A Crisis Lesson: Measuring Systemic Rik

CoVaR

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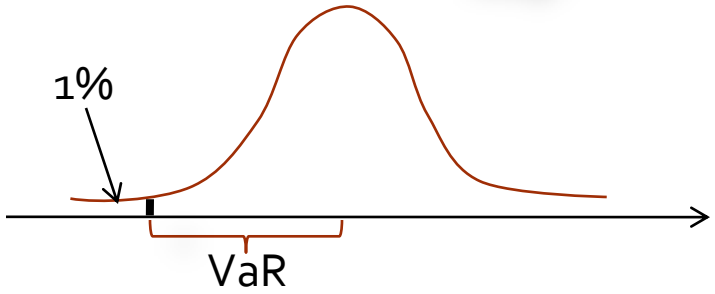
Current bank regulation

1. Risk of each bank in isolation ⇨ Value at Risk



2. Procyclical capital requirements
3. Focus on asset side of the balance sheet matter
   - Asset side
     - Asset by asset – risk weighted ⇨ diversify in off-balance SPV
     - Value at Risk (VaR)
   - Liability side – maturity mismatch gets little attention
     - Maturity rat race
     - Implicit subsidies for short-term funding

Three challenges ….

1. Focus on externalities – systemic risk contribution
   - What are the externalities?
   - How to measure contribution to systemic risk?
     - CoVaR influences
       - Who should be regulated? (AIG, …)
       - What is the optimal
         - capital charge (cap),
         - Pigouvian tax
         - Private insurance scheme?
2. Countercyclical regulation
   - How to avoid procyclicality?
3. Incorporate funding structure
   asset-liability interaction, debt maturity, liquidity risk

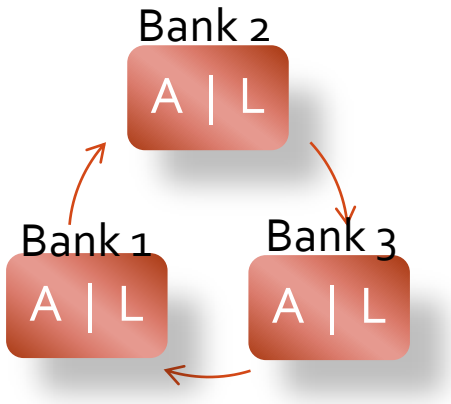
1. Externalities

"stability is a public good"

1. Fire-sale externality
   - Maturity mismatch + Leverage — *liquidity*
     - Raise new funds — **FUNDING LIQUIDITY** *(rollover risk)*
     - Sell off assets (at fire sale prices) — **MARKET LIQUIDITY**

   ⇨ *Fire-sales depress price also for others*

2. Hoarding externality
   - micro-prudent response: Hoard funds/reduce lending
   - not macro-prudent
   - Systemic risk is endogenous (multiple equl)

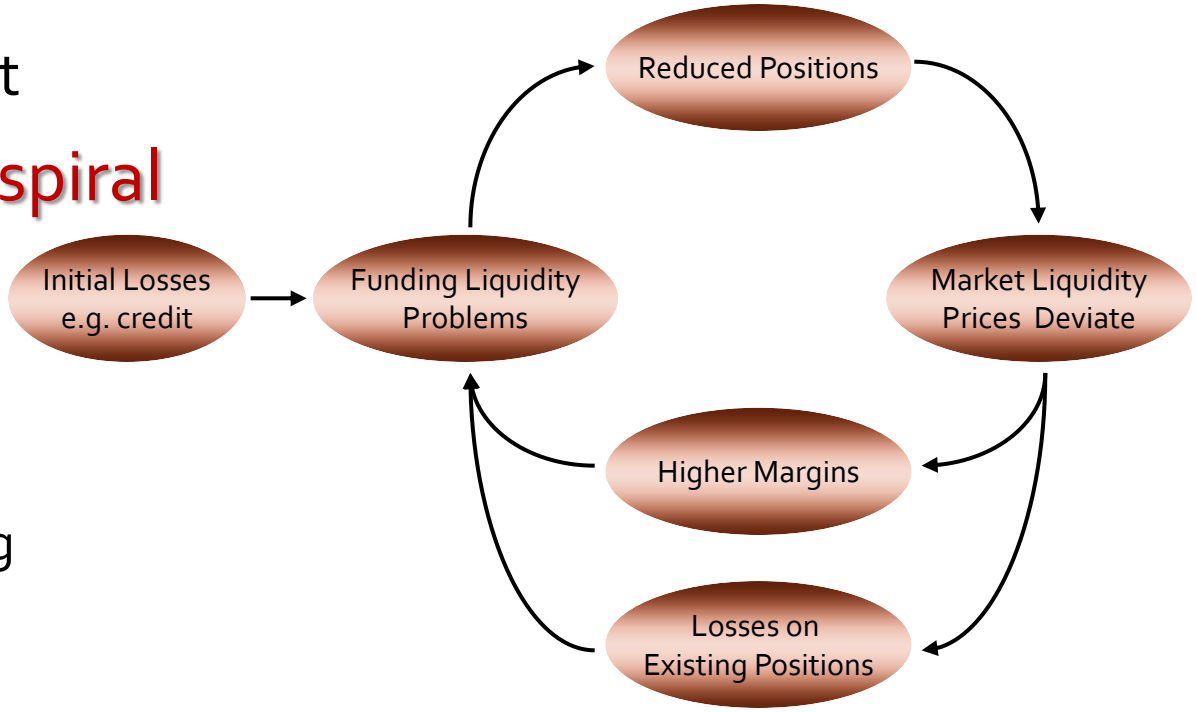


3. Runs – dynamic co-opetition
4. Network Externality
   - Hiding own's commitment ⇨ uncertainty for counterparties

2. Procyclicality due to Liquidity spirals

- Loss spiral
  - ⇨ same leverage
    - mark-to-market
- Margin/haircut spiral
  - ⇨ delever!
    - mark-to-model

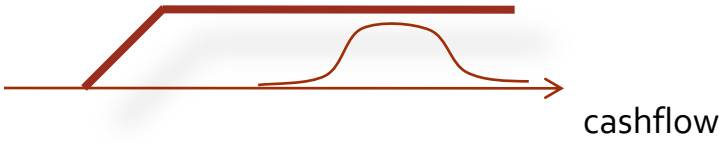
      - Mark-to-funding



Brunnermeier-Pedersen (2009)

Margin/haircut spiral - Procyclicality

- Margins/haircut increase in times of crisis ⇒ delever
  margin = f(risk measure)
- Two Reasons
  1. Backward-looking estimation of risk measure
     - Use forward looking measures
     - Use long enough data series
  2. Adverse selection
     - Debt becomes more information sensitive (not so much out of the money anymore)



- Credit bubbles
  - whose bursting undermines financial system

⇒ Countercyclical regulation

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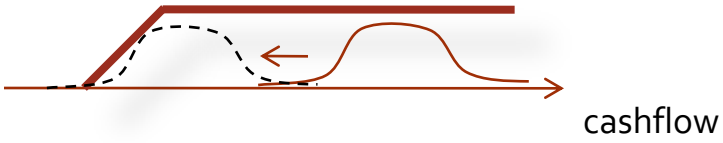

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⇒ Countercyclical regulation

Macro-prudential regulation

1. Externality:
   - Measure contribution of institution to systemic risk: CoVaR
   - Response to current regulation
     "hang on to others and take positions that drag others down when you are in trouble"
     (maximize bailout probability ⇨ **Moral Hazard**)
     - become big
     - become interconnected

2. Procyclicality:
   - Lean against "credit bubbles" – laddered response
     - Bubble + maturity mismatch impair financial system (vs. NASDAQ bubble)
   - Impose Capital requirements/Pigouvian tax/Private insurance scheme
     - *not directly* on ΔCoVaR, but on
     - frequently observed factors, like maturity mismatch, leverage, B/M, *crowdedness* of trades/credit, …

3. Funding: Asset-Liability Maturity Match

Who should be regulated?

group	examples	macro-prudential	micro-prudential
"individually systemic"	International banks (national champions)	Yes	Yes
"systemic as part of a herd"	Leveraged hedge funds	Yes	No
non-systemic large	Pension funds	No	Yes
"tinies"	unlevered	No	No

- Micro: based on risk in isolation
- Macro: Classification on systemic risk contribution measure, e.g. CoVaR or BSMD (Segoviano-Goodhart 2009)
- Annual list (not publicized)

CoVaR

- CoVaR = VaR conditional on
  institute *i* (index) is in distress (at it's VaR level)
- ΔCoVaR = CoVaR - VaR
- Various options (e.g. w.r.t. conditioning)

→ Exposure CoVaR
  - Q1: Which institutions are most exposed if there is a systemic crisis?
  - $VaR^{i} \mid$ system in distress

- Contribution CoVaR
  - Q2: Which institutions contribute (in a non-causal sense)
  - $VaR^{system} \mid$ institution *i* in distress

Overview

- Measuring Systemic Risk Contribution
  - contribution vs. exposure CoVaR
- One Method: Quantile Regressions
- CoVaR vs. VaR
- Addressing Procyclicality
  - Predict using institutions' characteristics
    - Balance sheet variables
    - Market variables (CDS, implied vol.,…)

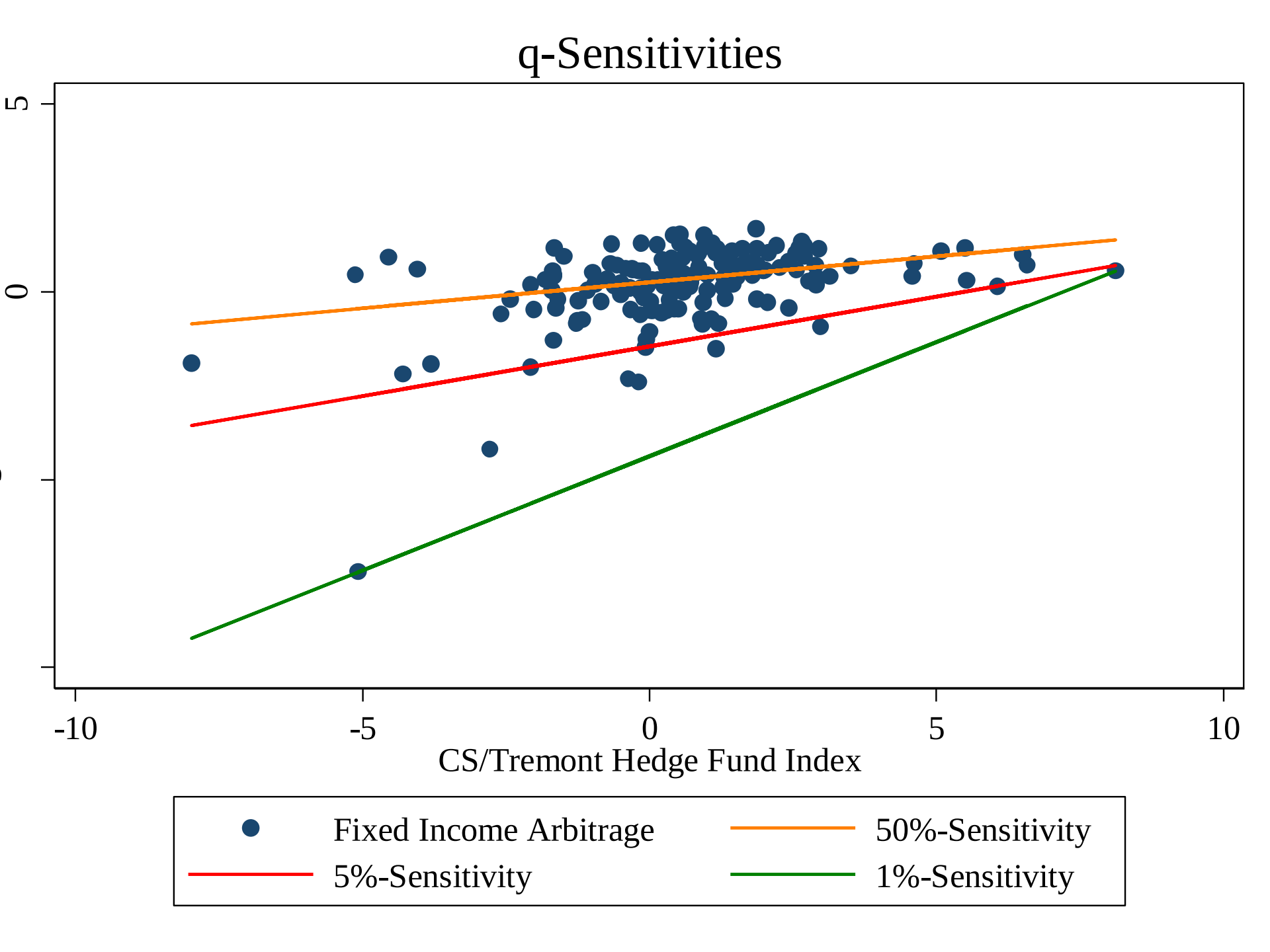
Quantile Regressions: A Refresher

- OLS Regression: min sum of squared residuals

$$\beta^{OLS} = \arg\min_{\beta} \Sigma_t \left(y_t - \alpha - \beta x_t \right)^2$$

- Quantile Regression: min weighted absolute values

$$\beta^{q} = \arg\min_{\beta} \Sigma_t \begin{cases} q\left| y_t - \alpha - \beta x_t \right| & \text{if } \left(y_t - \alpha - \beta x_t \right) \geq 0 \\ (1-q)\left| y_t - \alpha - \beta x_t \right| & \text{if } \left(y_t - \alpha - \beta x_t \right) < 0 \end{cases}$$


q-Sensitivities
5
0
-10
-5
0
5
10
CS/Tremont Hedge Fund Index
Fixed Income Arbitrage
50%-Sensitivity
5%-Sensitivity
1%-Sensitivity

Quantiles = -Value-at-Risk

- Quantile regression:
  - Quantile *q* of *y* as a linear function of *x*

$$\hat{y}_q \mid x = F_y^{-1}(q \mid x) = \alpha_q + \beta_q x$$

where $F^{-1}(q|x)$ is the inverse CDF conditional on x

- Hence, $F^{-1}(q|x)$ = *q*% Value-at-Risk conditional on *x*.
  - Note out (non-traditional) sign convention!

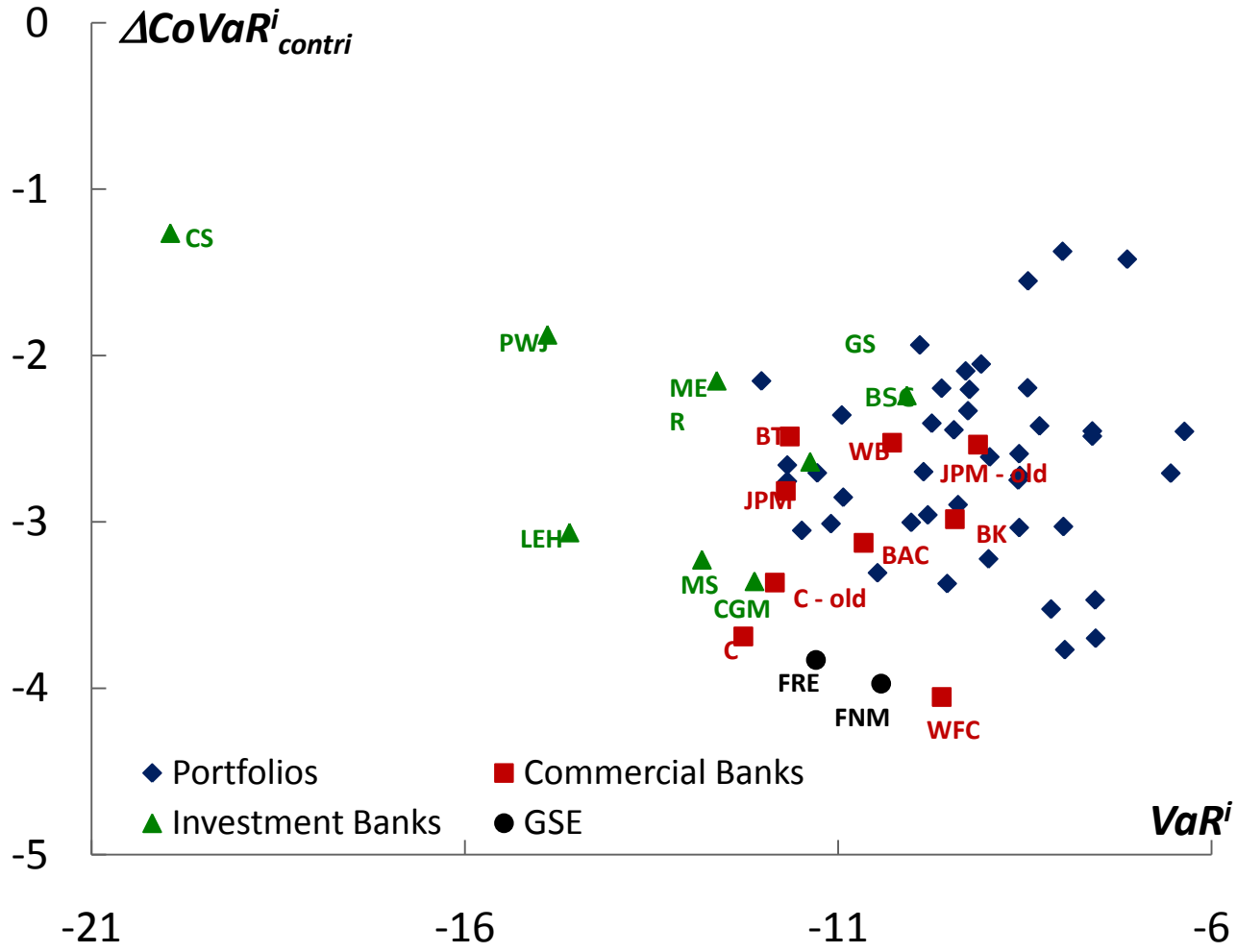
CoVaR - using quantile regressions

$$CoVaR_q^{ij} = VaR_q^i \mid VaR_q^j = \alpha_q^{ij} + \beta_q^{ij} VaR_q^j$$

$$\Delta CoVaR_q^{ij} = CoVaR_q^{ij} - VaR_q^i$$

- Illustration:
  - Same individual VaR, but A's CoVaR > B's CoVaR
  - Analogy to Covariance in CAPM
- Various conditionings?
  1. *Exposure CoVaR:* Individual institution on financial index
     - Who is vulnerable/exposed to?
  2. *Contribution CoVaR:* Financial index on individual institution
     - Who contributes?
  3. *Risk Spillover:* Institution/strategy *i* on institution/strategy *j*

Q2: Who "contributes" to systemic risk?



- VaR does not capture systemic risk contribution $\Delta\,\mathrm{CoVaR}_{\mathrm{contri}}$
- Data up to 2007/12

Overview

- Measuring Systemic Risk Contribution
  - contribution vs. exposure CoVaR
- One Method: Quantile Regressions
- CoVaR vs. VaR
- Addressing Procyclicality
  - Time-varying CoVaRs
  - Link to institution characteristics
    - Balance sheet variables
    - Market variables (CDS, implied vol.,…)

Avoid Procyclicality

- Regulatory charges on $\Delta CoVaR_{contri}$ may introduce procyclicality
  - Like VaR does in Basel II framework
- Way out:
  Link + ***predict*** $\Delta CoVaR_{contri}$ to frequently observed characteristics (use Panel data structure)
  - Maturity mismatch
  - Leverage
  - …. special data only bank supervisors have
    (e.g. crowdedness , interconnectedness measures)
- Steps:
  1. Time-varying CoVaR (linked to macro variables)
  2. Predict CoVaR with institution specific variables

Time-varying CoVaR

- Relate to macro factors — interpretation
  - VIX Level — "Volatility"
  - 3 month yield
  - Repo – 3 month Treasury — "Flight to Liquidity"
  - Moody's BAA – 10 year Treasury — "Credit indicator"
  - 10Year – 3 month Treasury — "Business Cycle"
  - (House prices)
  - (Aggregate Credit growth/spread)
  - (Haircut/margins (LTC ratios))

… let's figure out what matters!

- Obtain Panel data of CoVaR
  - Next step: Relate to institution specific (panel) data

Predictive (1 year lag)

PANEL A: INSTITUTIONS

PANEL B: PORTFOLIOS

	$CoVaR^i_{contri}$		$CoVaR^i_{exp}$		$CoVaR^i_{contri}$		$CoVaR^i_{exp}$	
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	FE, TE	FE	FE, TE	FE	FE, TE	FE	FE, TE	FE
VaR (lag)	0.02**	0.05***	-0.06**	0.03*	0.20***	0.14***		-0.26***
Mat-Mism(lag)	-0.30	-0.30	-1.84**	-1.79**	1.20***	0.25		0.04
Leverage (lag)	-0.02***	-0.02***	-0.01	-0.02	-0.01***	-0.04***		-0.01*
B/M (lag)	-0.27**	-0.19**	-0.08	0.71***	-0.14	0.57***		-0.53***
Size (lag)	9.94	10.61	27.43*	-15.68	-0.52	-1.34		2.52
Constant	-0.35	-0.65**	-5.04***	-3.84***	-0.55**	-0.63***		-6.13***
Observations	1657	1657	1657	1657	2486	2486		2486
R-squared	0.66	0.40	0.62	0.48	0.72	0.38		0.71

Predicting with Market Variables

	ΔCoVaR_contrib				ΔCoVaR_exp			
COEFFICIENT	1 Quarter	1 Year	1 Quarter	1 Year	1 Quarter	1 Year	1 Quarter	1 Year
CDS_beta (lag)	-0.25***	-0.58**			-1.24***	-2.54***		
	(0.05)	(0.23)			(0.39)	(0.85)		
ΔCDS (lag)	0.05	0.06			1.39	-1.28		
	(0.17)	(0.68)			(1.10)	(2.20)		
IV_beta (lag)			-0.34***	-0.67***			-1.75***	-3.33**
			(0.11)	(0.18)			(0.30)	(1.39)
DIV (lag)			-0.05	-0.77***			0.63	-0.56
			(0.28)	(0.19)			(0.59)	(1.04)
Constant	-1.17***	-1.28***	-1.13***	-1.15***	-4.65***	-4.82***	-4.33***	-4.20***
	(0.04)	(0.07)	(0.07)	(0.08)	(0.15)	(0.24)	(0.17)	(0.52)
Observations	178	148	178	148	178	148	178	148
R-squared	0.59	0.54	0.55	0.55	0.71	0.68	0.72	0.65

1) beta w.r.t. first principal component on changes in CDS spreads within quarter
2) panel regression with FE – (no findings with FE+TE)

Countercyclical Regulation

- *When market is relaxed*
  Strict Laddered Response
  - **Step 1:** supervision enhanced
  - **Step 2:** forbidden to pay out dividends
    - See connection to debt-overhang problem)
  - **Step 3:** No Bonus for CEOs
  - **Step 4:** Recapitalization within two months + debt/equity swap
- *When market is strict*
  Relax regulatory requirement

What type of charge?

- Capital charge
  - Strictly binding
  - Might stifle competition
- Pigouvian tax + government insurance
  - Generates revenue
  - In times of crisis it is cheap to issue government debt
  - very salient
- Private insurance scheme
  - (Kashap, Rajan & Stein, 2008 + NYU report)
  - Requires lots of regulation

Conclusion

- Macro-prudential regulation
  - Focus on externalities
  - Measure for systemic risk is needed, e.g. CoVaR
  - Maturity mismatch (+ Leverage) – encourage long-term funding
- Countercyclical regulation
  - Find variables that predict average future CoVaR
  - Forward-looking measures, spreads, …
- Also,
  - VaR measure is not sufficient – incorrect focus
  - Quantile regressions are simple and efficient way to calculate CoVaR