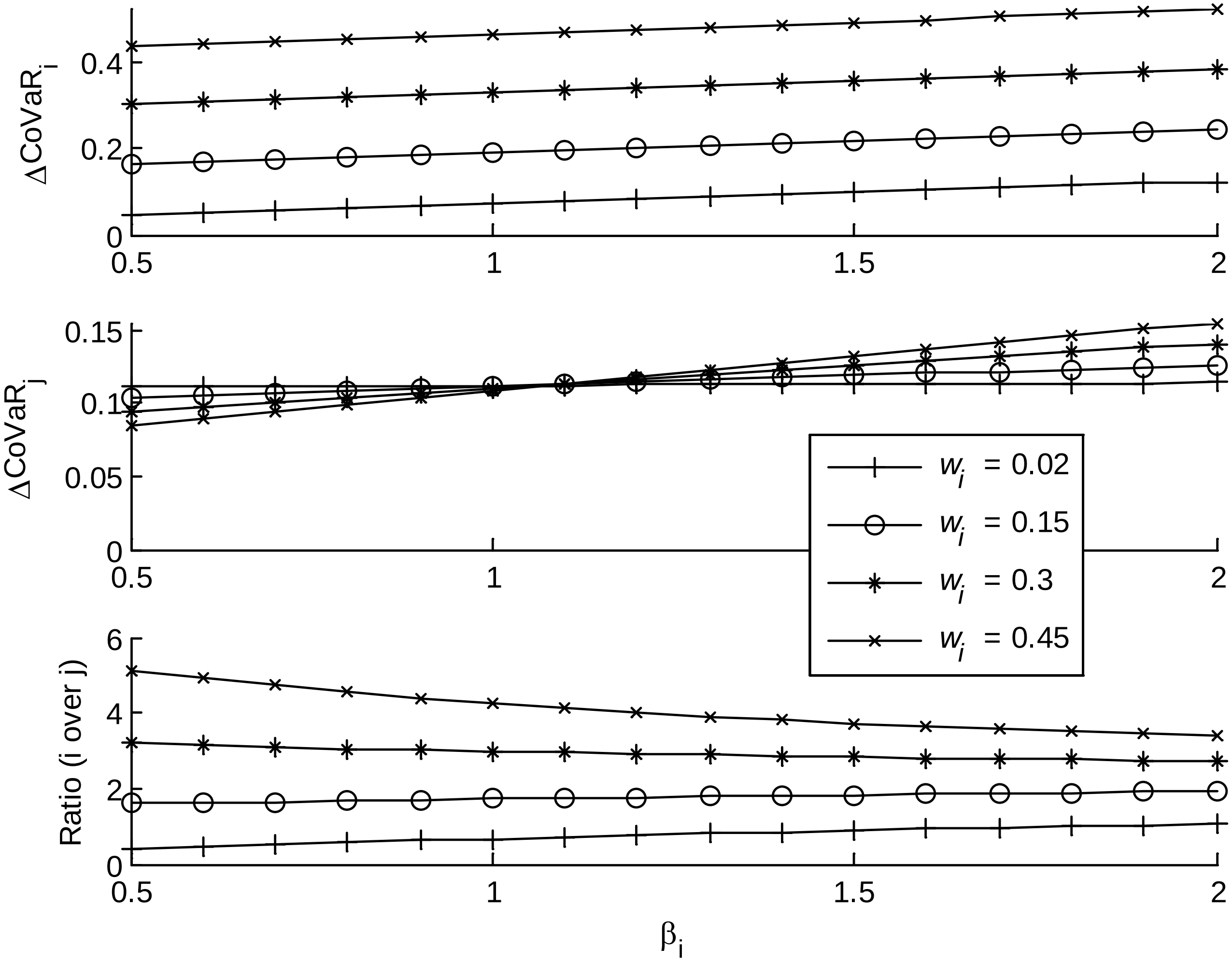
Do SRM set the right incentives?
Example: sensitivity of ΔCoVaR to systematic risk β_i



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? 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

Parameter	Effect type	Return type	ΔCoVaR	Exposure ΔCoVaR	MES	Beta
Idiosyncratic risk σ_i	direct	assets	–	+	+	+
		equity	–	+	+/–	+
	relative	assets	–	+	+	+
		equity	–	+	+/–	+
Systematic risk β_i	direct	assets	+	+	+	+
		equity	+	+	+	+
	relative	assets	+/–	+/–	+/–	+/–
		equity	+/–	+/–	+/–	+/–
Size w_i	direct	assets	+	+	+	+/–
		equity	+	+/–	+	+/–
	relative	assets	+	+	+	+
		equity	+/–	+/–	+	+

Σ: New negative effects, only for equity ➔ tail thickness matters.

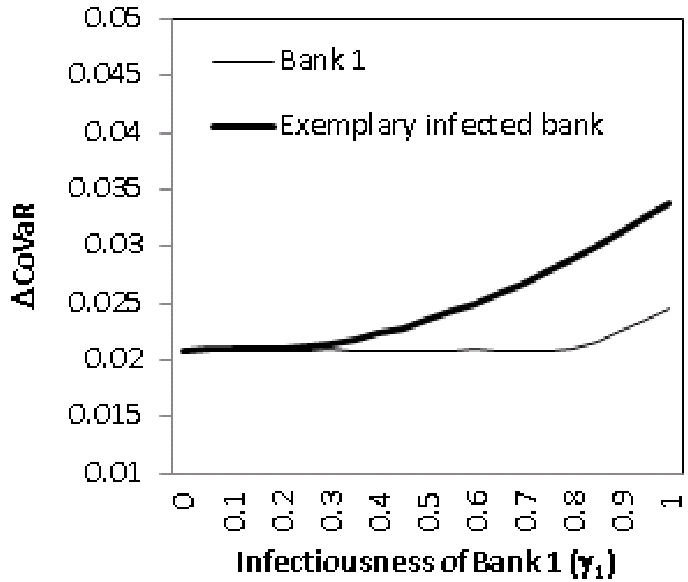
Previous negative effects confirmed.

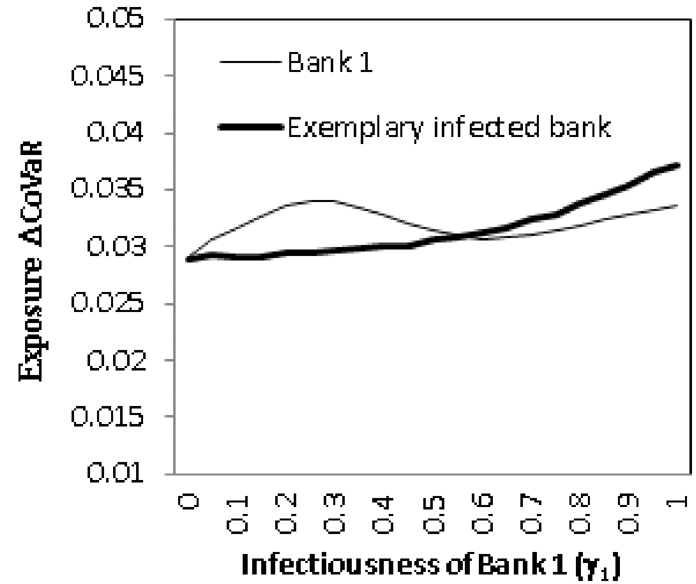
negative sensitivities that did not appear in the linear normal model

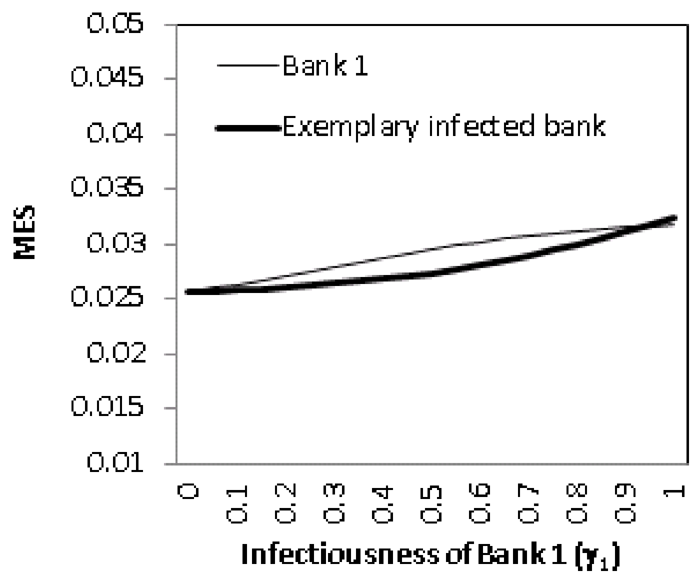
Can SRM identify an "infectious" bank?
Model setup

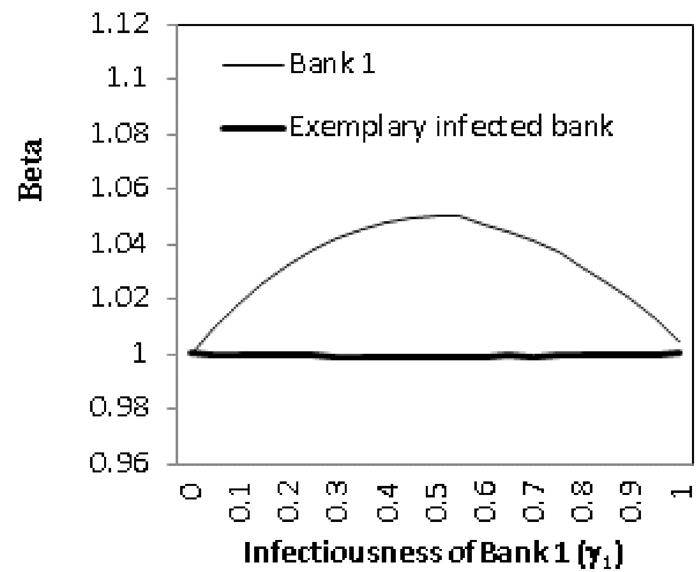
- A single infectious bank: $R_1 = \beta_1 F + \varepsilon_1$
- Infected banks: $R_j = \beta_j F + \varepsilon_j + \gamma_1 I_{\{\varepsilon_1 < \kappa\}} \varepsilon_1, \quad j = 2, \dots, N$
- Bank sector index $R_S = \frac{1}{N} \sum_j R_j$
- Same beta and idiosyncratic risk for all banks
- Monte Carlo simulation
  - varying impact parameter γ_1 and „infection threshold" κ
  - $N = 50$

Can SRM identify an “infectious” bank? Varying the impact parameter γ_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 κ (quantiles at 1% , 0.1%)
- Making the infectious bank big (25% weight in the index return)
- Raising the loading to systematic risk β_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: $R_j = \beta_j F + \varepsilon_j \times \left(I_{\{\varepsilon_1 \geq \kappa\}} + m I_{\{\varepsilon_1 < \kappa\}} \right)$
- 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.