Systemic Risk: Models and Policy
Narodna Banka Srbije

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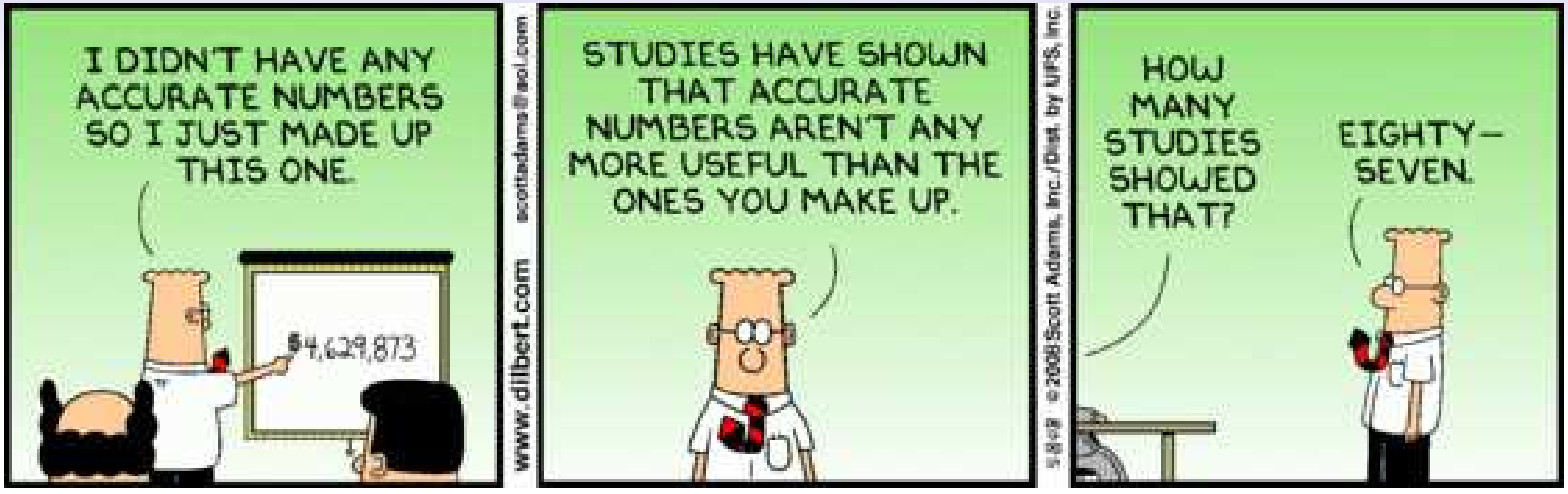
http://www.RiskResearch.org


I DIDN'T HAVE ANY ACCURATE NUMBERS SO I JUST MADE UP THIS ONE.
$4,629,873
www.dilbert.com scottadams@aol.com
STUDIES HAVE SHOWN THAT ACCURATE NUMBERS AREN'T ANY MORE USEFUL THAN THE ONES YOU MAKE UP.
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HOW MANY STUDIES SHOWED THAT?
EIGHTY-SEVEN.

Two Papers

Both with with Kevin R. James, Marcela Valenzuela and Ilknur Zer

- "Model Risk of Systemic Risk Models"
- "Dealing With Systemic Risk when We Measure It Badly"

Disclaimer

- I like models
  - I even dated one
- I create them
- I teach them
- I have a book on forecasting market risk with models

Still they have limits we should know

I will discuss the use of risk models for systemic risk, it does not apply to internal risk management in financial institutions.

What is Systemic Risk (SysRisk)

What is systemic risk?

- BIS: risk that the failure of a participant to meet its contractual obligations may in turn cause other participants to *default*
- Jean–Claude Trichet: risk that widespread instabilities in the financial system translate into adverse effects on *growth and welfare* in the economy at large

Financial system focussed or real economy focussed

Extreme but common view of systemic risk

The risk that the entire financial system may collapse, causing a real economy collapse, as opposed to risk confined to an individual part of the financial system.

Systemic risk arises from the interlinkages present in the financial system, where the failure of an individual institution may cause cascading failures, bringing down the entire financial system, i.e. cause a systemic event.

Differing views on systemic risk

- Some look at extreme events, those that never happen (definition on last slide)
- Others call common crises systemic events (IMF database)
- Most empirical systemic risk measures find that market turmoil happening 2.5 times a year (CoVaR) or 12 times a year (SES/MES) systemic
- Or something in between
- Policy response depends on ones notion of systemic risk

Role of the market

- Profit maximizing behavior can cause financial institutions to take on considerable risk.
- Minsky (1992) argued that economies have either *stable or unstable* financial regimes. Even if the economy starts out stable, continued prosperity paves the way for an unstable system
- *Stability is destabilizing* because financial institutions have a tendency to extrapolate stability into infinity, investing in ever more risky debt structures, followed an abrupt correction
- Like before 2007s when all were blind to the hidden risk during the "*great moderation*".

Role of the government

- Systemic risk can be greatly increased by some government policies adopted in the name of preventing systemic risk
- *Analogy*: Governments provide flood insurance and hence encourage home owners to build in flood plains
- The EU is now creating systemic risk

Fisher Black (1995)

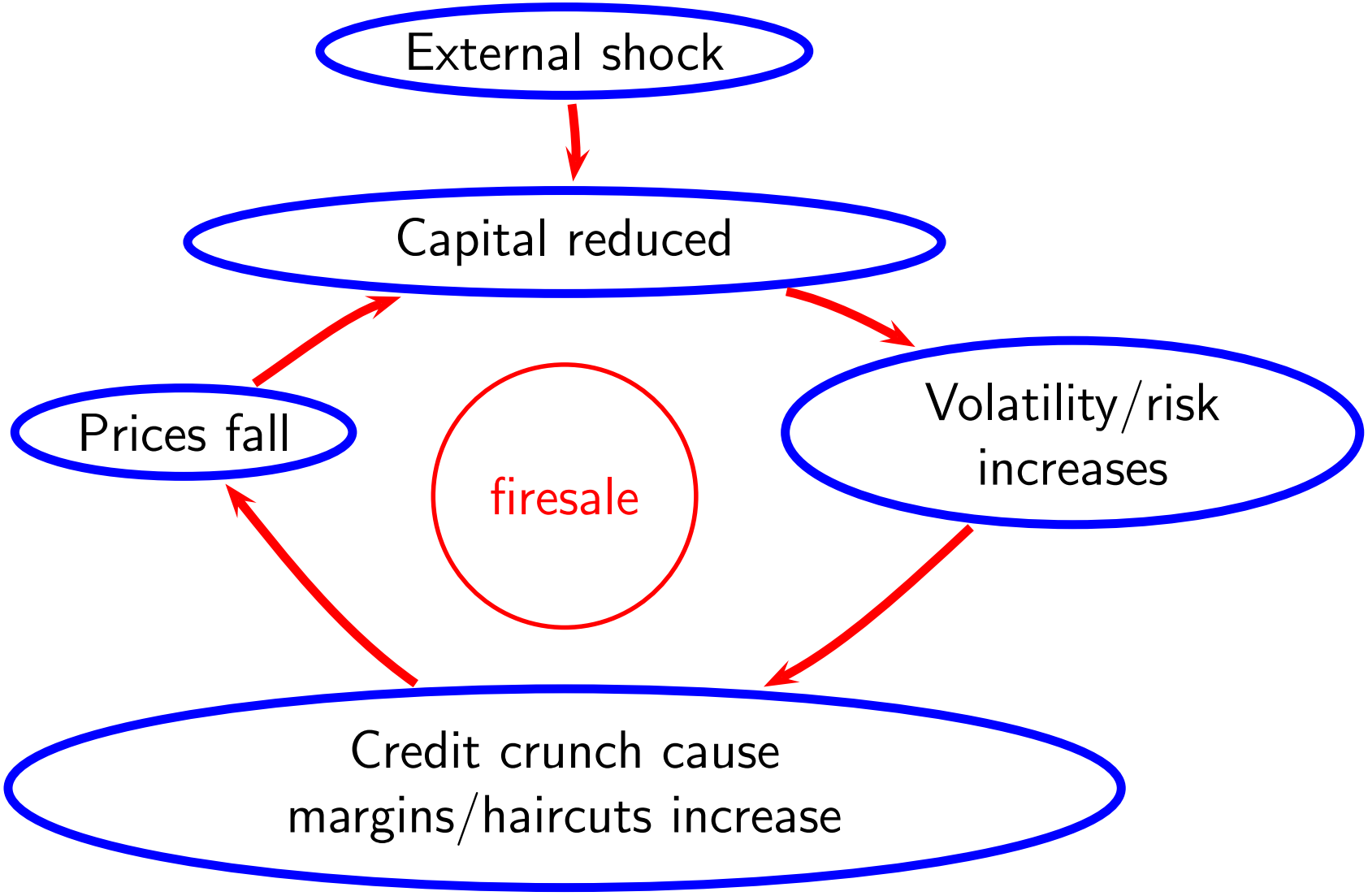
Fisher Black, (1995) has even a stronger view:

When you hear the government talking about systemic risk, hold on to your wallet!
It means that they want you to pay more taxes for more regulations, which are likely to create systemic risk by interfering with private contracting ...
In sum, when you think about systemic risks, you'll be close to the truth if you think of the government as causing them rather than protecting us from them.

Channels for systemic risk

1. Contagious failure in confidence
2. Interdependence
3. Amplification mechanisms (like fire sale externalities on next slide)

Fire sale externalities



Enabling factors for systemic risk

this list is not complete, there will be disagreements and overlaps

- Fire sale externalities (not addressed)
- Liquidity (Basel III)
- Complexity (UK government)
- Leverage (Basel III)
- Information asymmetry (CCP)
- Endogenous risk (not addressed)
- Network effects (not addressed)
- Perverse incentives (not addressed)
- High frequency trading (UK government)

Some proposed remedies for systemic risk

This is of course incomplete

- Activity restrictions
- *Bank capital* (my focus today)
  - Risk sensitive capital
  - Countercyclical capital
- Central bank liquidity provision
- Addressing too big to fail
- Narrow banking
- Living wills
- Central counterparty (CCP)
- Leaning against the wind

Modelling Systemic Risk

Assumptions behind almost every risk and pricing model known

- Risk is *exogenous* (we are strictly price takers)
- Market prices are the best reflection of value
- Today's price has most information

If true, consequently

- The best way to forecast risk (even prices) is to combine a *historical sample* of prices
  - With a model like EWMA, HS, IV, etc. ...
- Best to *down weigh history*
- Price dynamics in a crisis belong to the *same stochastic process* as price dynamics outside of crisis

However . . .

- Risk is really *endogenous*
- Prices reflect *constraints* (margins, capital, politics, etc.)
- These effects are stronger during crises
- Forces driving prices and risk are different in a crisis than out of crisis
- The underlying economic process may be the same, but we are talking statistics

So ...

- A different class of models (currently mostly nonexistent) is required to forecast *extremes* or *crisis* or *systemic risk*
- From a fundamental economic point of view the financial system may follow the same economic process over time
- From a practical and statistical point of view the *stochastic processes are different* in crisis and non–crisis
- With implications for how to do modeling
  - What is the point of things like extreme value theory in finance?

The quest for the riskometer

Like the quest for the holy grail or alchemy? (A lot of good came out of alchemy)

- We are chasing after a mythical beast called a *riskometer* (with same accuracy as thermometers)
- Existing risk–modelling technology enables us to construct only wildly imprecise riskometers
- Hence, risk models often provide a poor foundation for decision making

Is the riskometer a myth?

Models and time

- Most risk models are based on snapshot measurements (maybe sequence of daily observations)
- Stochastic model
- Covering *all states of the world*
- Usually no *structural breaks* entertained

How reliable is observed data?

- Does current data on the European sovereigns reflect the real risk?
- Market prices reflect procyclical external constraints (margins, politics, etc)
- Observed data may indicate what is going on right now
  - sometimes well, sometimes badly
- But often is a very poor input into a forecast model

Risk in crises

- Estimating a model on *non–crisis* data is unlikely to say very much about risk *during* times of stress
- Very little data available
- Risk building up in quiet times

We can not get from the failure process in normal times to the failure process in crisis times

Empirical Models of Systemic Risk

Bank failures and the financial system

- Bank failure probabilities are dependent
- The social cost of a failure increases with the failure probabilities of *other banks*, so...
- A banks socially optimal level of capital depends upon both its shock distribution and the state of the financial system

Some popular sysrisk models

- CoVaR — Adrian & Brunnermeier
- SES — Acharya, Pederson, Philippon & Richardson
- Shapley — Tarashev, N., C. Borio and K. Tsatsaronis
- Banking stability measures — Segoviano & Goodhart

All start with daily 99% or 95% value–at–risk (VaR)

General Model

- R_i is risky outcomes of institution i
- R_S is outcomes from the entire financial system
- Joint distribution is:

$$f\left(R_i, R_S\right)$$

- *Marginal* density is $f\left(R_i\right)$, and the two *conditional* densities are $f\left(R_i|R_S\right)$ and $f\left(R_S|R_i\right)$
- *VaR*, (where Q is a quantile)

$$\text{pr}[R_i \leq Q_i] = p$$

Common measures

these things are much more similar than often maintained

Marginal risk measure	Condition on system	Condition on institution
	MVaR	*CoVaR*
VaR	$\text{pr}[R_i \leq Q_i \mid R_S \leq Q_S] = p$	$\text{pr}[R_S \leq Q_S \mid R_i \leq Q_i] = p$
	MES	CoES
ES	$\text{E}[R_i \mid R_S \leq Q_S]$	$\text{E}[R_S \mid R_i \leq Q_i]$

- Other measures like Shapley fit into this
- *All depend on daily VaR*

Data

- Daily total returns January 1997–December 2010 (+ some state variables for CoVaR)
- 92 largest US financial institutions
- Here four representative stocks: Bank of New York Mellon (BK), JP Morgan Chase& Co. (JPM), State Street (STT) and US Bancorp (USB)
- Full results and all code for estimation can (will) be found in the Webappendix, `www.RiskResearch.org/sysrisk`

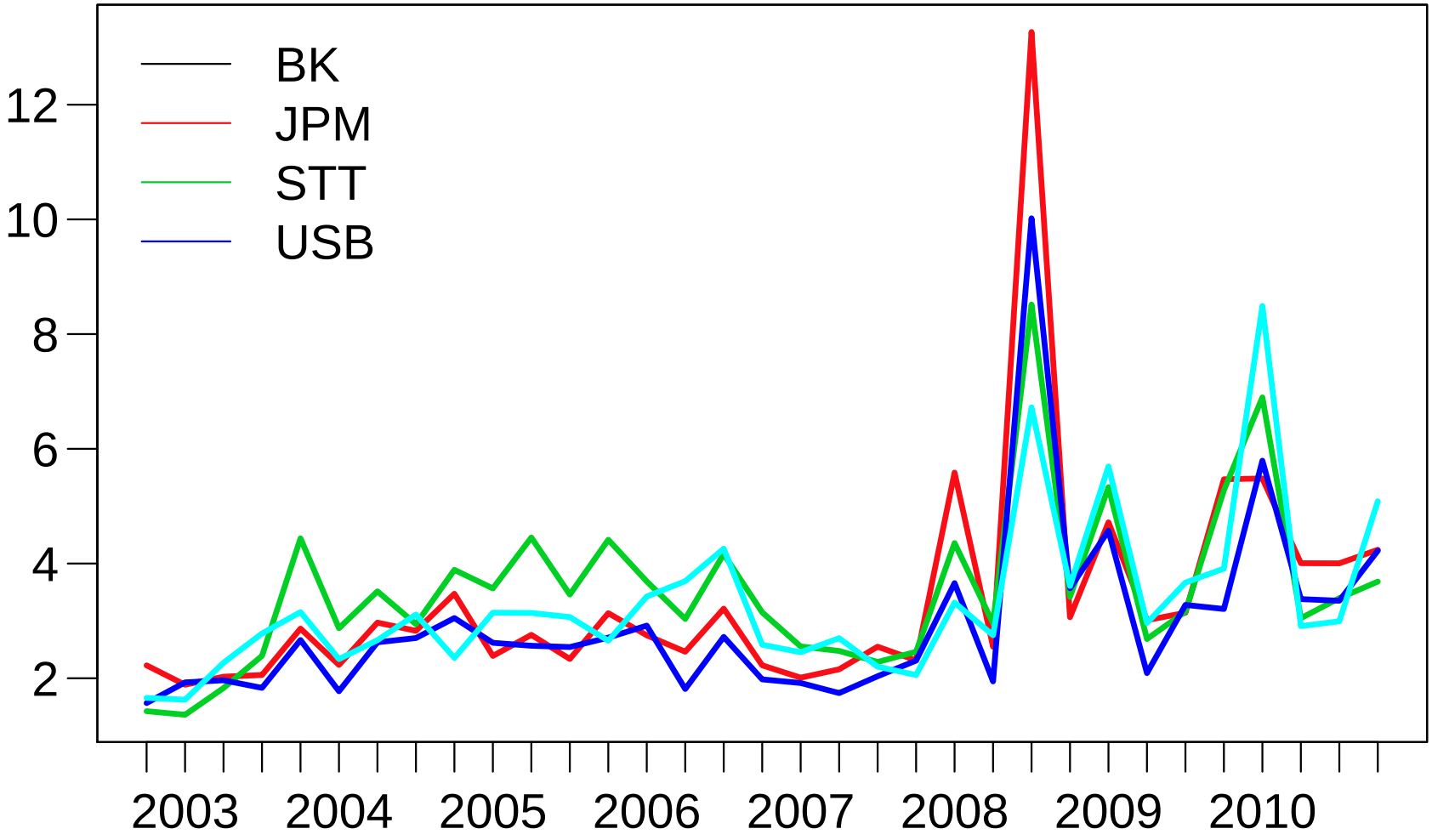
Results

VaR

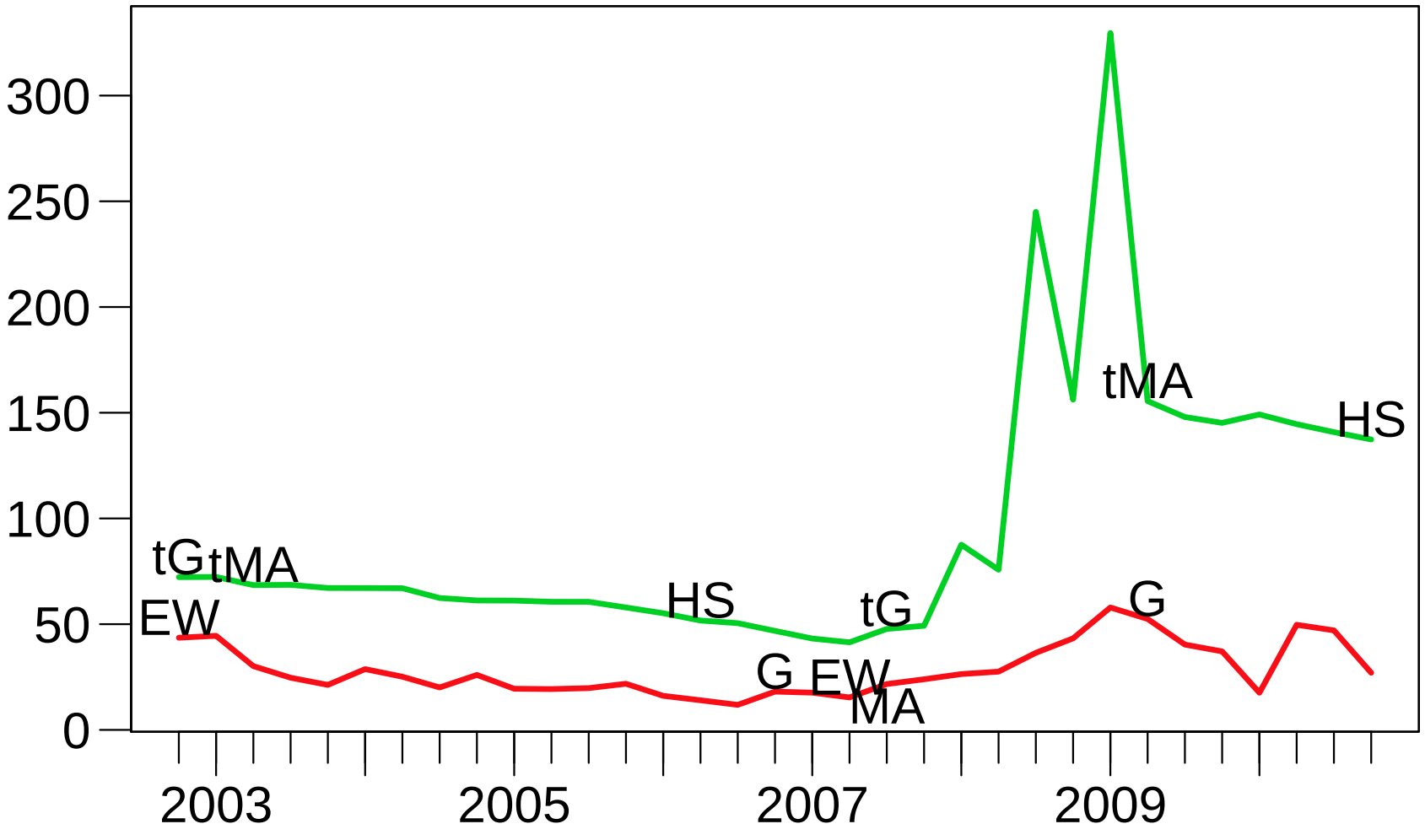
- Forecast 99% VaR with the most widely used state–of–the–art methods
  - HS, MW, student-t MW, EWMA, GARCH and student-t GARCH
  - Range of estimation windows (500, 1000, 1500)
  - \$1000 portfolio

Ratio of highest to lowest daily 1% VaR

End of quarter results. Probability is 1%



JP Morgan highest and lowest VaR

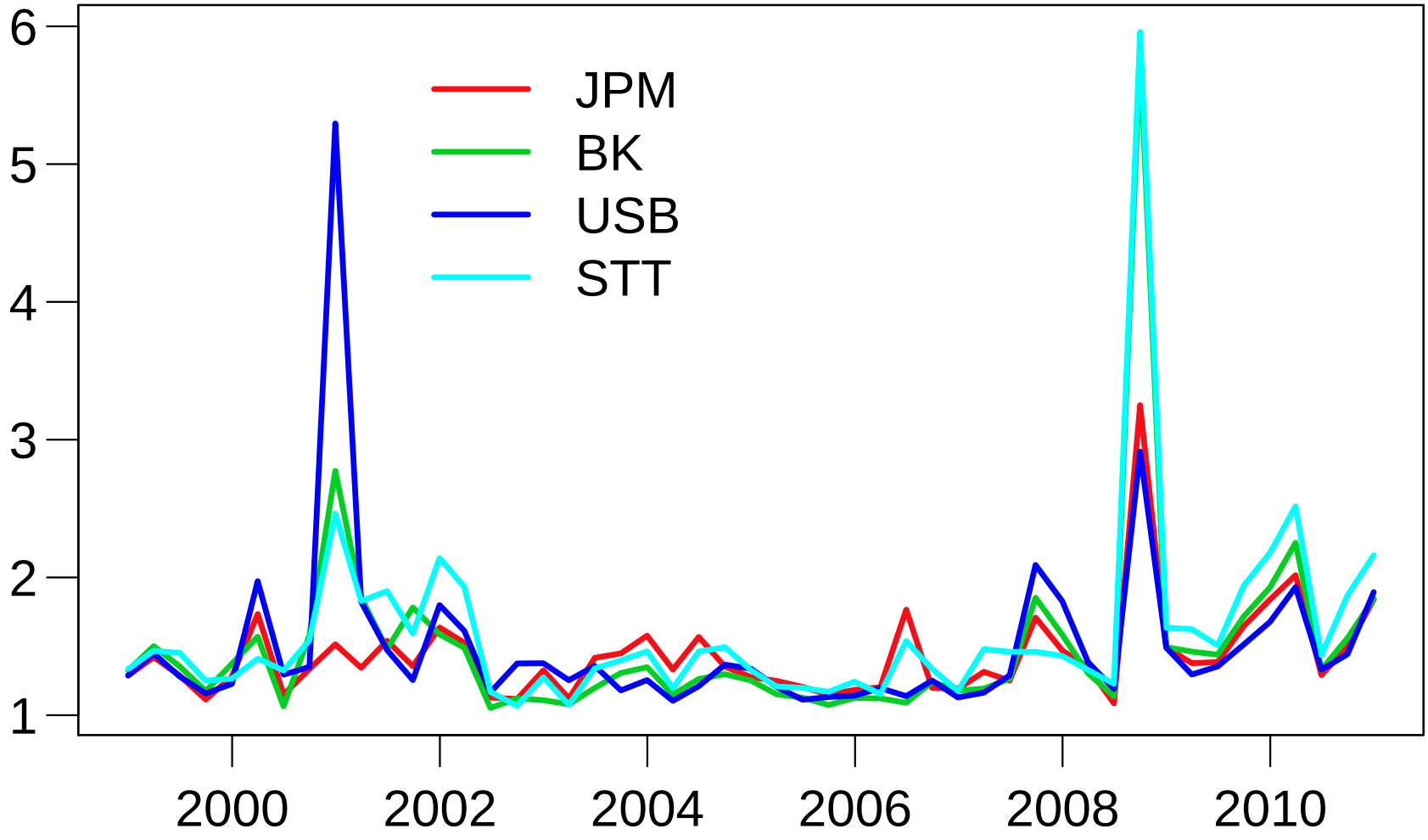


MES

- Expected return on bank given system is in a crisis (well having the worst day of the month)
- 5% daily probability
- $\mathrm{E}[R_i | R_S \leq Q_S]$
- Not as bad results since the 5% is not as extreme

MES model risk

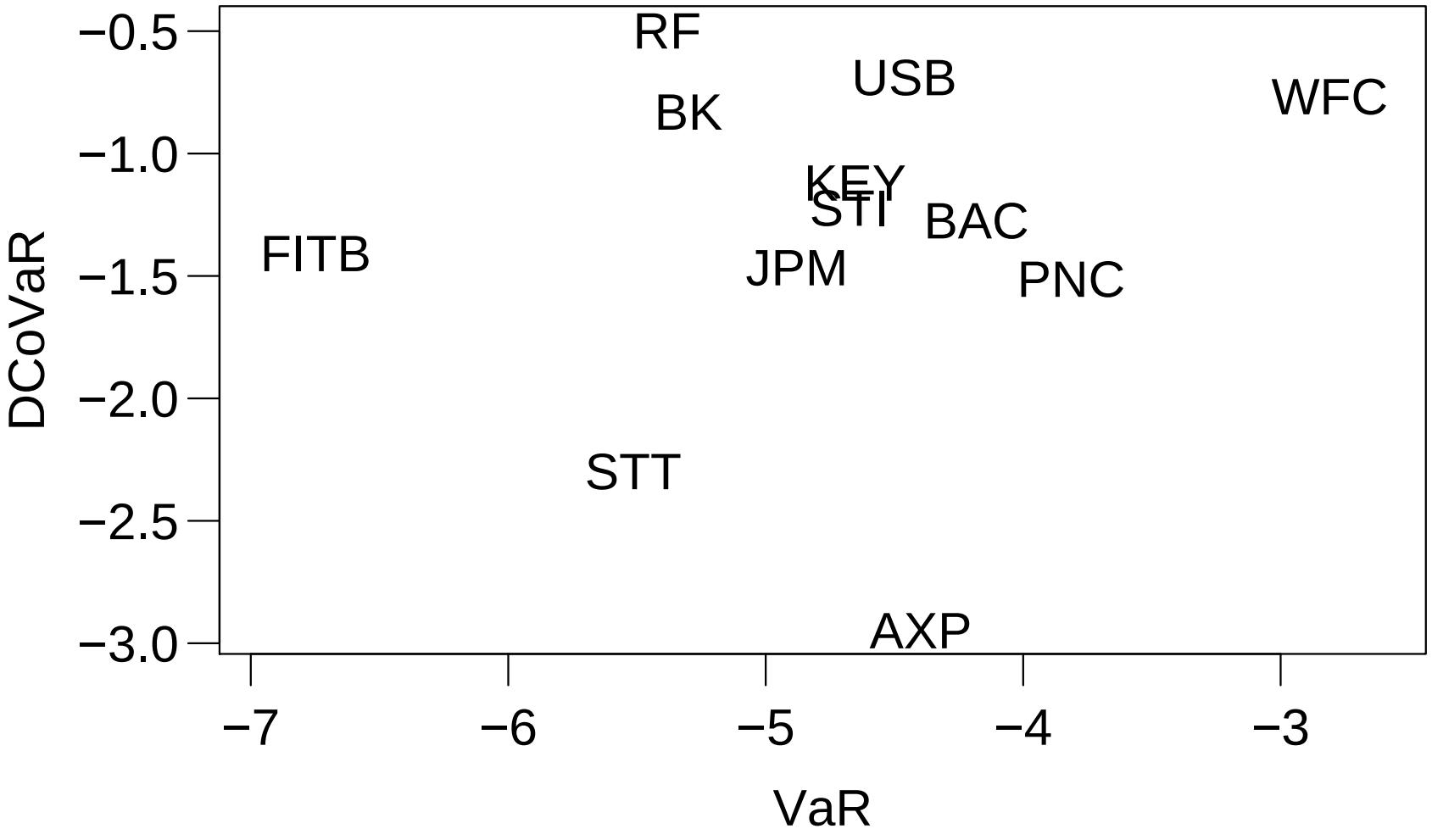
Ratio of maximum and minimum daily 5% MES



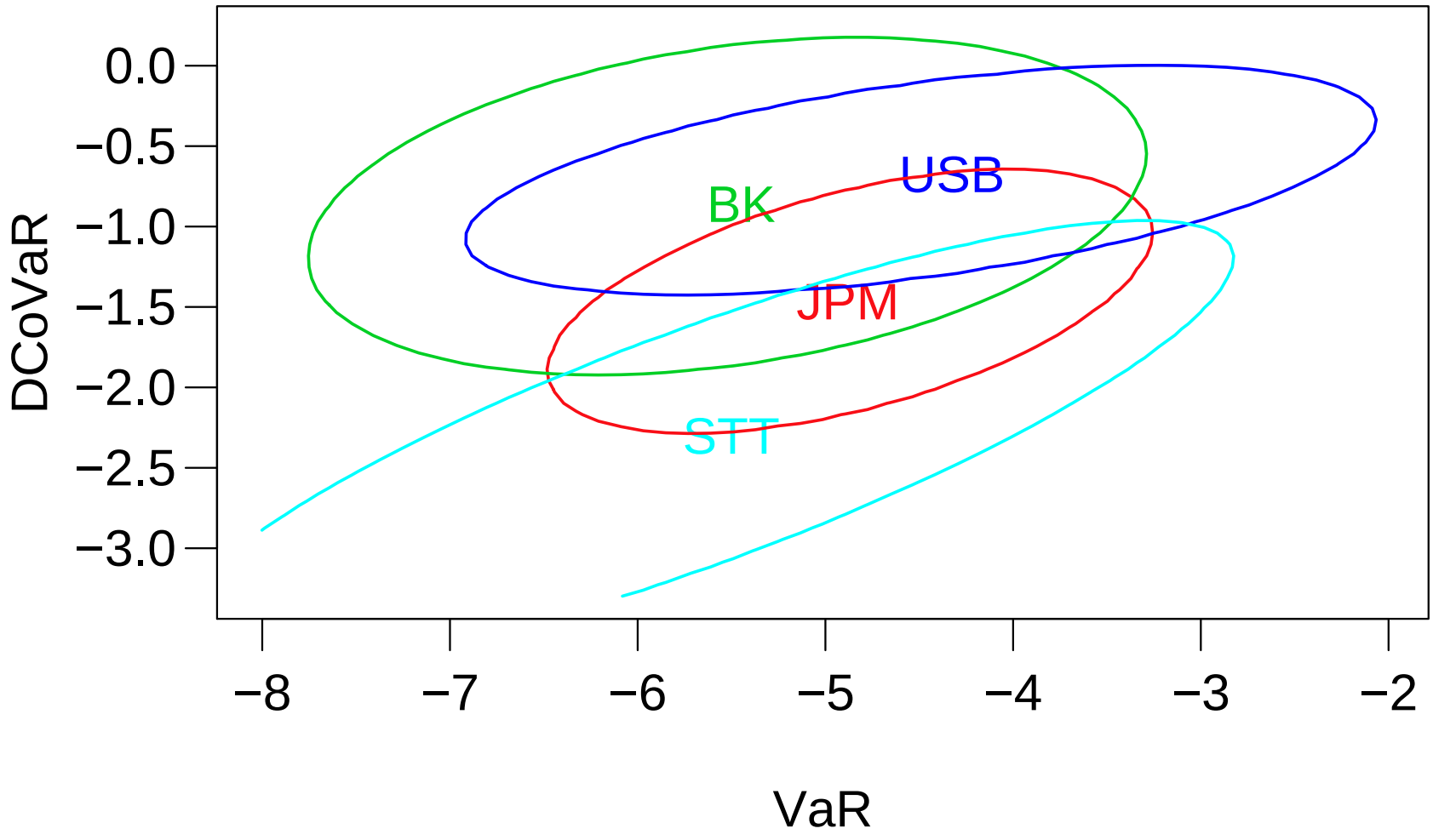
CoVaR and ΔCoVaR

- VaR for system given institution is in crisis
- $\text{pr}[R_S \leq Q_S | R_i \leq Q_i] = p$
- They prefer ΔCoVaR
- $\Delta\text{CoVaR}_{t,i} = \text{CoVaR}_t^{R_i=\text{VaR}_i^p} - \text{CoVaR}_t^{R_i=\text{VaR}_i^{50\%}}$

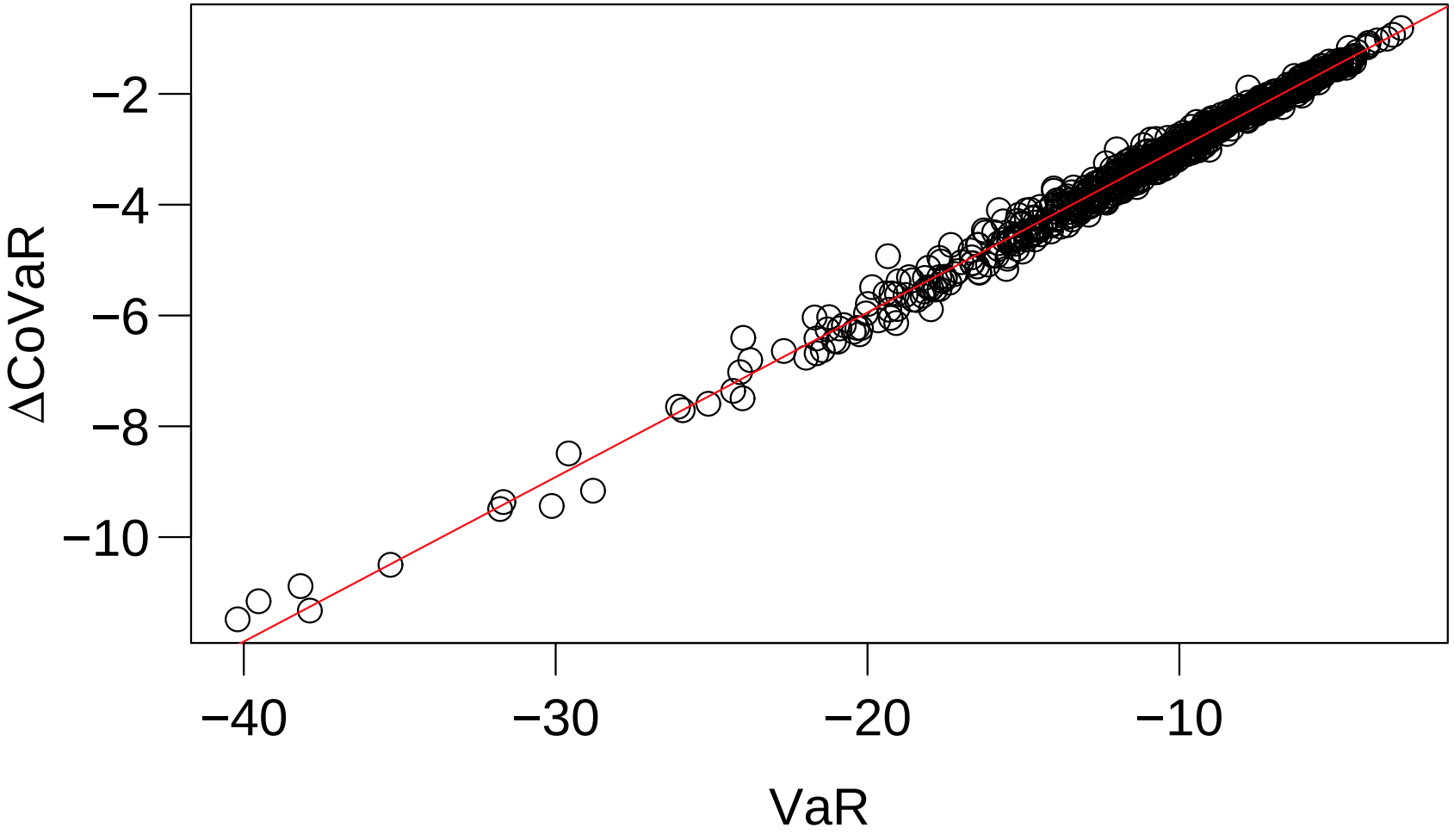
VaR and ΔCoVaR in Q4 2006



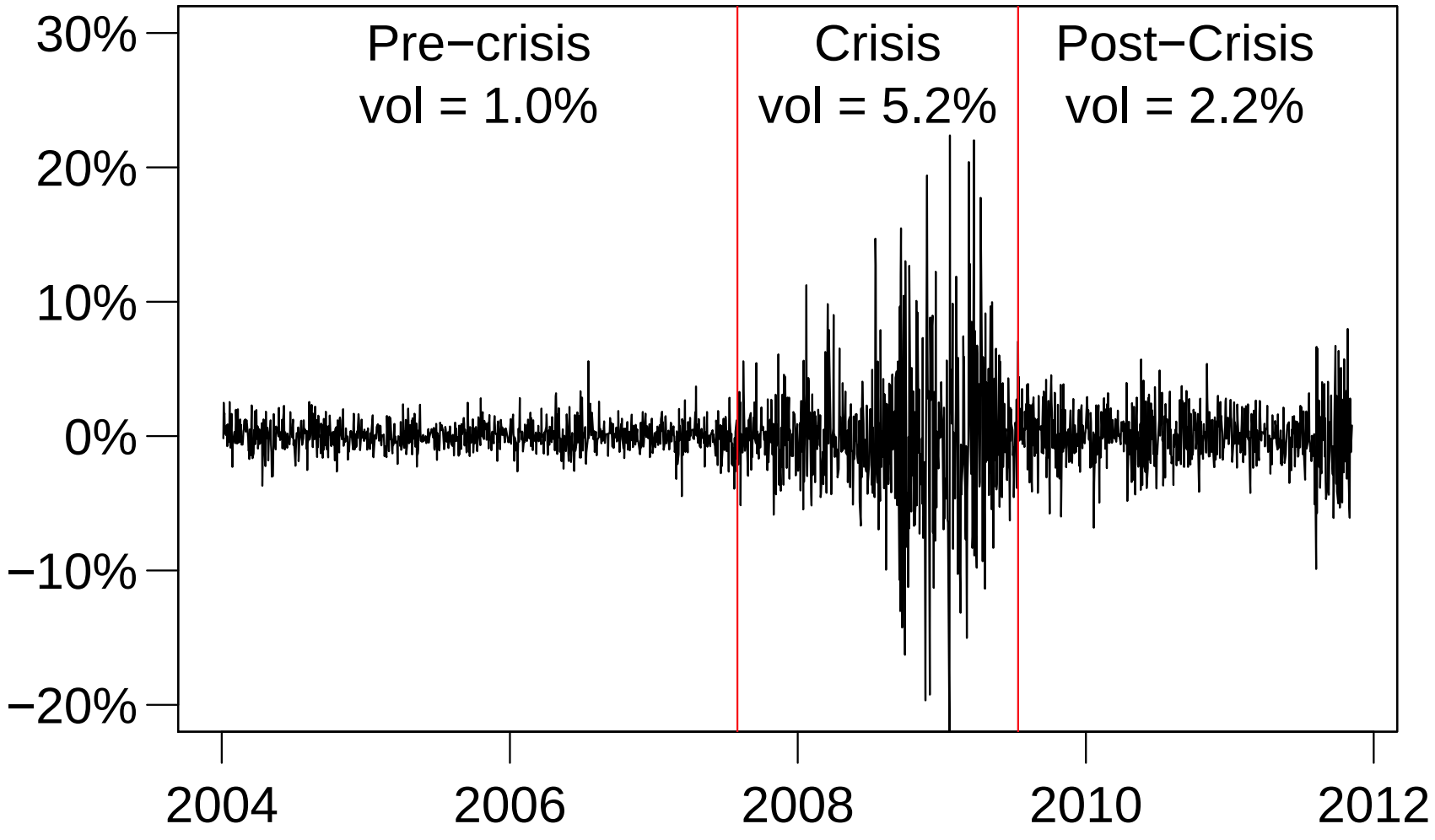
99% confidence intervals



Time series VaR vs ΔCoVaR, JPM



Usefulness of pre-crisis data: JPM



When risk is created

Former head of the BIS, Andrew Crockett in 2000

"The received wisdom is that risk increases in recessions and falls in booms. In contrast, it may be more helpful to think of risk as increasing during upswings, as financial imbalances build up, and materialising in recessions."

Dual role of prices

- They are a passive reflection of the underlying economic fundamentals, an aggregation of all available information but on the other
- Also an imperative to action
- Implications (see next slide)

Role of prices

- Market prices during periods of calm may be a poor input into forecast models
- They are not informative about the distribution of prices that follow after a crisis is triggered
- Price dynamics during one crisis may be quite different in the next, limiting the ability to draw inference from crisis events

Risk models underestimate risk during calm times and overestimate risk during crisis — they get it wrong in all states of the world

Systemic risk forecasting

- Models generally attempt to use observed market variables to provide an indication of the risk of some future systemic event
- Systemic risk is concerned with events that happen during crisis conditions, looking far into the tails of distributions
  - Little relevant data
  - Over the last fifty or so years we have observed less than a dozen episodes of extreme international market turmoil, all unique
  - Models that are fed with inputs from calm periods will perform much less well during periods of stress
- Extant empirical systemic risk forecast models is likely to fail

Quality control for systemic risk measures (SRMs)

1. Point forecasts are not sufficient: need *confidence intervals* incorporating both estimation risk and model risk
2. Data should be *predictive* and not reactive
3. Statistical method needs to include *backtesting*
4. Event probabilities need to correspond with the probability of systemic events
   - If such events happen once every 10 years, 99% probabilities (2.5 times a year) are of little relevance
   - One *can not* map failure probabilities from less extreme to more extreme. (estimate at 99% use for 99.9%)

Is a bad SRM better than none?

- Current SRMs are quite bad, perhaps indistinguishable from random noise or at best weakly better in prediction
- SRMs to be used for policy purposes
- High cost of using an incorrect method
- A bad SRM should not be acceptable for policy purposes, it should be of a proven quality
- *Type 2 errors are very costly* (falsely finding high sysrisk)
- Avoid the fallacy of requiring a number for decision–making regardless of the number quality

Outline of a Model

Model

"Dealing With Systemic Risk when We Measure It Badly"

- Regulator sets capital requirements for a system consisting of high risk and low risk banks
- High capital reduces the likelihood of crisis
- But is socially costly

- System has large number of high and low risk banks (Q_H and Q_L)
- Banks prefer low capital, K_L
- Regulator does not know who is low risk or high risk
- and can either use a risk model or impose same capital on all (leverage ratio)

Intermediate results

- Optimal policy depends on quality of riskometer
- Sufficiently good riskometer implies using it to set capital
- Sufficiently poor riskometer implies using leverage ratio, either with low or high capital

Current policy

Main flaws in Basel 2 and 3

- Focuses on individual prevent behavior, not the system
- Depends on risk measures to set capital

$$\frac{\text{Capital, tier 1 + tier 2}}{\text{Risk weighted assets}} \geq 8\%$$

- A leverage ratio better

$$\frac{\text{Capital, tier 1 + tier 2}}{\text{Total assets}}$$

Policy implication

- Ideally, one has a good model of what causes systemic risk
- and so targets policy
- Depends on having accurate riskometer
- Identify how banks contribute to systemic risk
- Use that to set capital, intensity of supervision, etc.
- Can we do this?

- Empirical systemic risk models all depend upon VaR in one way or another
- We can't reliably estimate VaR
  - If VaR was reliable, we might have foreseen, and even prevented the crisis starting in 2007
- Systemic risk measures are founded on VaR
  - so by construction they have more model risk

Conclusion

- So, we can't really target the banks that create the most systemic risk
- Trying to do so based on a bad riskometer is worse than not doing so
- Implication: Simple policies may work better in practice
  - Avoid risk sensitivity
  - For capital use leverage ratio