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Spillover effects among financial institutions: A state dependent sensitivity Value at Risk (SDSVaR) approach

Zeno Adams Roland Füss Reint Gropp
European Business School

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Inspiring Personalities.

Motivation: What do we have in mind?

Investment banks that own corporate bonds may use the swap market to hedge against corporate defaults. But hedge funds frequently take the other side of the swap and at the same time depend on loans from the same bank.

The Economist, August 9, 2007

In addition to complex interactions between banks, there may be complex interactions between banks and non-bank financial institutions

Are these effects first order or can we ignore them?

Contribution

Two main points:

- Develops an approach to modeling the VaR of a system of different institutions or sets of institutions
- Permits time varying model parameters to allow for the possibility that financial institutions interact with each other differently in a crisis than during normal times

Literature

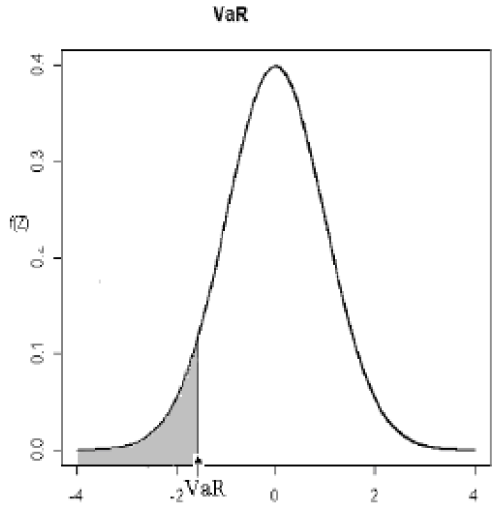
Adds to the growing literature of estimating spill over effects between sets of institutions, in particular hedge funds:

- Marginal Expected Shortfall (MES) (Brownlees and Engle 2010)
- Boyson, Stahel, and Stulz (2010) model contagion in the hedge fund industry using quantile regression
- regime-switching framework to estimate probabilities of switching to a "systemic risk regime" (Chan, Getmansky, Haas, and Lo 2006; Billio, Getmansky, and Pellizon 2009)
- Adrian and Brunnermeier (2010) CoVaR: contribution of financial institutions to systemic risk

Starting point: value at risk

Value-at-Risk

- Maximum loss of an asset/a portfolio over a given time horizon that is only exceeded with small probability θ (in most cases $\theta = 5\%$)
- $prob[return_t < -VaR_t|\Omega_t] = \theta$
- e.g. normal VaR: $VaR = \mu + z \cdot \sigma$
- $z = -1.645$ is the 5% quantile of the standard normal distribution



$\Rightarrow$ only depends on its own return history; does not account for spillover effects

Adrian-Brunnermeier Co-Value-at-Risk (CoVaR)

Co denotes *conditional* or *comovement*

- $prob[return_t < -CoVaR_t|\Omega_t] = \theta$
- $\Omega_t(VaR) = \{r_{i,t-1}, r_{i,t-2}, \ldots, r_{i,0}\}$
- $\Omega_t(CoVaR) = \{r_{i,t-1}, r_{i,t-2}, \ldots, r_{i,0}, VaR_{j,t}\}$

Estimation using quantile regression:

- $CoVaR_{i,j} = \hat{R}_{i,\theta}|VaR_j = \hat{\alpha} + \hat{\beta} \cdot VaR_j$

$\Rightarrow$ CoVaR also accounts for spillover effects

We use a two step approach to obtain SDSVaR

1. compute VaR_i and VaR_j using GARCH(1,1) in order to get a consistent estimate of the volatility dynamics

   $VaR_m = \mu_{m,t} + z \cdot \sqrt{h_{m,t}}$ for $m = i, j, k, l$

   $h_{m,t} = \omega + \alpha \epsilon^2_{m,t-1} + \beta h_{m,t-1}$ (or EGARCH model)

2. use quantile regression to estimate the spillover effects between VaR_i, VaR_j, VaR_k, and VaR_l.

Using quantile regression, we estimate a system of equations of the form:

$$VaR_{i,t,\theta} = \alpha_{i,\theta} + \beta_{1,i,\theta} VaR_{j,t} + \beta_{2,i,\theta} VaR_{k,t} + \beta_{3,i,\theta} VaR_{l,t} + \beta_{4,i,\theta} VaR_{i,t-1} + +u_{i,t}$$

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$$VaR_{l,t,\theta} = \alpha_{l,\theta} + \beta_{1,l,\theta} VaR_{i,t} + \beta_{2,l,\theta} VaR_{j,t} + \beta_{3,l,\theta} VaR_{kt} + \beta_{4,l,\theta} VaR_{l,t-1} + u_{l,t}$$

where i, j, k, l represent the four different sets of financial institutions (commercial Banks, investment banks, insurance companies and hedge funds
Could also be estimated for individual institutions, but the problem obviously becomes intractable quickly

We estimate the system of equations for tranquil, normal and crisis times

Using quantile regression, we estimate a system of simultaneous equations of the form:

$$VaR_{i,t,\theta} = \alpha_{i,\theta} + \beta_{1,i,\theta} VaR_{j,t} + \beta_{2,i,\theta} VaR_{k,t} + \beta_{3,i,\theta} VaR_{l,t} + \beta_{4,i,\theta} VaR_{i,t-1} + +u_{i,t}$$

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We estimate the system of equations for tranquil, normal and crisis times, denoted by θ

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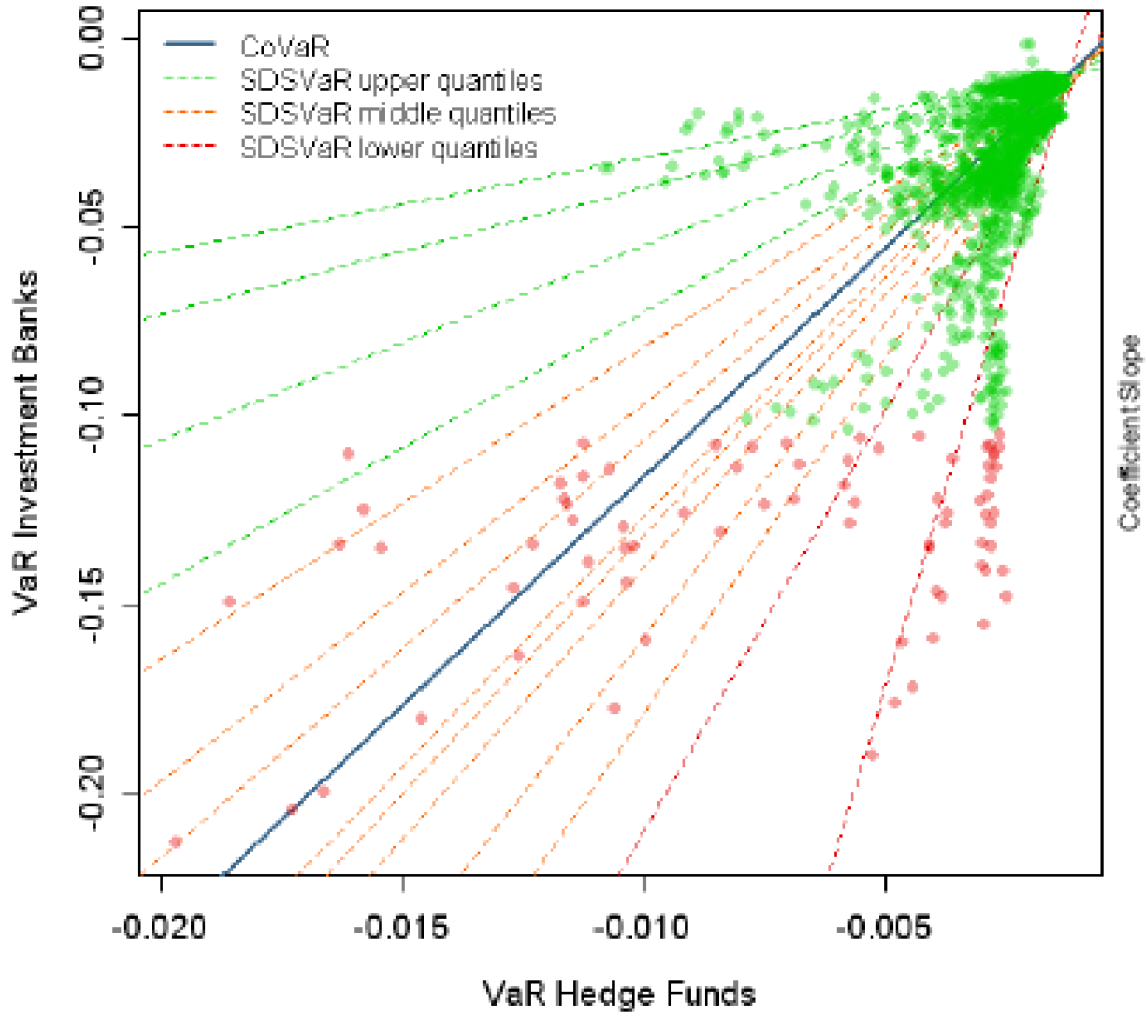
Data on sets of financial institutions

1. Insurance Company Index: 31 Institutions. List taken from Acharya, Pedersen, Philippon, and Richardson (2010); index weights are constructed using PCA
2. Commercial Banks Index 26 Institutions from APPR (2010); index weights are constructed using PCA
3. Investment Banks Index: 8 major investment banks; index weights are constructed using PCA
4. Equally Weighted Hedge Fund Index from Hedge Fund Research (HFR); hedge fund styles: equity hedge, event driven, global macro, and relative value

Daily stock prices from 02/04/2003 - 12/31/2010 (2,023 obs.)

Weekly data yield consistent results.

Why is it so important to estimate spill over coefficients for different market conditions?



from... / to...	Spillover Coefficient B_θ				Lag
	Insurance Companies	Commercial Banks	Investment Banks	Hedge Funds	
			Tranquil		
Insurance Companies	-	0.006***	0.000	0.047***	0.935***
Commercial Banks	-0.003*	-	0.004***	0.014*	0.957***
Investment Banks	0.001	0.005***	-	0.042***	0.940***
Hedge Funds	0.000	0.000	0.000	-	0.867***
Systemic Risk = 0.116	-0.002	0.011	0.0040	0.1030	
			Normal		
Insurance Companies	-	0.018***	0.005	0.044**	0.934***
Commercial Banks	-0.007**	-	0.007**	0.060***	0.975***
Investment Banks	0.001	0.003	-	0.053***	0.957***
Hedge Funds	0.001	-0.001*	0.001*	-	0.913***
Systemic Risk = 0.185	-0.005	0.020	0.013	0.157	
			Volatile		
Insurance Companies	-	0.041***	-0.001	0.293***	1.028***
Commercial Banks	0.009	-	0.016	0.104	1.035***
Investment Banks	-0.002	0.040***	-	0.604***	0.988***
Hedge Funds	-0.009***	0.001	0.010***	-	1.085***
Systemic Risk = 1.106	-0.002	0.082	0.025	1.001	

- Uses the full sample from 4/02/2003 – 12/31/2011 (2,023 obs.)
- ***, **, and * for significance at the 1%, 5%, and 10% level

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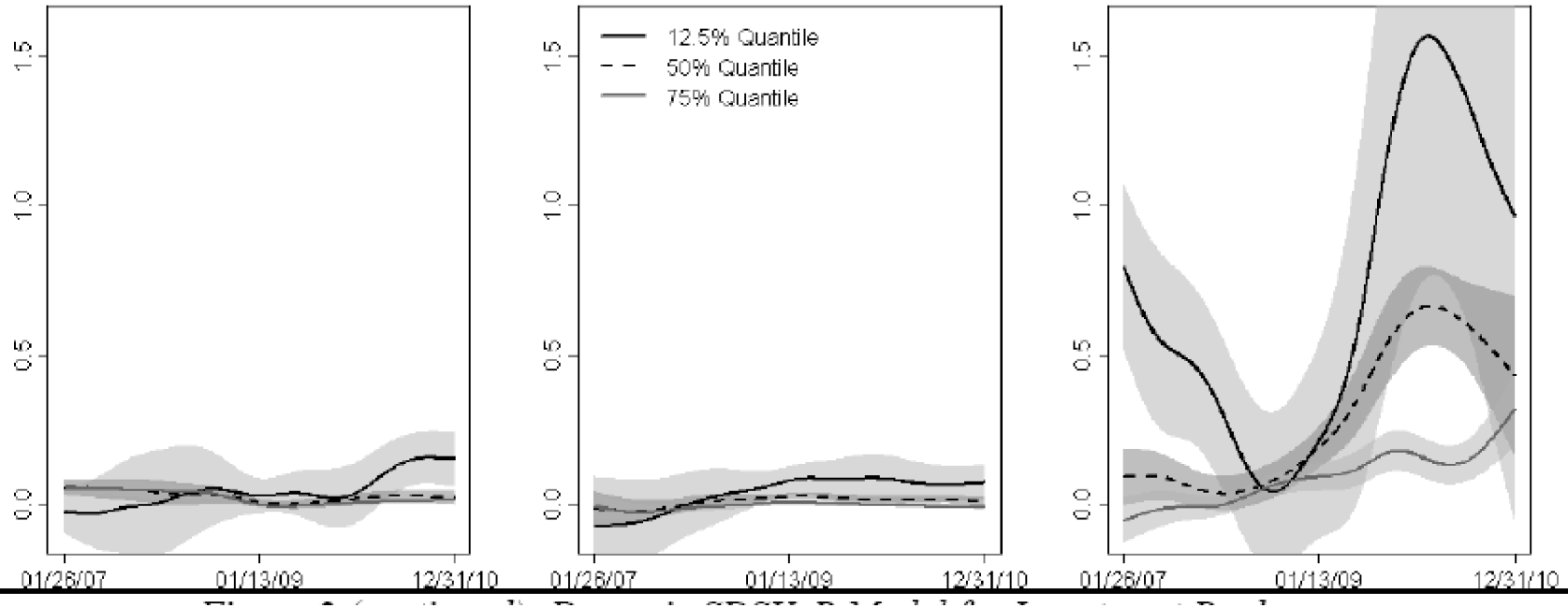
Panel B: Time Varying Coefficients and Error Bands

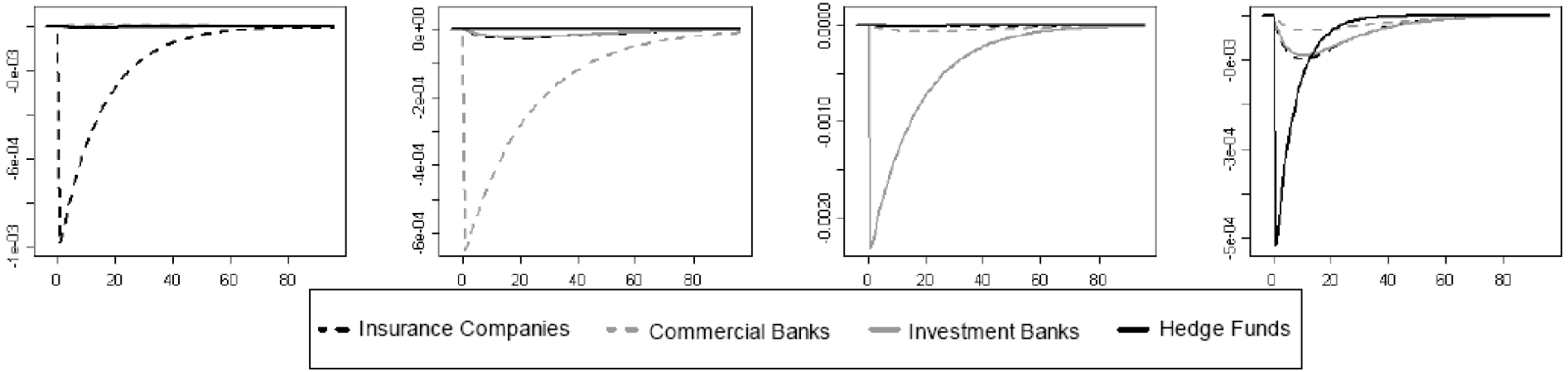
Spillovers from Insurance Comp. *Spillovers from Commercial Banks* *Spillovers from Hedge Funds*



Impulse response functions for a 1% shock of VaR

Figure 3: Impulse Response Functions for Tranquil, Normal, and Volatile Market Conditions

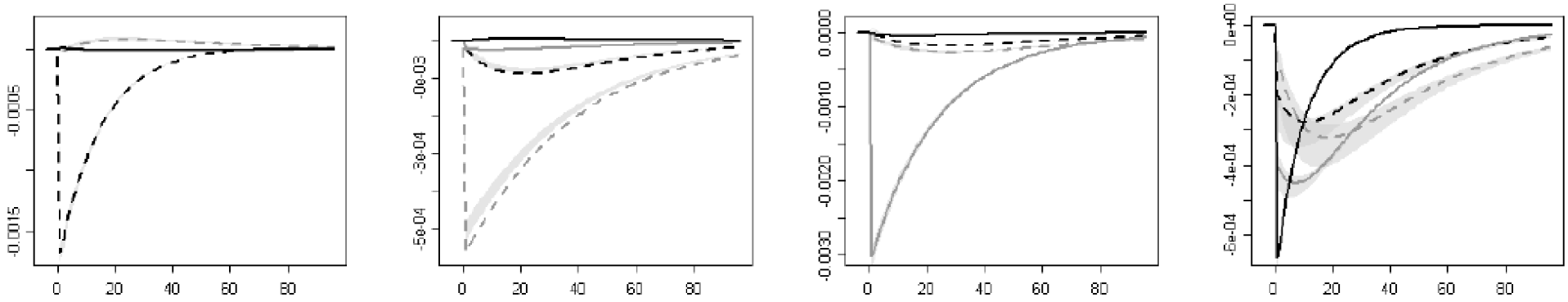
Tranquil Market Conditions: 0.75-Quantile



Calm times

Impulse response functions for a 1% shock of VaR

Volatile Market Conditions: 0.125-Quantile



Crisis times

What can we learn from this exercise?

- Interaction between different institutions, especially hedge funds, is important and probably first order
- But: cannot be accurately measured in calm times
- We measured spill over effects for one particular crisis; unfortunately, we cannot be sure that the effects would be the same during the next crisis
- Hedge Funds seem to play a major role in the transmission of shocks within the financial sector during crisis times

Investment banks that own corporate bonds may use the swap market to hedge against corporate defaults. But hedge funds frequently take the other side of the swap and at the same time depend on loans from the same bank.

The Economist, August 9, 2007

Lessons

- Can a case be made to regulate hedge funds?
  - We focus on the cost of non-regulation, but we do not measure the potential benefits
- Risk map?
- Is this approach useful for risk management?
  - Highlights the imortance of time varying spill-over effects
    - The failure of an institution in calm times will have a different effect than the failure of that same institutions if the market is already “weak”
    - Lehman’s failure may have had very different consequences depending on initial conditions