DEUTSCHE BUNDESBANK
EUROSYSTEM

Robustness and informativeness of systemic risk measures

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

2nd EBA research workshop "How to regulate and resolve systemically important banks", 14-15 Nov 2013

What the paper is about

- 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?

- SRM focus on – usually unobserved – extreme losses in the system, e.g. the 0.1% tail of aggregate returns
- For estimation, less extreme losses have to be used instead, e.g. the 5% tail
- Do risk measures based on moderate tails behave like those on extreme tails?
- Do they, at least, rank banks similarly?
- Estimation errors for realistic data?

gunter.loeffler@uni-ulm.de, peter.raupach@bundesbank.de

Systemic risk measures 1

- We only consider measures of *contributions* of financial institutions to system (in-) stability.
- R_i …return of bank i

  R_S … market return, or „system“ return

ΔCoVaR (Adrian, Brunnermeier, 2010):

- *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 CoVaR:

- *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)

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

Tail Risk Gamma (Knaup, Wagner, 2012)

- p_t … price of a put option on the market index, deep out of the money
- Regression:

$$R_t^i = \alpha + \beta R_t^S - \gamma \frac{p_t - p_{t-1}}{p_{t-1}} + u_t$$

- γ measures the sensitivity of R_t^i to extreme losses *beyond* the sensitivity captured by β
- For systemic risk charges, $\gamma + \beta$ may be preferrable.

Do these SRM set the right incentives?
Linear model

- Classic market model: N banks, returns:
  $R_i = \beta_i F + \varepsilon_i$
- Bank sector index $R_S = \sum_{j=1}^{N} w_j R_j$ represents „the system“

- Sensitivities for ΔCoVaR:
  - rising β_i ➔ rising $\left|\Delta CoVaR_\alpha^{S,i}\right|$ **(OK)**
  - rising $\sigma(\varepsilon_i)$: ambiguous effect
    - moderate size, beta ➔ falling $\left|\Delta CoVaR_\alpha^{S,i}\right|$ **(wrong incentive!)**
    - huge size or beta ➔ rising $\left|\Delta CoVaR_\alpha^{S,i}\right|$ **(OK)**
  - rising w_i (~size): ambiguous effect **(a matter of taste…)**

Do these SRM set the right incentives? Linear model

Sensitivity of the SRM to:

	idiosyncratic risk $\sigma(\varepsilon_i)$	**systematic risk β_i**	**size**
ΔCoVaR (conditioning on R_i)	largely problematic	OK	ambiguous
Exposure ΔCoVaR (conditioning on R_S)	OK	OK	OK
MES	OK	OK	OK
(tail risk gamma): regression beta	OK	OK	largely problematic

Do these SRM set the right incentives?
SRM in a model with contagion

- One infectious bank: $R_1 = \beta_1 F + \varepsilon_1$
- Infected banks: $R_j = \beta_j F + \varepsilon_2 + \lambda I_{\varepsilon_1 < \kappa} \varepsilon_1, \quad j = 2, ..., N$
- Bank sector index $R_s = \frac{1}{N} \sum_j R_j$
- All banks have the same beta and return volatility
- Analysis by Monte Carlo simulation
  - varying impact parameter λ and „infection threshold“ κ
  - $N = 50$

Do these SRM set the right incentives?
SRM in a model with contagion

		$\Delta CoVaR^{S\|R_i}_{0.01}$	$\Delta CoVaR^{R_i\|S}_{0.01}$	MES	Tail risk gamma
$\lambda = 0.5$	Infectious	–2.16%	–3.18%	–3.00%	0.63%
$\kappa = -0.0208$	Infected	–2.44%	–3.01%	–2.79%	–0.01%
$\lambda = 0.5$	Infectious	–2.12%	–3.00%	–2.77%	0.20%
$\kappa = -0.0294$	Infected	–2.32%	–3.06%	–2.67%	–0.00%
$\lambda = 0.5$	Infectious	–2.27%	–2.92%	–2.64%	0.04%
$\kappa = -0.0391$	Infected	–2.14%	–3.07%	–2.62%	0.00%
$\lambda = 0.2$	Infectious	–2.14%	–3.29%	–2.75%	0.14%
$\kappa = -0.0208$	Infected	–2.20%	–2.90%	–2.65%	–0.00%
$\lambda = 0.2$	Infectious	–2.05%	–3.10%	–2.67%	0.05%
$\kappa = -0.0294$	Infected	–2.29%	–3.11%	–2.63%	–0.00%
$\lambda = 0.2$	Infectious	–2.25%	–3.14%	–2.62%	0.02%
$\kappa = -0.0391$	Infected	–2.04%	–2.84%	–2.62%	0.00%

wrong order; right order, small difference; right order

How informative are the SRM?
The problem: Inferring from moderate tails on extreme tails

- The very bad system state of interest is rarely observed, e.g. the 0.1% tail of index return

- When estimating SRM, less extreme states have to be used instead, e.g. the 5% tail.

How informative are the SRM?
Analysis framework

- Classic market model $R_t^i = R_f + \beta_i (R_t^M - R_f) + \varepsilon_t^i$
- Bank i holds a baseline portfolio with return R_t^i.
- In addition, put options on the market index with low strike can be held

How informative are the SRM?
Test setup

- Sequences of portfolios 1…16,
  increasing order of their “true” risk on 0.1% level.

Analyses:

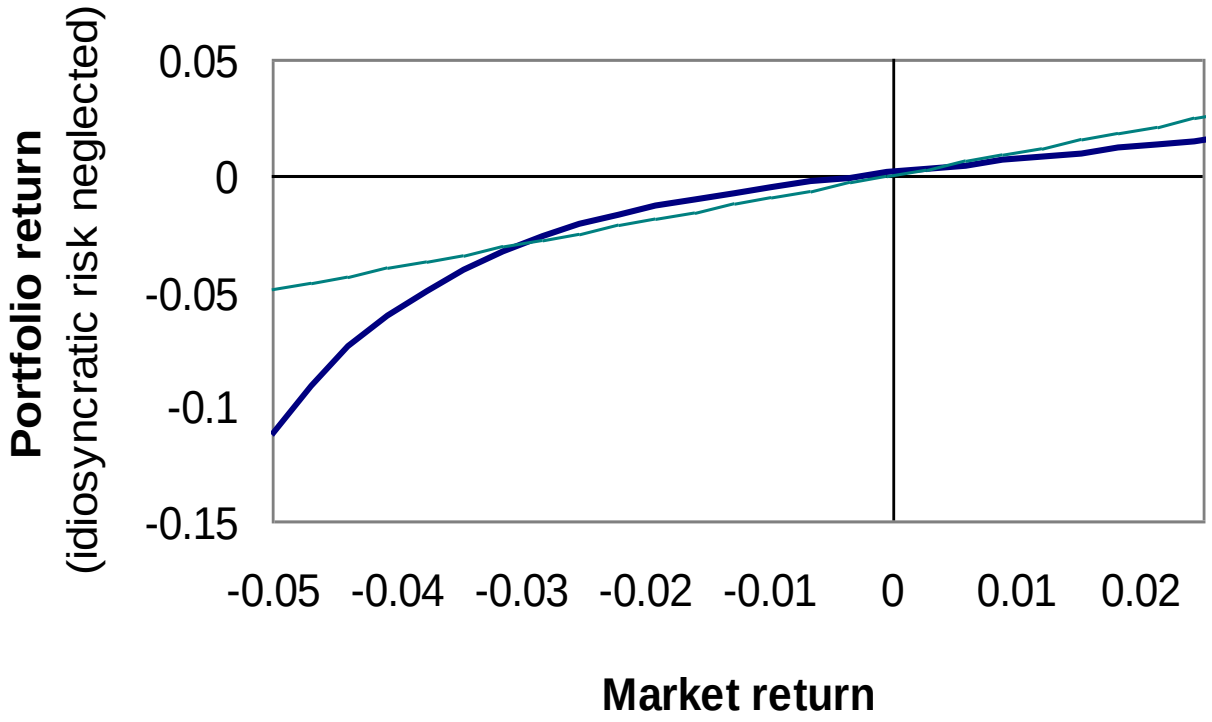
- Comparison of risk ordering from 1 to 16 at different confidence levels, for each SRM
- We simulate returns and (repeatedly) estimate risk measures from realistic amounts of data. We then compare true and estimated risks

How informative are the SRM?
Portfolio type A: “baseline”

- Portfolios A1…A16
- Rising risk only through Beta running from $\beta = 1$ (A1) to $\beta = 2$ (A16)
- No options

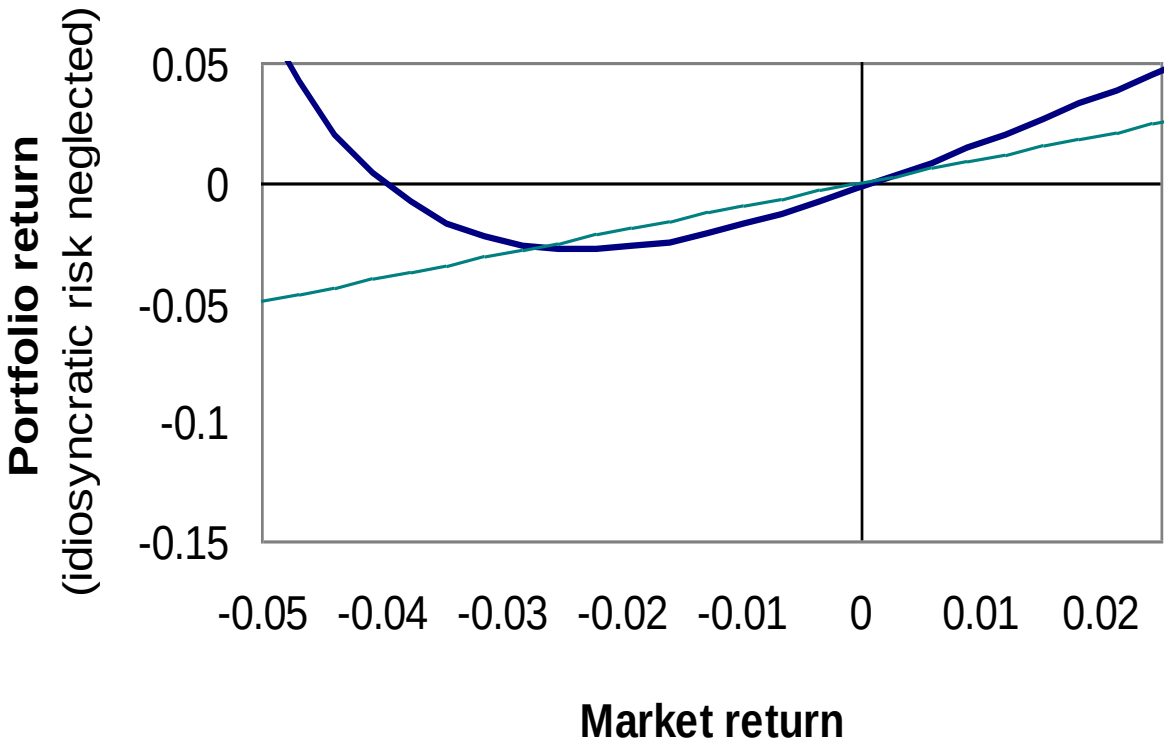
How informative are the SRM?
Portfolio type B: “large risk – concave”

- Portfolios B1…B16; constant Beta = 1
- Linearly growing weight of option positions
- For B16: Put with strike 0.8, weight = –0.45%
  Put with strike 1, weight = 3%



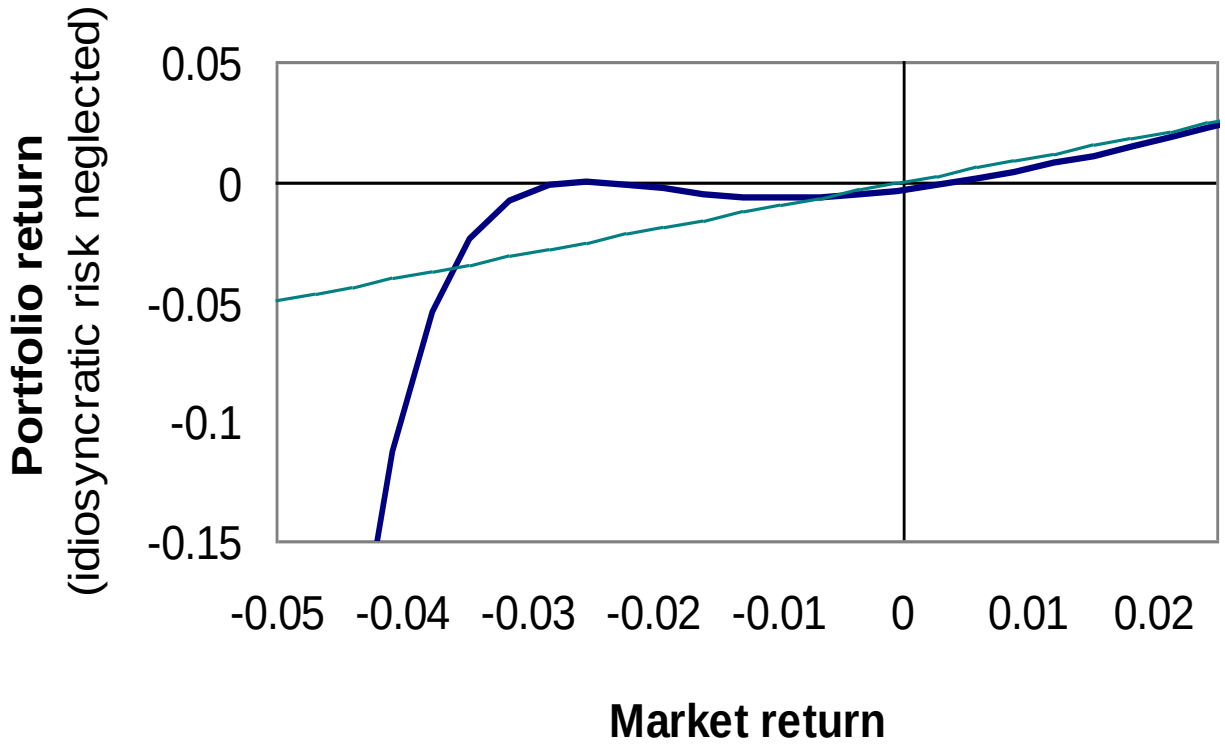
How informative are the SRM?
Portfolio type C: “convex profile”

- Portfolios C1…C16; rising Beta from 1 to 2.15
- Linearly growing weight of option positions
- For B16: Put with strike 0.8, weight = 0.75%



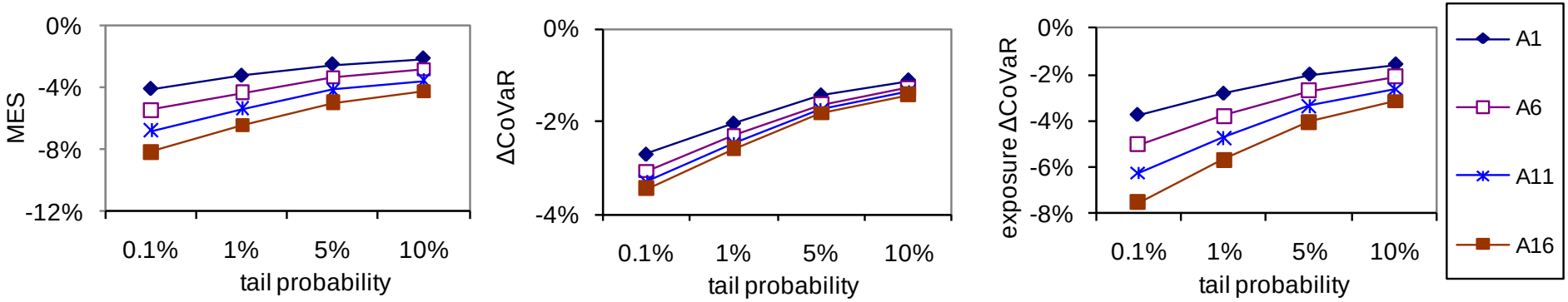
How informative are the SRM?
Portfolio type D: “extreme risk – convex / concave”

- Portfolios D1…D16; rising Beta from 1 to 1.375
- Linearly growing weight of option positions
- For B16: Put with strike 0.7, weight = –4.5%
  Put with strike 0.725, weight = 5.7%



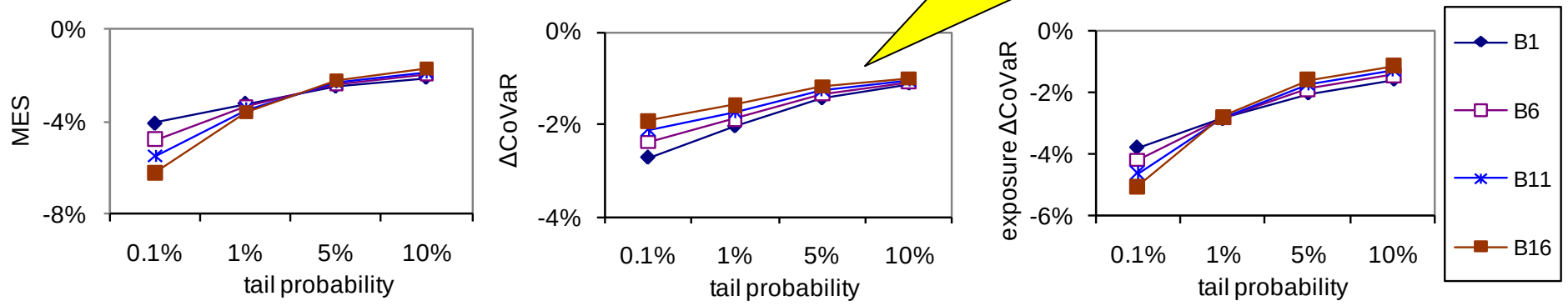
How informative are the SRM?
Exact SRM for different tail probabilities

Portfolio type A: “baseline”



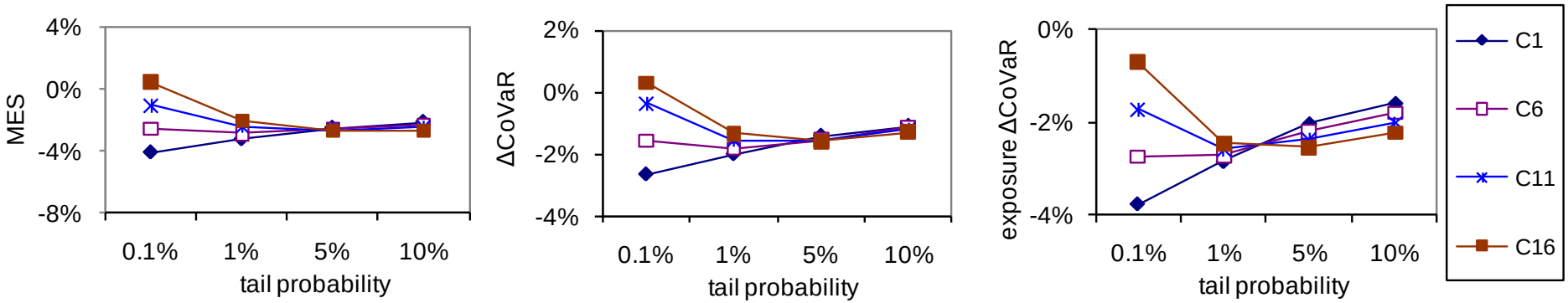
Portfolio type B: “large risk – concave”

wrong order throughout

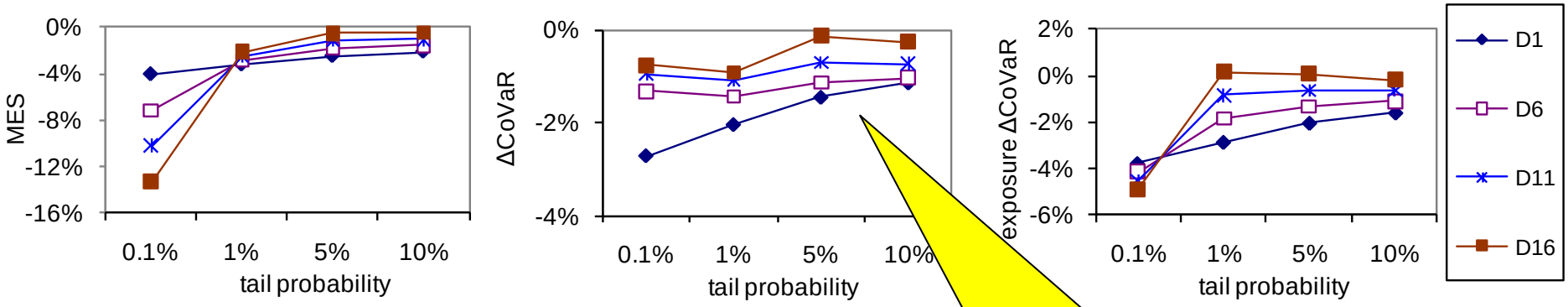


How informative are the SRM?
Exact SRM for different tail probabilities

Portfolio type C: “convex profile”



Portfolio type D: “Extreme risk – convex / concave”



wrong order throughout

How informative are the SRM?
Estimation under realistic conditions: Test set

(1) Choose portfolio setting A or D.

(2) Simulate daily market return and the 16 portfolio returns.

(3) Estimate the risk measures in line with literature:

MES:	260 days, 5% confidence level
ΔCoVaR:	1,300 weeks (each 5 daily returns), quantile regression on 1% confidence level
Tail risk gamma:	260 days, put option with maturity 4 months and strike 70%

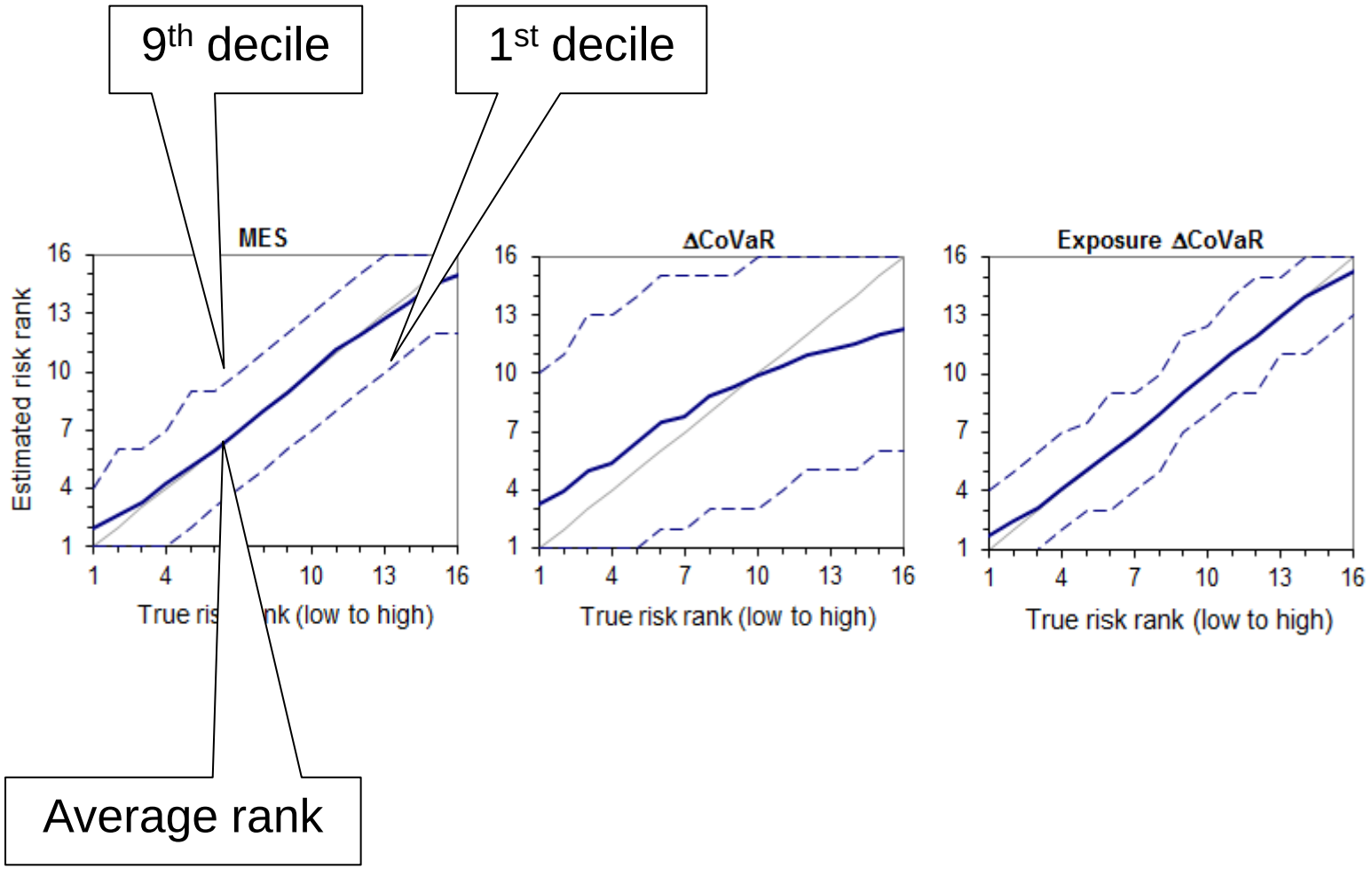
(4) Repeat steps (2) to (3) 1,000 times.

(5) For each simulation, calculate ranks 1…16 of the risk measures of the 16 portfolios.

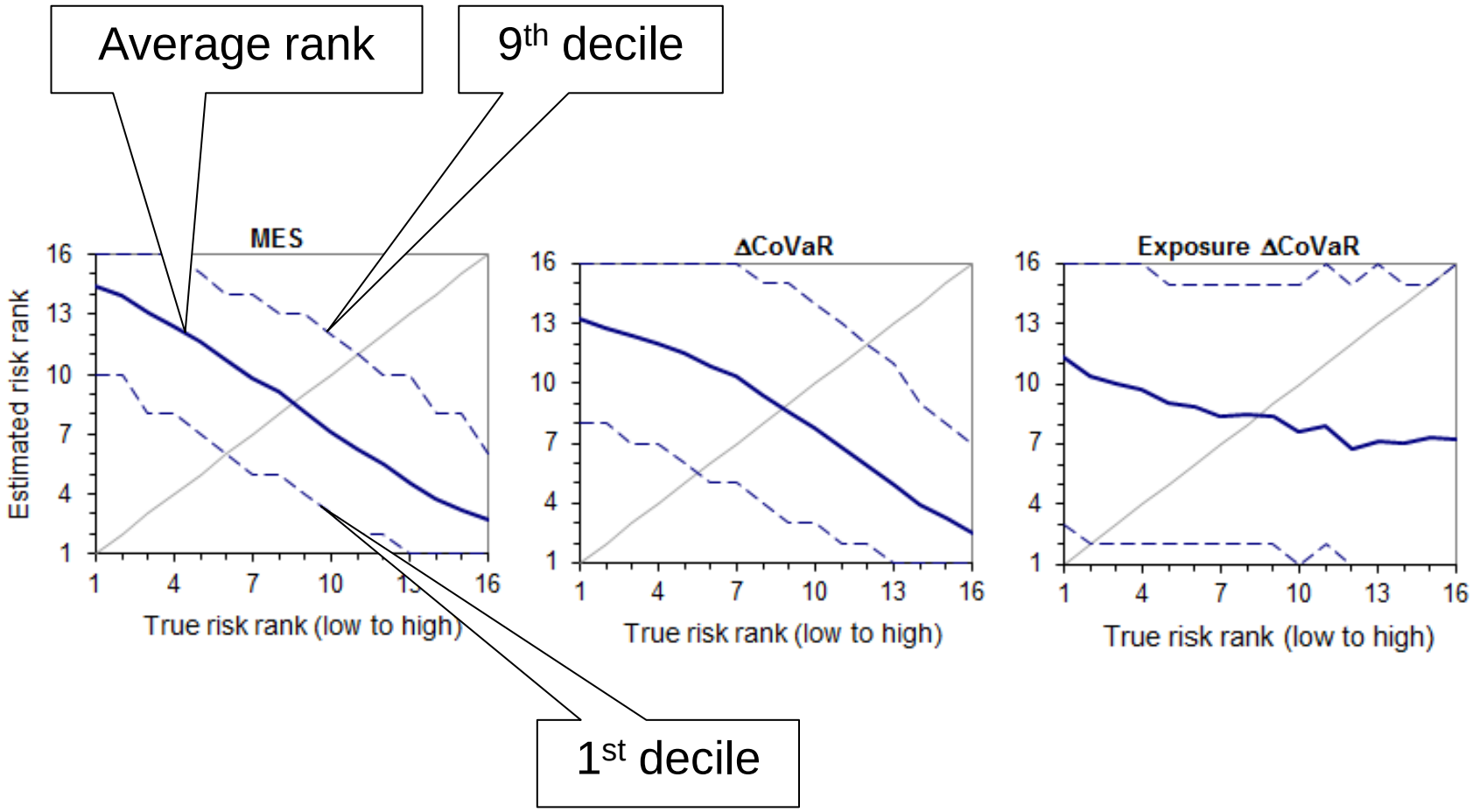
(6) For each portfolio type, evaluate sample of ranks (N=1000)

(7) The exact 0.1% MES (ΔCoVaR) defines the „true“ risk rank

Estimation under realistic conditions: Portfolio type A: “baseline”



Estimation under realistic conditions: Portfolio type D: “Extreme risk – convex / concave”

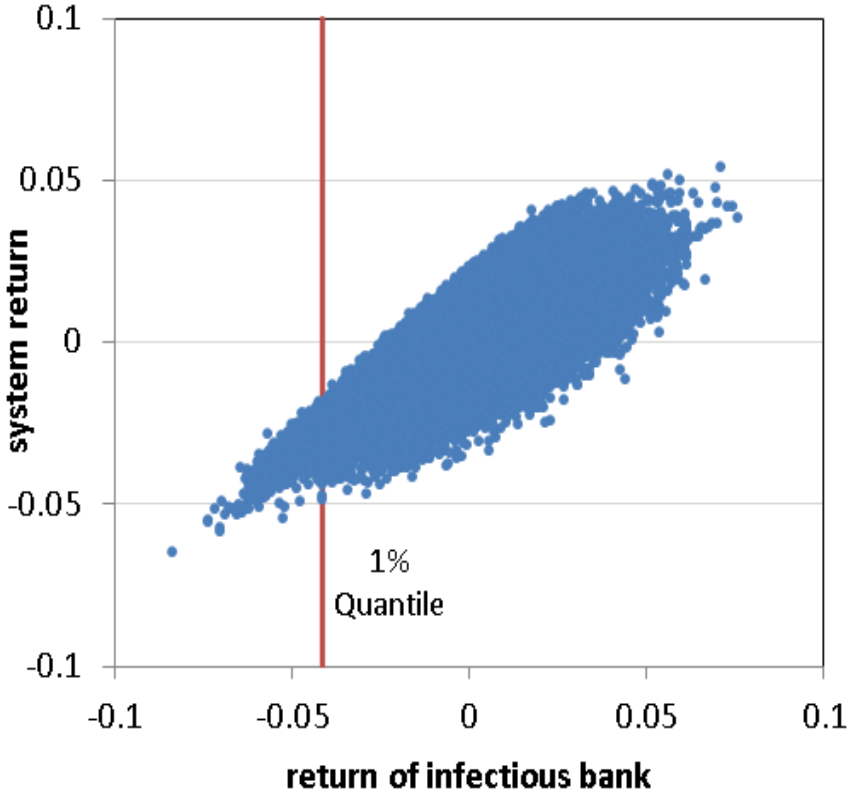


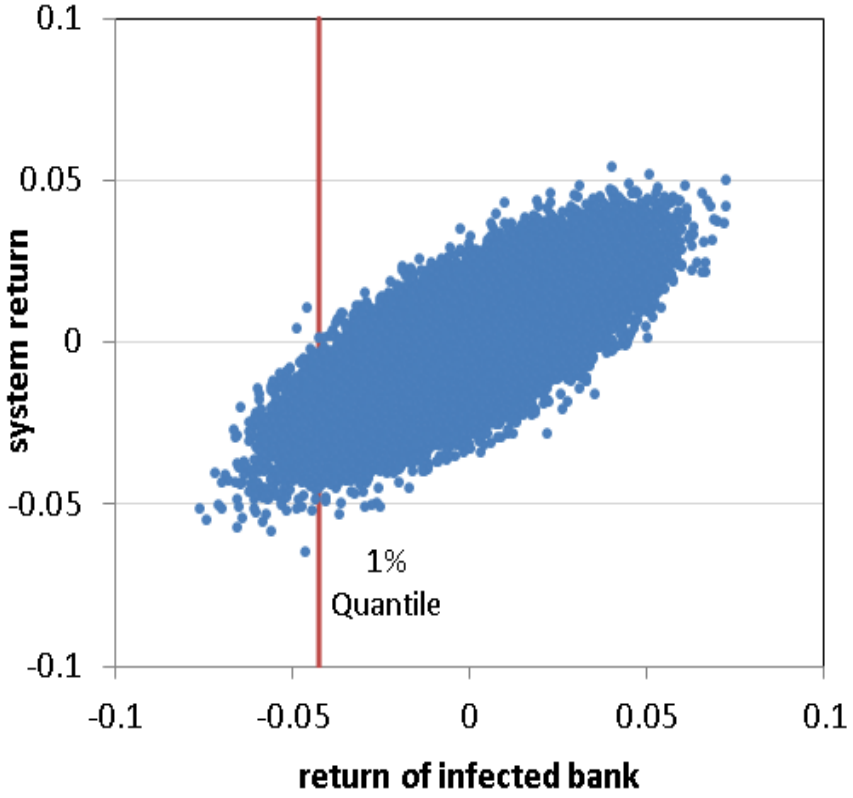
Conclusion

- Some SRM imply strange incentives w.r.t. idiosyncratic risk and size, even in a cosy linear model.
- Contagion model: no clear picture whether, when and by which SRM an infectious banks would be identified.
- No reliable link between SRM for moderate and extreme tails.
- Large risks in the extreme tail can be masked by derivatives.
- Large estimation errors.

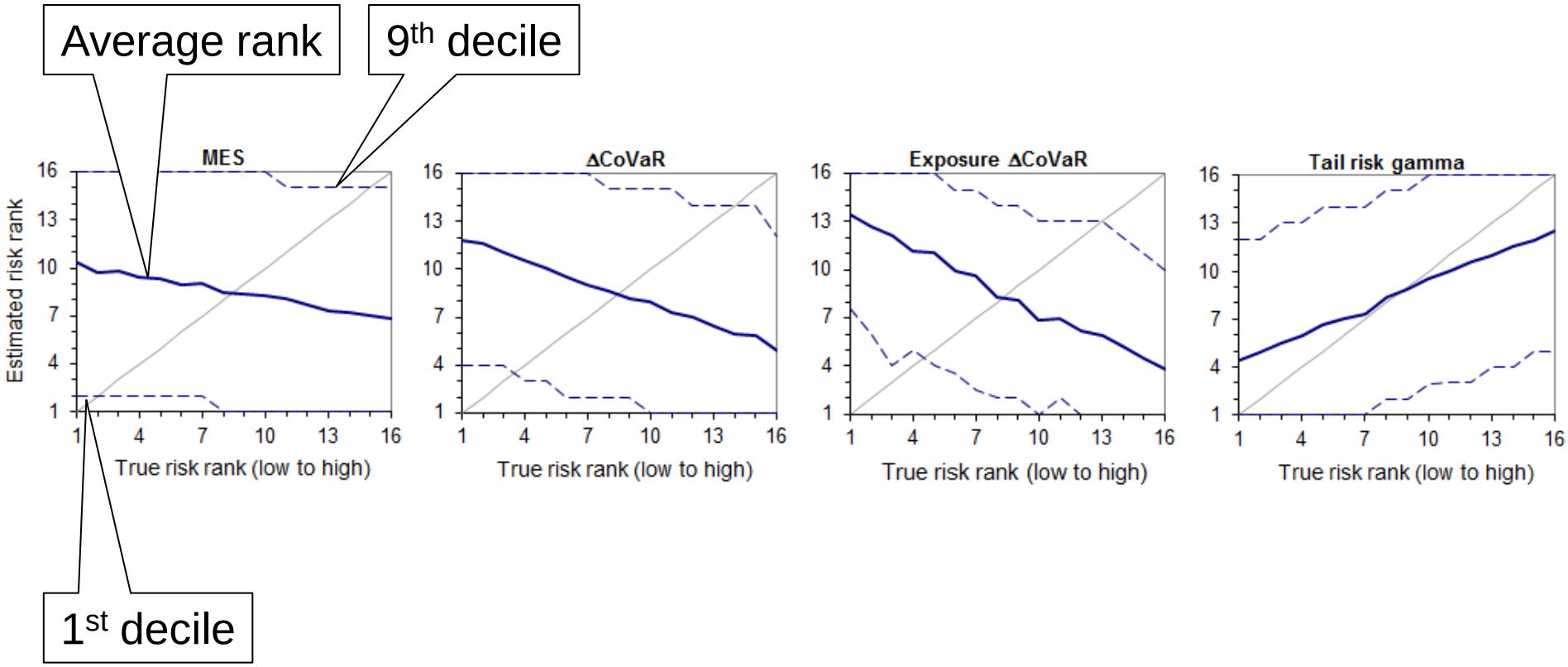
➔ A direct application of the proposed measures to regulatory capital surcharges for systemic risk could create a lot of noise and wrong incentives for banks.

Do these SRM set the right incentives?
Why ΔCoVaR gives the wrong relationship:





Estimation under realistic conditions: Portfolio type B: “large risk – concave”



Estimation under realistic conditions: Portfolio type C: “convex profile”