DEUTSCHE BUNDESBANK
EUROSYSTEM

Pitfalls in the use of systemic risk measures

Peter Raupach, Deutsche Bundesbank; joint work with Gunter Löffler, University of Ulm, Germany

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Research questions, literature

- Various proposals how to measure contributions of financial institutions ("banks") to system (in)stability
- Do these systemic risk measures (SRM) set the right incentives?
  - Sensitivities to risk parameters controlled by banks
- How informative are they?
  - Can they identify an "infectious" bank?
- in an earlier version, Bundesbank Discussion Paper 04/2013 Robustness and informativeness of systemic risk measures:
  - Estimation errors
  - "Fooling" a SRM by derivatives positions

- Most related work
  - Benoit, S., Colletaz, G., Hurlin, C., Perignon, C., 2013. A theoretical and empirical comparison of systemic risk measures. Working paper.

Systemic risk measures 1

- Topic: *contributions* of financial institutions to system (in-) stability; returns-based measures
- 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
- $\Delta CoVaR_\alpha^{S|i} \equiv Q_\alpha\left(-R_S \mid R_i = Q_\alpha\left(R_i\right)\right) - Q_\alpha\left(-R_S \mid R_i = Q_{0.5}\left(R_i\right)\right)$

Exposure ΔCoVaR:

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

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

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:

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

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

peter.raupach@bundesbank.de

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:

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

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

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

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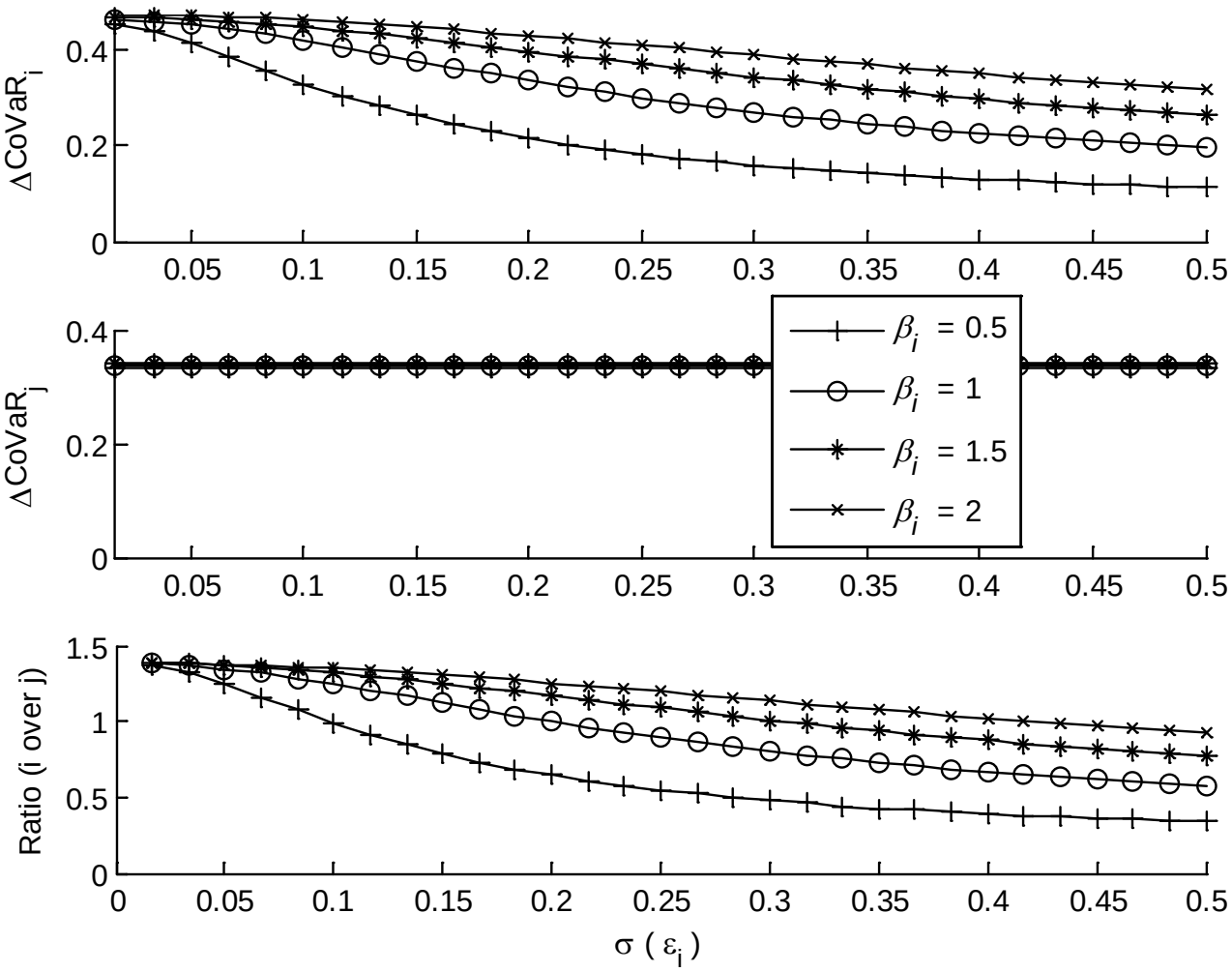
Do SRM set the right incentives?
Linear model; sensitivity to risk parameters

Parameter	Effect type	ΔCoVaR (Bank *i* stressed)	Exposure ΔCoVaR (System stressed)	MES	Beta
idiosyncratic risk σ_i	direct	+/–	+	+	+
	relative	+/–	+	+	+
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
+/(–)	SRM can fall with risk parameter, but only if system risk also falls
+ [n]	SRM rises under non-exotic conditions

Do SRM set the right incentives?
Sensitivity of ΔCoVaR to idiosyncratic risk σ_i



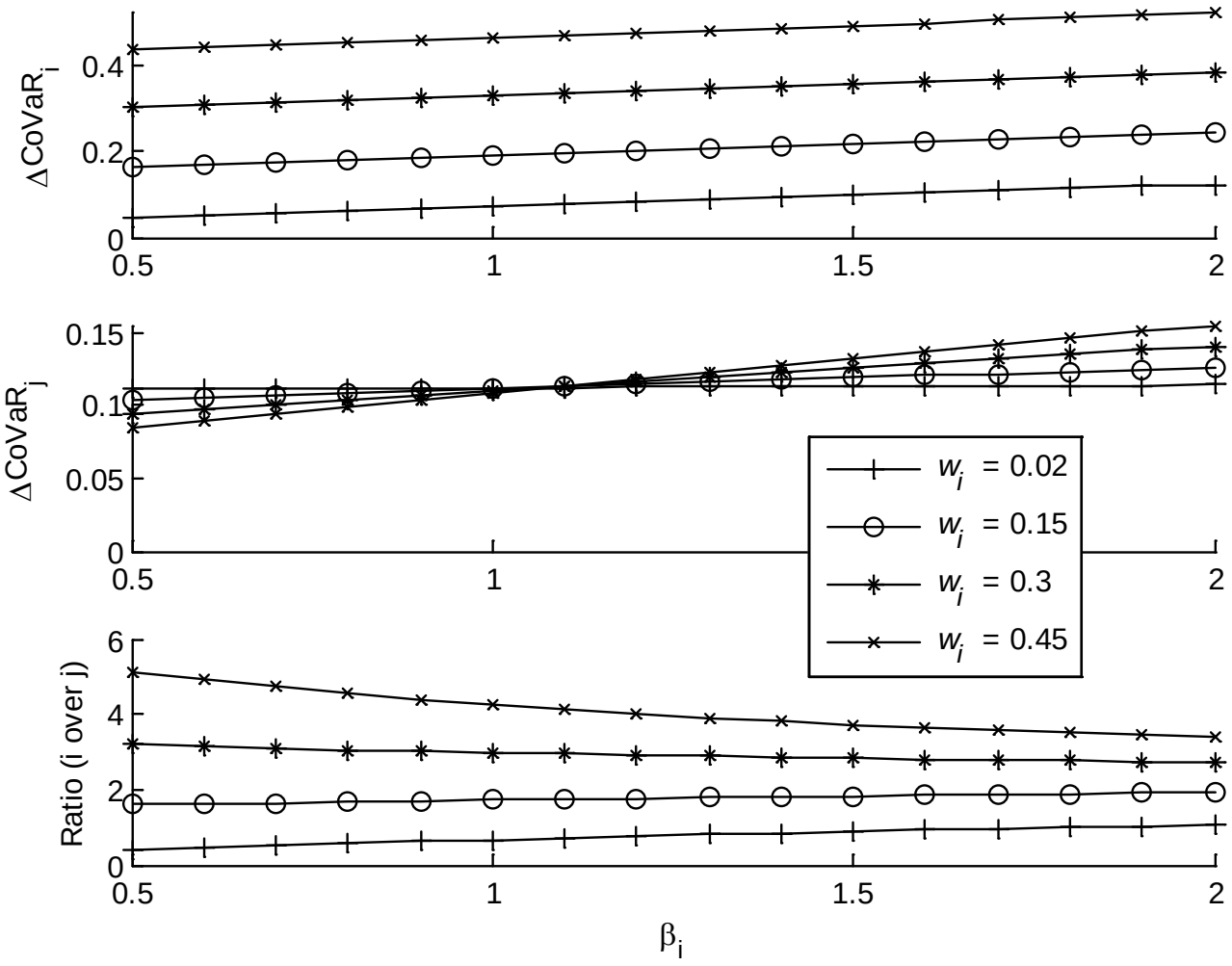
Direct effect

[Side effect]

Relative effect

$\sigma_j = 0.2; \sigma_F = 0.2$

Do SRM set the right incentives?
Sensitivity of ΔCoVaR to systematic risk β_i



Direct effect

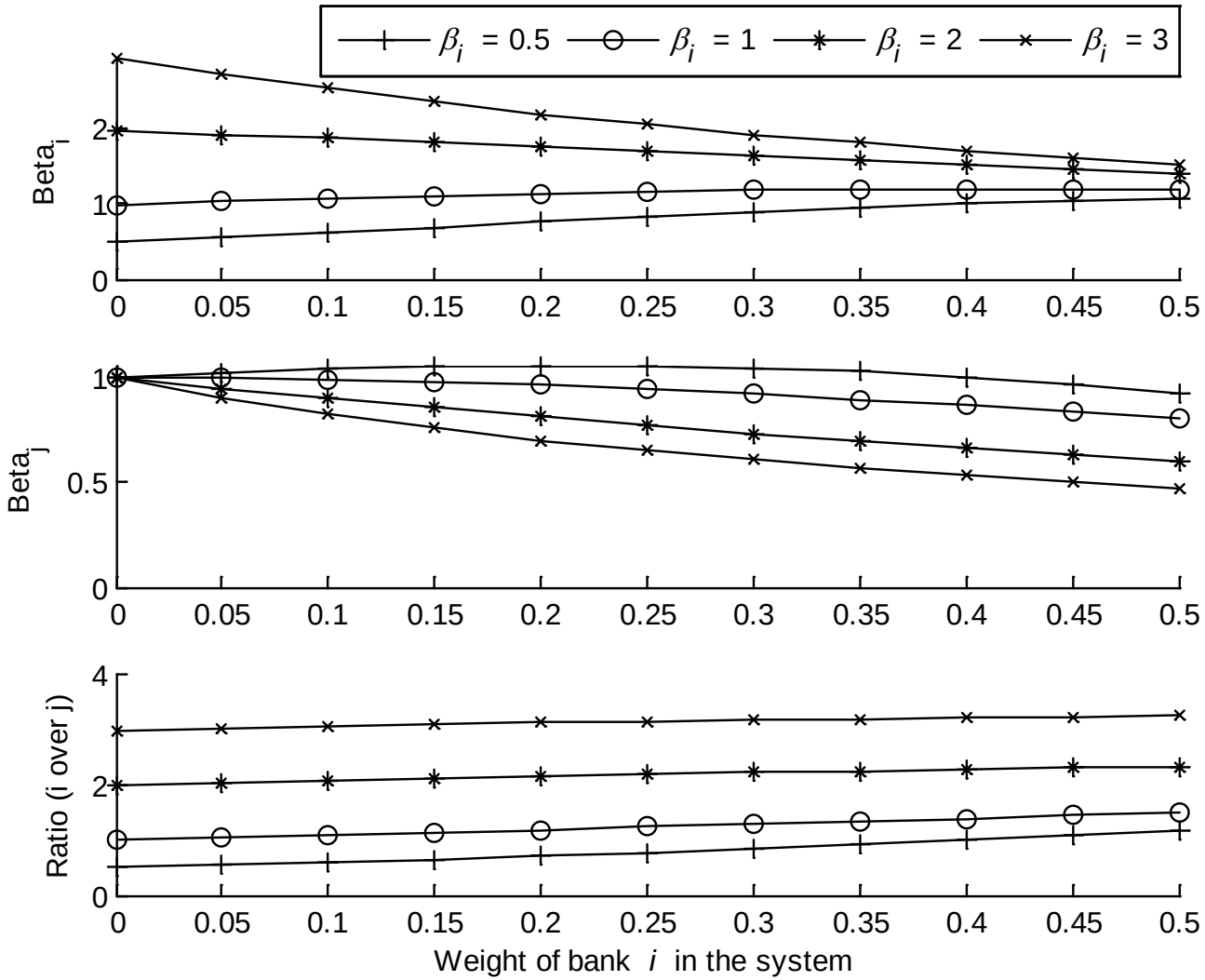
Similar graphs for the other SRMs

(Side effect)

Relative effect

$\sigma_i = 0.4;\ \sigma_j = 0.1;\ \sigma_F = 0.1$

Do SRM set the right incentives?
Sensitivity of beta to size



Direct effect

(Side effect)

Relative effect

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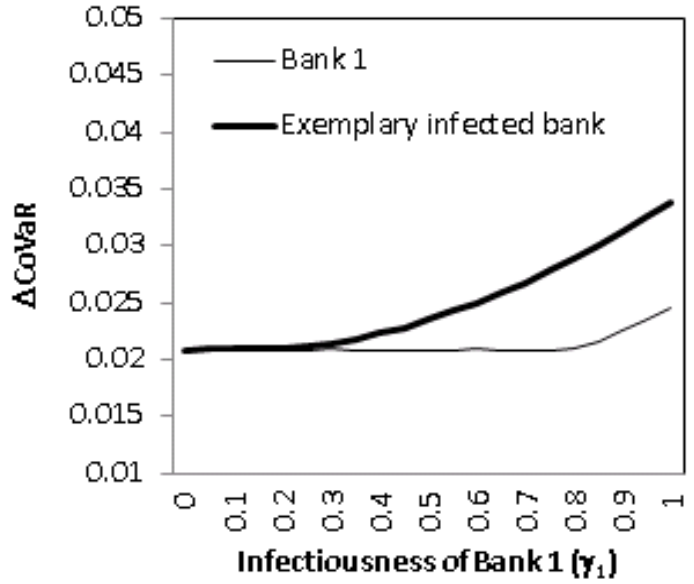
Do SRM set the right incentives?
Robustness to distributional assumptions

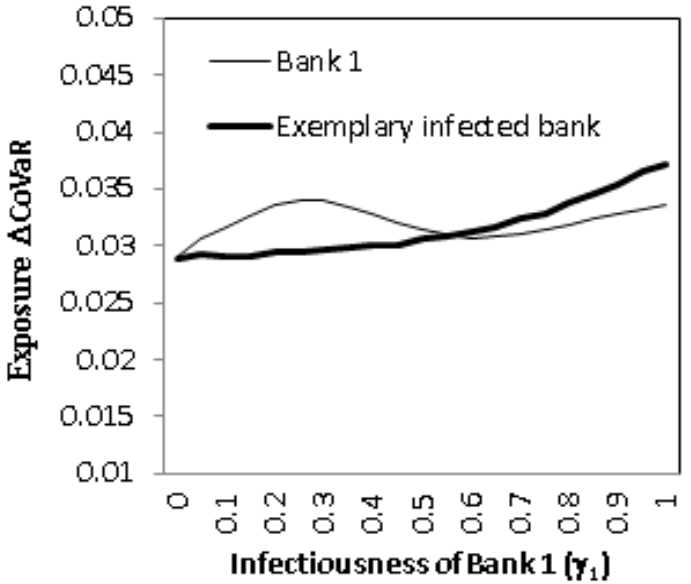
- Multivariate *t*-distributed returns, increasing tail thickness
  - New negative effects that did not appear under the normal model
  - Some negative effects disappear
- Dynamic structural model; multivariate extension of Collin-Dufresne / Goldstein (2001)
  - Lognormal asset returns, 1 systematic factor
  - Stationary leverage
  - Stationary equity returns with thicker-than-normal tails
  - Results:
    - New negative effects, only for equity ➔ tail thickness matters
    - All negative effects found under the normal model confirmed

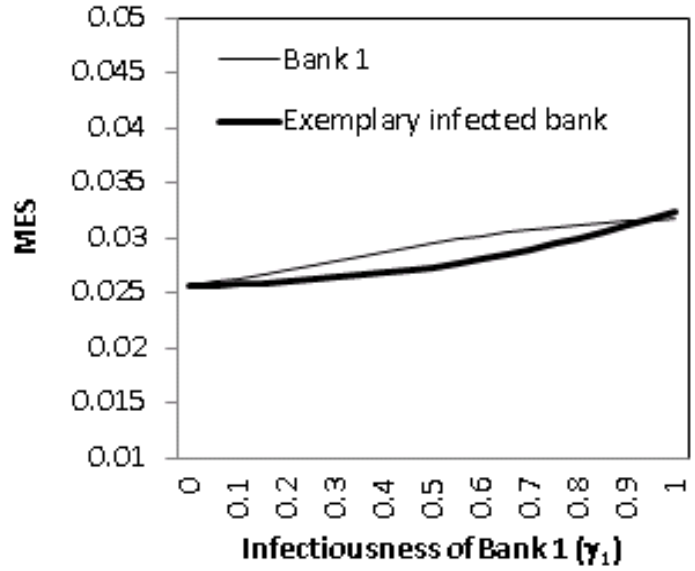
Can SRM identify an “infectious” bank?
Model setup

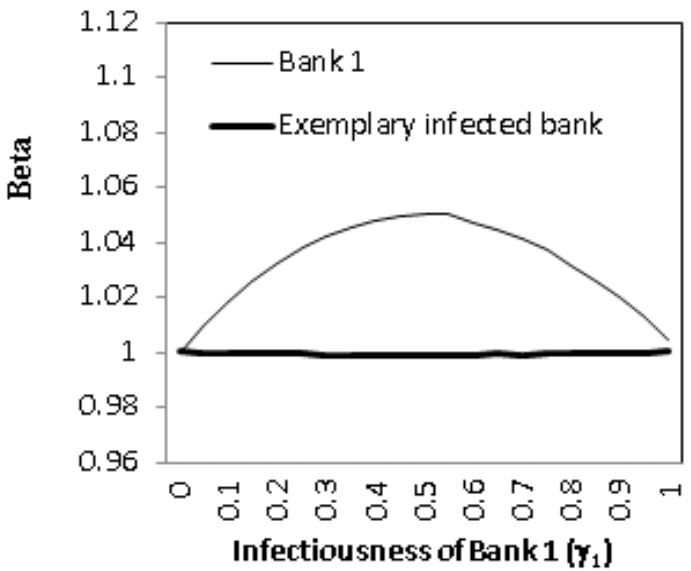
- A single infectious bank: $R_1 = \beta_1 F + \varepsilon_1$
- Infected banks: $R_j = \beta_j F + \varepsilon_j + \gamma_1 I_{\{\varepsilon_1 < \kappa\}} \varepsilon_1, \quad j = 2,...,N$
- Bank sector index $R_S = \frac{1}{N} \sum_j R_j$
- Same beta and idiosyncratic risk for all banks
- Monte Carlo 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 neat linear 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.

Supplementary
Sensitivities under the dynamic structural model

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	+	+/–	+/–	+

negative sensitivities that did not appear in the linear normal model