# Pitfalls in the use of systemic risk measures*

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# Systemic risk and bank regulation

**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

Indicators and their weights

Table 1

| Category | Indicator | Line item | Indicator weight |
|---|---|---|---|
| Size | Total exposures[1] | 2o | 1/5 = 20% |
| Interconnectedness | Intra-financial system assets | 3f | 1/15= 6.$\bar{6}$% |
| | Intra-financial system liabilities | 4g | 1/15= 6.$\bar{6}$% |
| | Securities outstanding | 5i | 1/15= 6.$\bar{6}$% |
| Substitutability/financial institution infrastructure | Payment activity | 6n | 1/15= 6.$\bar{6}$% |
| | Assets under custody | 7a | 1/15= 6.$\bar{6}$% |
| | Underwritten transactions in debt and equity markets | 8c | 1/15= 6.$\bar{6}$% |
| Complexity | Notional amount of OTC derivatives | 9c | 1/15= 6.$\bar{6}$% |
| | Trading and AFS securities | 10f | 1/15= 6.$\bar{6}$% |
| | Level 3 assets | 11a | 1/15= 6.$\bar{6}$% |
| Cross-jurisdictional activity | Cross-jurisdictional claims | 12c | 1/10= 10% |
| | Cross-jurisdictional liabilities | 13d | 1/10= 10% |

From: Basel Committee on Banking Supervision: The G-SIB assessment methodology – score calculation . November 2014

# 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

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:
- $\Delta CoVaR_\alpha^{i|S} \equiv Q_\alpha\left(-R_i \mid R_S = Q_\alpha(R_S)\right) - Q_\alpha\left(-R_i \mid R_S = Q_{0.5}(R_S)\right)$

# 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:

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

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

# 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:

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

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

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

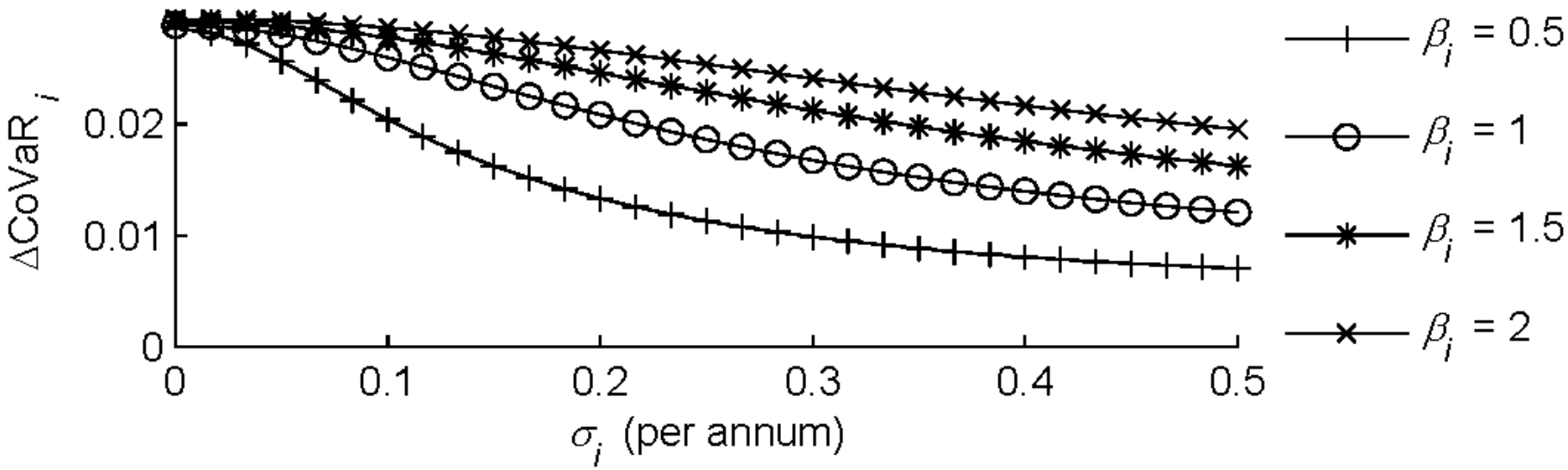
# Do SRM set the right incentives?
# Linear model; sensitivity to risk parameters

| Parameter | Effect type | ΔCoVaR (Bank *i* stressed) | Exposure ΔCoVaR (System stressed) | MES | Beta |
|---|---|---|---|---|---|
| idiosyncratic risk $\sigma_i$ | direct | +/– | + | + | + |
| | relative | +/– | + | $+^n$ | + |
| systematic risk $\beta_i$ | 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 |

# Do SRM set the right incentives?
# Sensitivity of ΔCoVaR to idiosyncratic risk $\sigma_i$

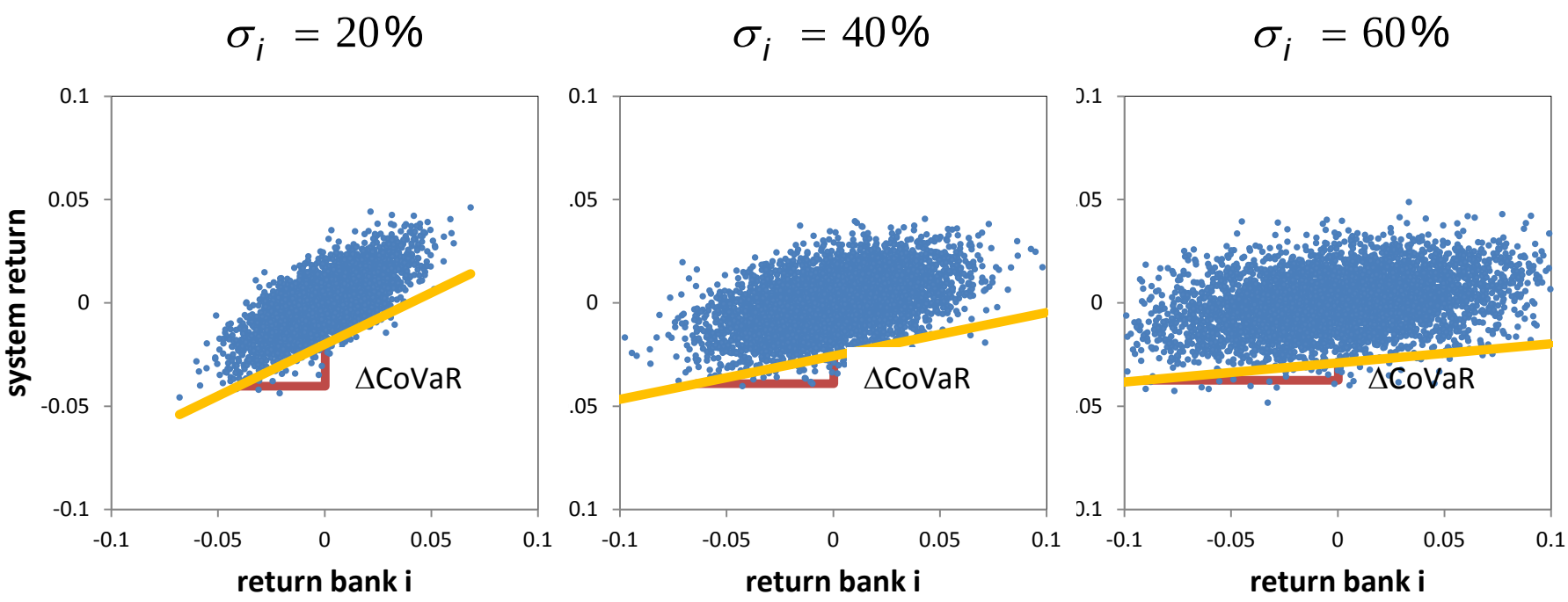



$(\sigma_j = 0.2, \sigma_F = 0.2)$

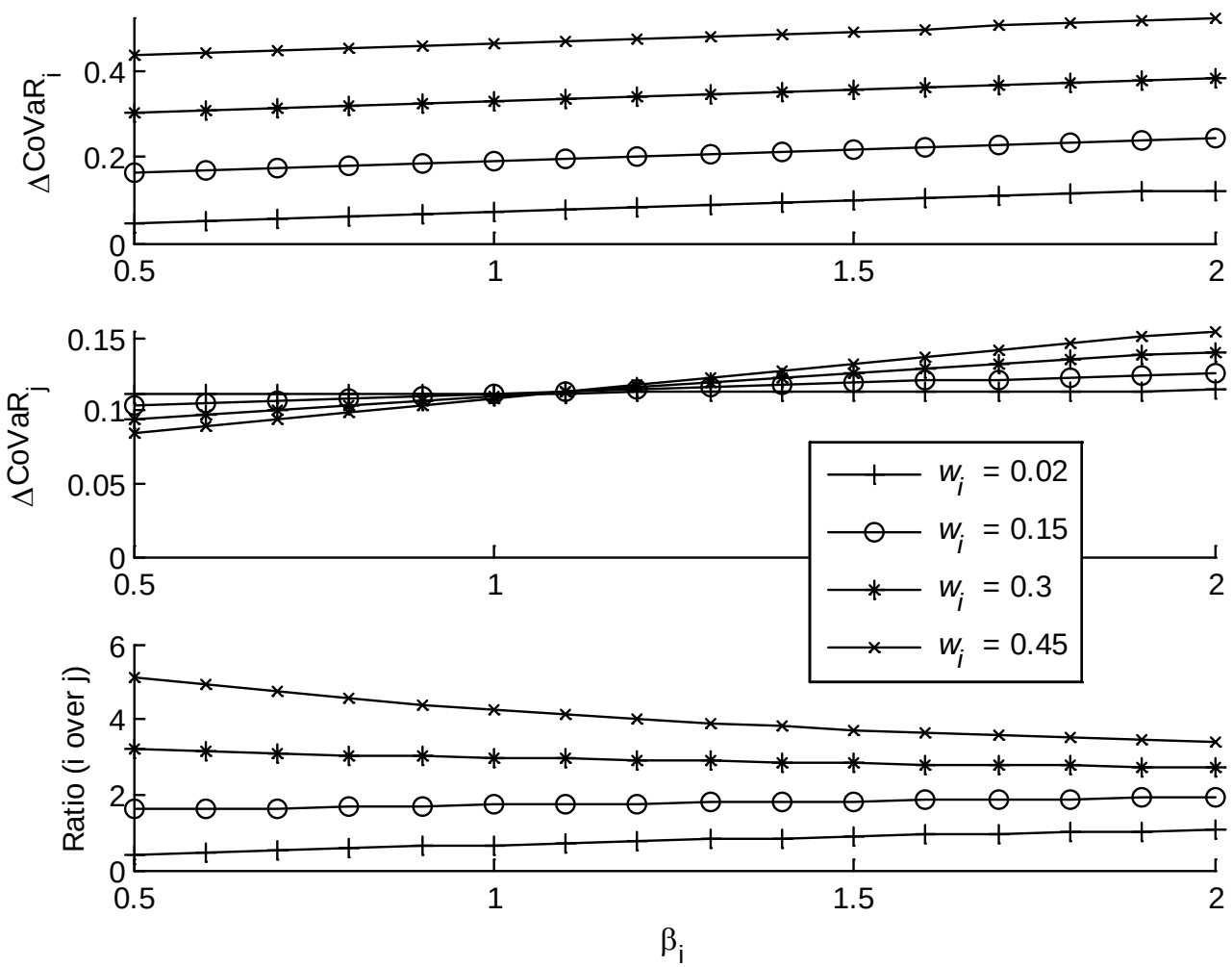
$$\Delta CoVaR_{\alpha}^{S|i} = \frac{\mathrm{cov}\left(R_S, R_i\right)}{\sigma\left(R_i\right)} \Phi^{-1}(1-\alpha)$$

# Sensitivity of ΔCoVaR to idiosyncratic risk $\sigma_i$

$$R_i = \beta_i F + \varepsilon_i \ , \quad R_S = \sum_i w_i R_i \ \ with \ F \sim N(\mu, \sigma_F^2), \ \varepsilon_i \sim N(0, \sigma_i^2)$$



# Do SRM set the right incentives?
# Sensitivity of ΔCoVaR to systematic risk $\beta_i$




Direct effect

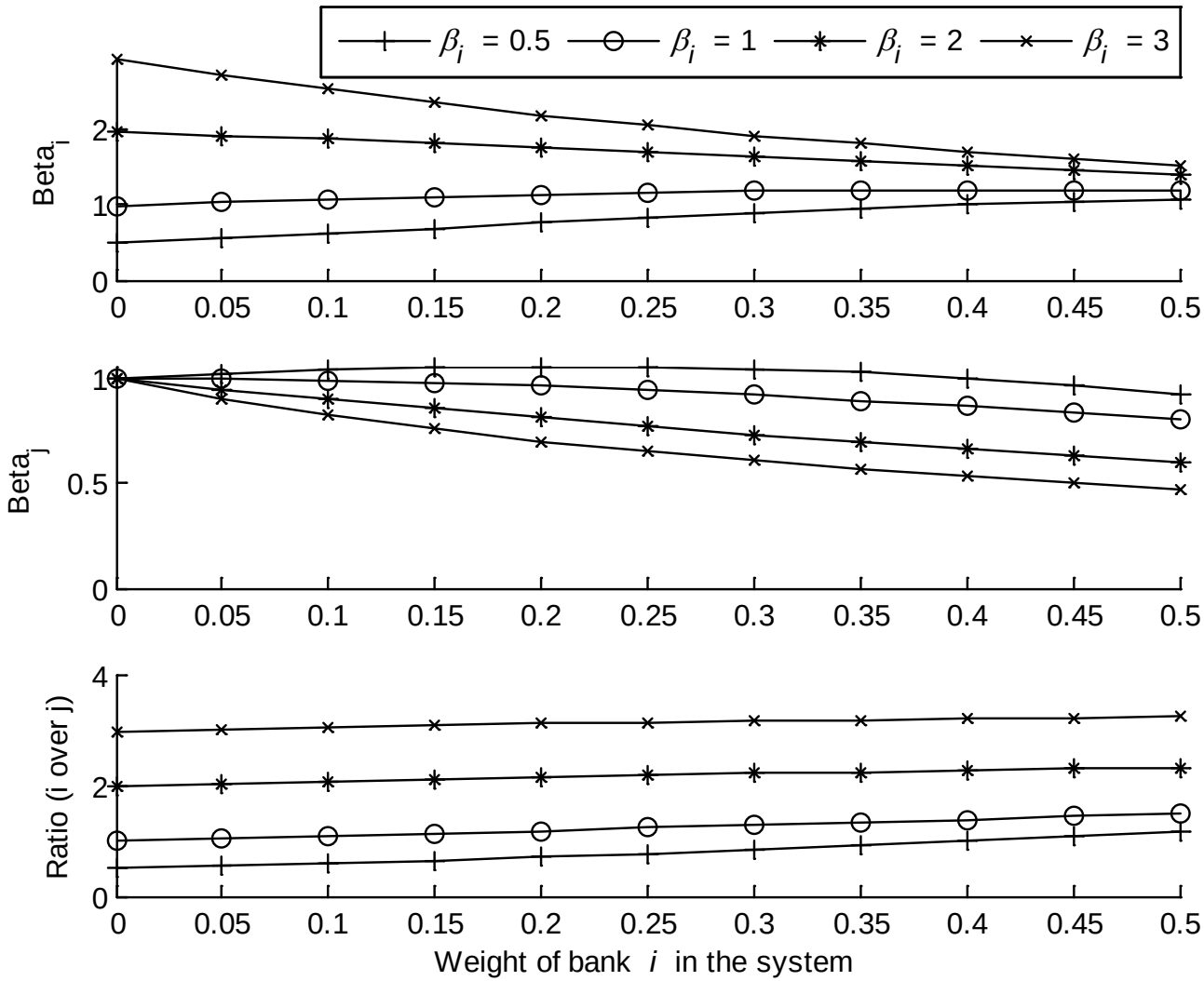
**Similar graphs for the other SRMs**

(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

# 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

| Parameter | Effect type | Return type | ΔCoVaR | Exposure ΔCoVaR | MES | Beta |
|---|---|---|---|---|---|---|
| Idiosyncratic risk $\sigma_i$ | direct | assets | – | + | + | + |
| | | equity | – | + | +/– | + |
| | relative | assets | – | + | + | + |
| | | equity | – | + | +/– | + |
| | | equity | +/– | +/– | +/– | +/– |
| Size $w_i$ | direct | assets | + | + | + | +/– |
| | | equity | + | +/– | + | +/– |
| | relative | assets | + | + | + | + |
| | | equity | +/– | +/– | + | + |

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

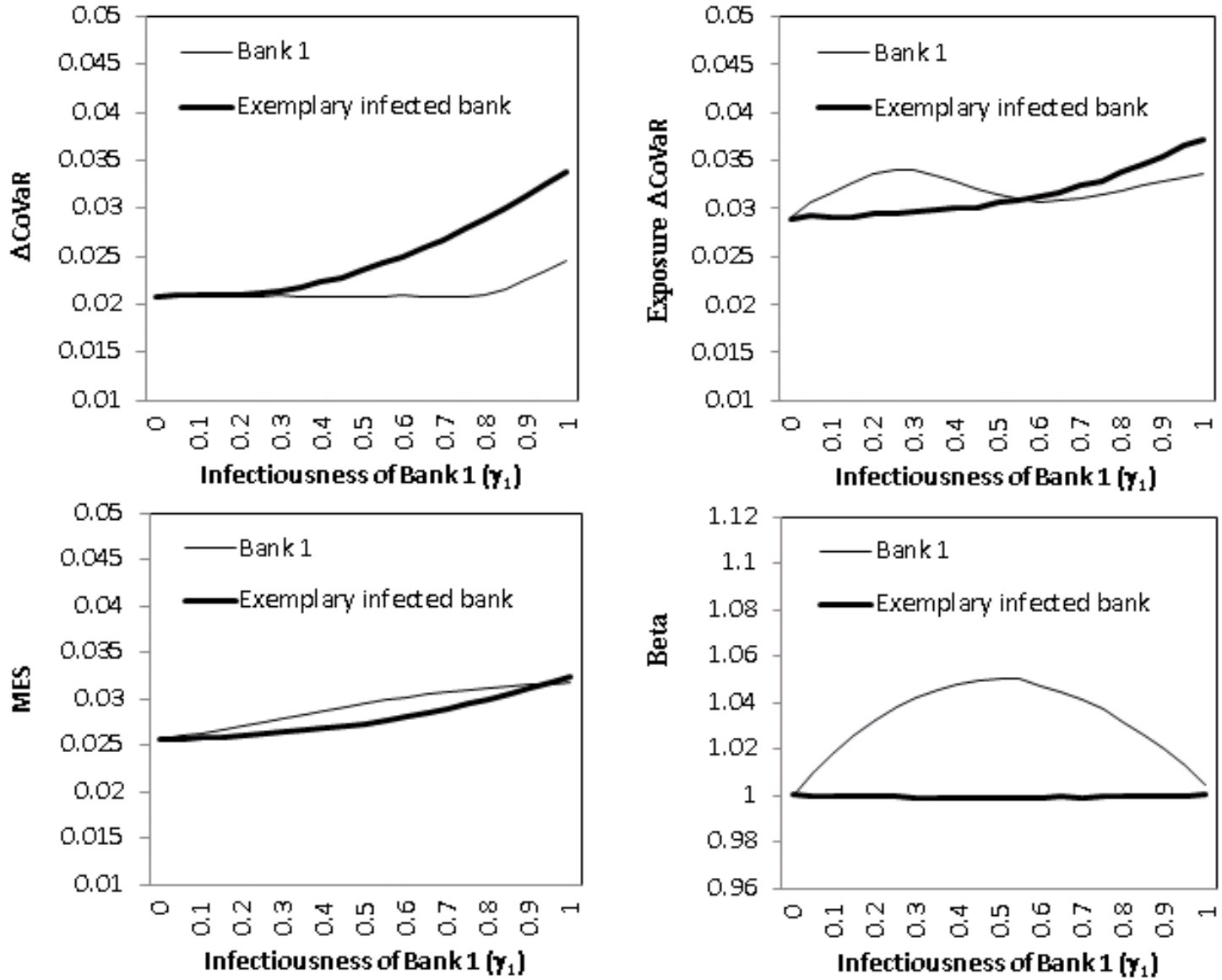
Previous negative effects confirmed.

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: $R_j = \beta_j F + \varepsilon_j + \gamma_1 I_{\{\varepsilon_1 < \kappa\}} \varepsilon_1, \quad j = 2, \ldots, N$
- 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: $R_j = \beta_j F + \varepsilon_j \times \left( I_{\{\varepsilon_1 \geq \kappa\}} + m I_{\{\varepsilon_1 < \kappa\}} \right)$
- 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.