

Backtesting counterparty risk



Vladimir Chorniy
Market and Counterparty Risk Analytics
Group Risk Management

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Backtesting - basics

Backtesting - basic notion:

- compare prediction vs.. realisation
- realised values can be from
 - external systems (Front Office)
 - internal

Market risk – simple universe:

- predict the 1-day move at given percentile → compare with realisation
→ count numbers of 'wrongs'
- simple pass/fail statistical test
- easy to get time series: 4 months – 100 points

Credit (counterparty) risk – not so simple. Immediate question:

- what prediction measures we want to test?
- which time horizon?

What are the goals : banks vs.. regulators?

Simple answer:

- Similarity: both bank and regulators want to test exposure predictions
- Difference: tenor; exposure level (90% vs.. EE)

Complete answer?

EPE model steps and Bank's view

- Step 1. Create potential future universe(s) of market values
- Step 2. Value all trades in each of the potential universe
- Step 3. Aggregate according to legal rules and risk mitigants

Controls and validation beside backtesting

- In perfect risk system setup:
 - Step 2 - covered by model validation; errors are known – backtesting will repeat examination done by model risk (and test implementation)
 - Step 3 - repeats legal and operational steps
backtesting will measure legal and operational risk (and test implementation)
 - implementation tests are done as standard (both new and regression)
- Truly new and unknown: step 1 only

Backtesting of final result (exposure) will:

- test implementation
- aggregation of “known” errors
- provide easy way to derive weight for step 1. Weights?

But who will believe that we are perfect?... Regulator's perspective:

Backtesting – a Basel II requirement

- “Starting at a particular historical date, backtesting would use the internal model to forecast each portfolio’s probability distribution of exposure at various time horizons. Using historical data on movements in market risk factors, backtesting then computes the actual exposures that would have occurred on each portfolio at each time horizon assuming no change in the portfolio’s composition. These realised exposures would then be compared with the model’s forecast distribution at various time horizons. The above must be repeated for several historical dates covering a wide range of market conditions [...]”.
- In addition, Regulators stipulate that it must be performed:
 - as part of the validation process
 - at regular intervals at the request of regulators
 - on real or dummy representative portfolios
 - on representative portfolios chosen for their sensitivity to material risk factors and correlations to which the bank is exposed.
- No particular test is specified for backtesting of EPE models.

Regulator's additional requests

- All instruments, all desks
- Both collateral and uncollateralised exposure profiles
- Each individual step of the engine process must be tested: simulation, pricing, aggregation, margin calls
- Not only should the portfolio tested be representative, but also include outliers
- Test the entire distribution
- The EPE and effective EPE, realisation is unclear, no statistical measure to define a “pass”

Simple problems

OK - we are testing exposures and all intermediate steps

- Starting point - follow Market Risk footsteps
- Predict – record – compare with (Front Office or internal) realisation
- Front office (PnL) or other independently validated source is preferred by regulators
- sufficient length of time-series
 - no guidance
 - statistics not clear cut as for market risk

“Forward looking” approach first step

The forward-looking approach

Description

- **Daily archiving** of FO PVs and exposure profiles at different percentiles
- It is then possible for any day to compare the realisation of the PV with the forecast the engine had done of it in the past at a given confidence interval

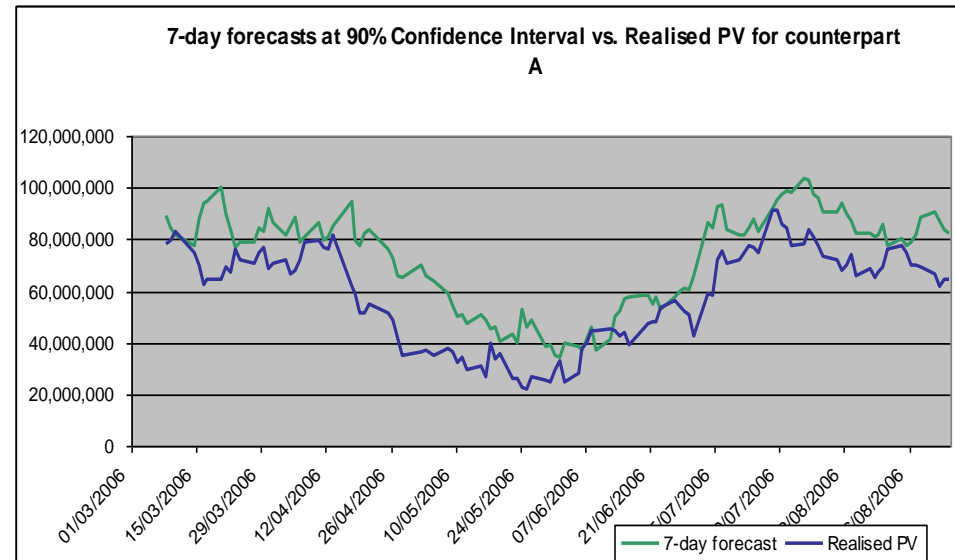
Advantages

- Predictions are tested against **realised** values.
- No batch to run

Limitations

- All methodological improvements cannot be tested until enough data accumulate
- Sensitive to system changes (e.g. systems feeds, deal ID's)
- Counterparty portfolio needs to remain unchanged
- Long term predictions cannot be tested (windows are over-lapping if all available data to be used)

A good test for short time intervals



Simple problems

Forward looking shortcomings to solve

- Sensitive to system and methodology changes - delays
- Counterparty portfolio needs to remain unchanged
- Long term prediction cannot be tested

To solve - “Backward looking” approach

- re-set the **current** system to the past
- re-run to more recent date (or today)
- keep repeating

Choices:

- Do we look at today's portfolio from the past or move today's' portfolio to the past
 - trade dates absolute or relatives
 - trade parameters (strike, barrier etc) absolute or relatives
 - what is “representative”?
- test against system or FO – affects first two choices (“today” FO PV exist)
 - re-run to today - “cheapest” option, but one run per interval
 - single run to be representative - efficient market as our counterparties – no directional trading: assume randomness or assign weights
 - PV+Add-on exotics: FO PV’s available

Re-set the system?!

System overview

- Coverage: IR derivatives, FX, Commodities, Equities, Credit derivatives, Repos
- Number of deals: > 600,000
- Number of counterparties: ~10,000
- Number of scenarios: 1000 or 2500 daily;
- Number of time steps: >300
- Time per batch: 2 - 5 hours
- Computing power: ~ 100 blades (2 or 4 processor)
- Ability to run calculations on different asset classes on standalone basis
- Backtesting, stress testing, more simulations - more power needed! (more blades are being added)

The backward-looking approach

(“cheap” version)

Description

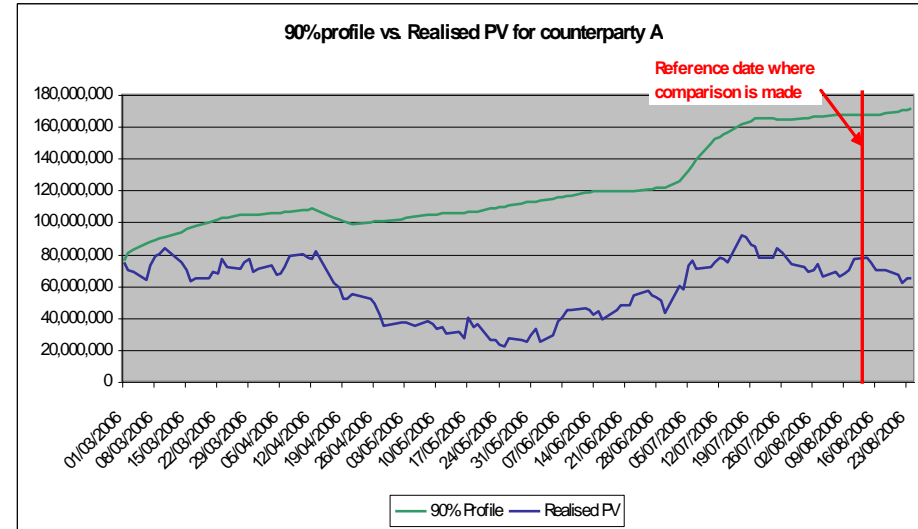
- Run today’s portfolio on old market data
- Compare today’s engine PV with engine forecasted exposure
- One time point but many counterparties

Advantages

- Portfolio is necessarily representative.
- Non-sensitive to methodological changes

Limitations

- Requires one batch per time interval tested
- Statistical significance relies on the number of counterparties in the sample and on keys assumption(s):
 - randomness of trading pattern (not true in real world) or
 - efficient market of our c/p universe (need weights for analysis)
- Correlations can make analysis difficult.
 - Still sensitive to system changes (e.g. data feeds, deal ID’s)



Less simple problems

Group I. Measure

Percentile vs.. Expectation. Pass/fail criteria

Percentile (above/below - simpler, but not always, see group II)

Group II. Testing each step and each part

What is the pass/fail on vector, surface etc. (simulation IR curve, stochastic volatility surface)

Representative – what is it?

or test everything - what is pass/fail (equal weight for each parameter?)

having things to test - short term portfolios

Group III. EAD - conditional on default

Correlation between counterparty state and exposure

Collateralised exposure

Group IV. Legal and limit framework intrudes

Collateralised exposure (again)

Group I. Measure

- **Test all percentiles - test distribution**
 - No need test EE based measures?
- **Regulators - test EPE and effective EPE separately**
 - What is pass/fail criteria - no Basel guidance
- **EPE - average measure, no roll off correction**
 - Portfolio is “as now”
- **Effective EPE - average measure, with roll off correction**
 - Portfolio (bank) as going concern - risk continue to be taken

To test prediction we need to define “realisation” - what is realisation for EPE and EEPE?

- Test against average of realised exposures over next year
 - Record difference, build distributions
- Count days single day exposure was in excess
 - Demonstrate conservatism
- EPE - static or semi-static portfolios
- EEPE - all portfolios (non static), bank as going concern

All subject to regulator approval!

Group II. Testing each step

1. What is the pass/fail on vector, surface etc. (IR curve, volatility surface) ?

- solution: exposure as weight?

2. “Representative” – what is it? (“...include outliers”)

- type
- notional
- c/p exposure
- credit charge or capital contribution
- long/short (track the bias)

*What does it mean:
“a representative outlier”?*

or test everything - what is pass/fail?

- equal weight for each parameter?

3. Having things to test - short term portfolios

- constant over individual prediction – system intensive – answer: dummies
 - dummy trades and dummy portfolios (both real and ‘what-if’)
 - running series principle (as for credit index)
- daily changes (open repo) - track the re-booking
- Low churn portfolio as crude approximation

Group II. Testing each step

Testing Step 1: future universe of market values

What is the pass/fail on vector, surface etc. (IR curve, volatility surface) ?

Example: Yield curve

- **Solution: exposure as weight? – already covered by Step 3**
 - **Test all points - comprehensive - what does it mean?**
 - Pass/fail exist per per point - “pass” on 1, 3, 7, 20 y, “fail” 2 and 15?
 - Very difficult to analyse the results
 - **Select “representative” term - short, medium and long segments**
 - Good start, but what about curve dynamics?
 - Parameters to measure main drivers of curve shape
 - **Select curve shape parameters: level, slope... “hump” ...?**
-
- **Market scenarios conditional on default?**

Group III. Exposure conditional on default

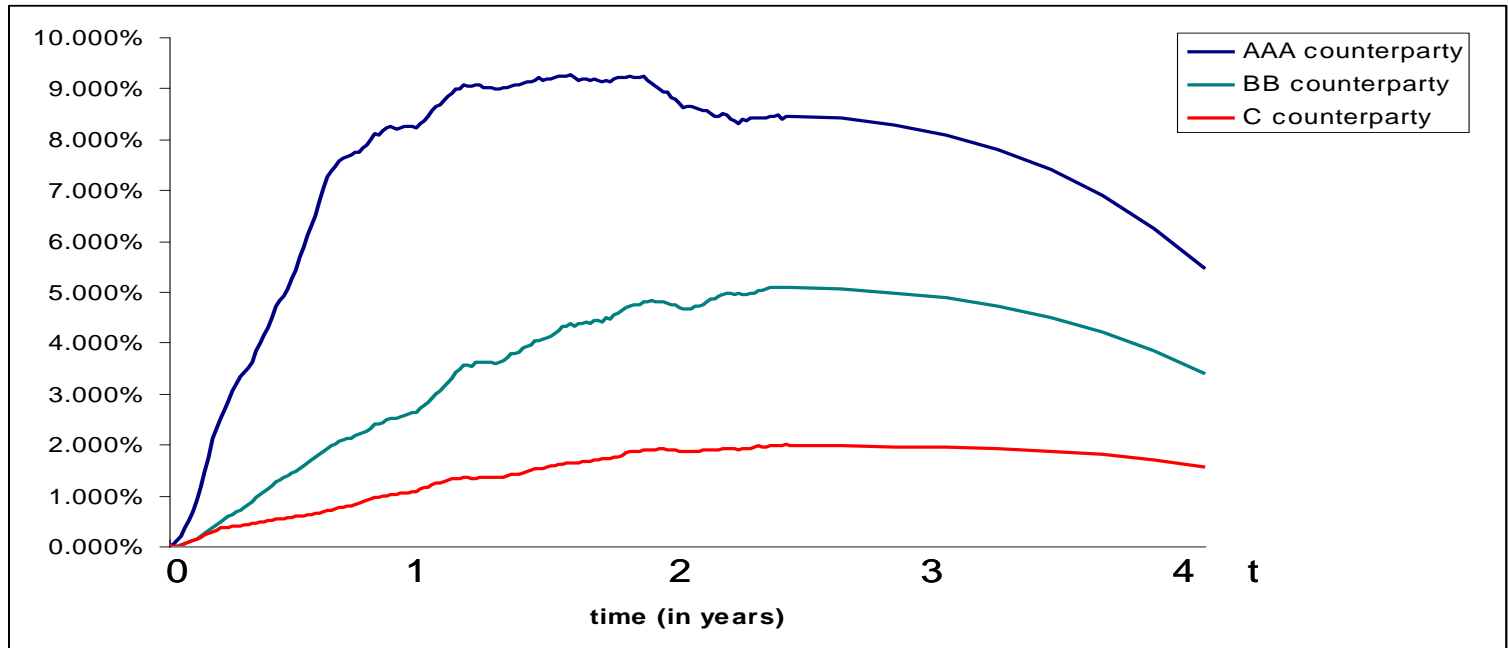
- If the exposure is measured assuming the counterparty has defaulted
- PFE profile affected by counterparty condition

Example - credit derivatives:

- Repo B (B2) 1 year against AA+ (Aa1)
 - strongly correlated universe: 7.3%
 - weakly correlated universe: 4.0%
 - Repo B (B2) 1 year against A- (A3)
 - strongly correlated universe: 6.0%
 - weakly correlated universe: 3.3%
-
- Backtesting - predictions are conditional
 - So “realisation” should be conditional - it is not
 - No Basel guidance

Group III. Exposure conditional on default

Correlation between counterparty state and exposure:

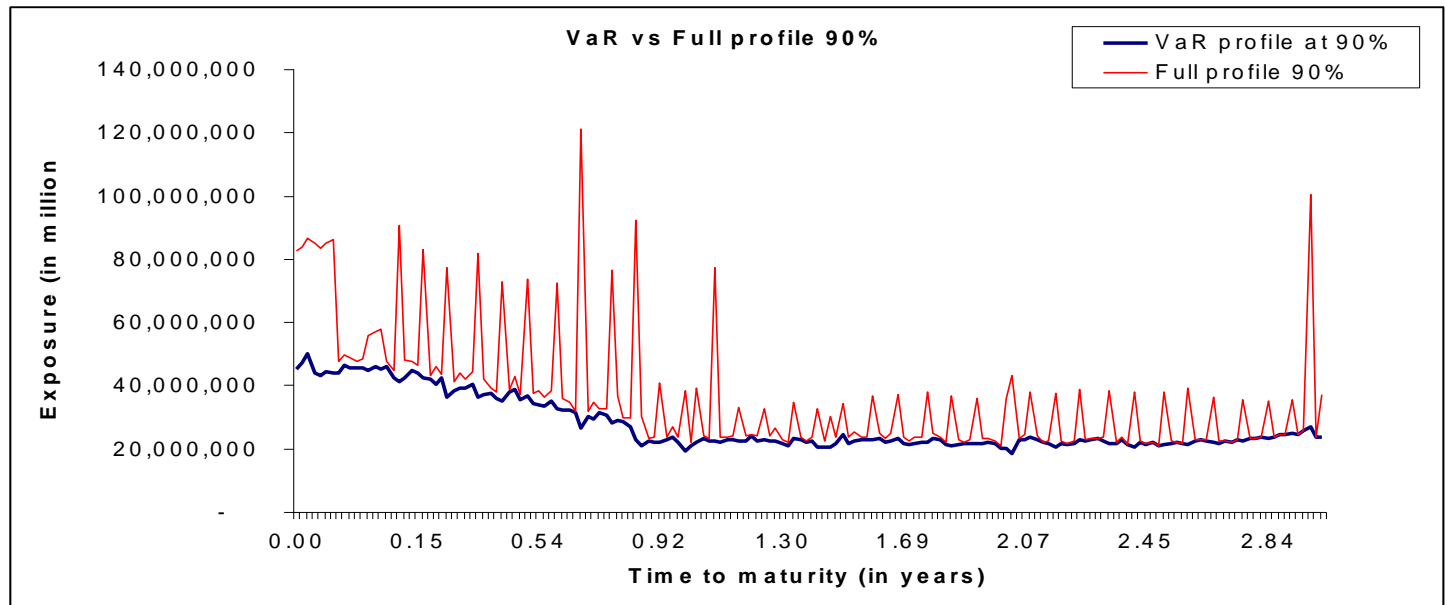


- Switch off conditionality? – problem with “usage” test
 - Create balanced (conditionality neutral) dummy portfolios? – not representative
 - Back test against defaults - not enough defaults, certainly cannot be part frequent (quarterly) retesting
 - Ideally both “on”
 - demonstrate bias to pass (qualitative)
 - statistical pass/fail on unconditional (quantitative)
- extra resource requirements – again!

Group III. Exposure conditional on default

Collateral - actual cash flows conditional on default

- Defaulted counterparties do not pay during grace period
 - no cashflows in, but initially we still pay out (“no control” period)
- We do not pay once default is clear
 - Nothing in, nothing out
- Realised valued (no default)
 - All in, all out
- Full profile = VaR profile + Payment Risk



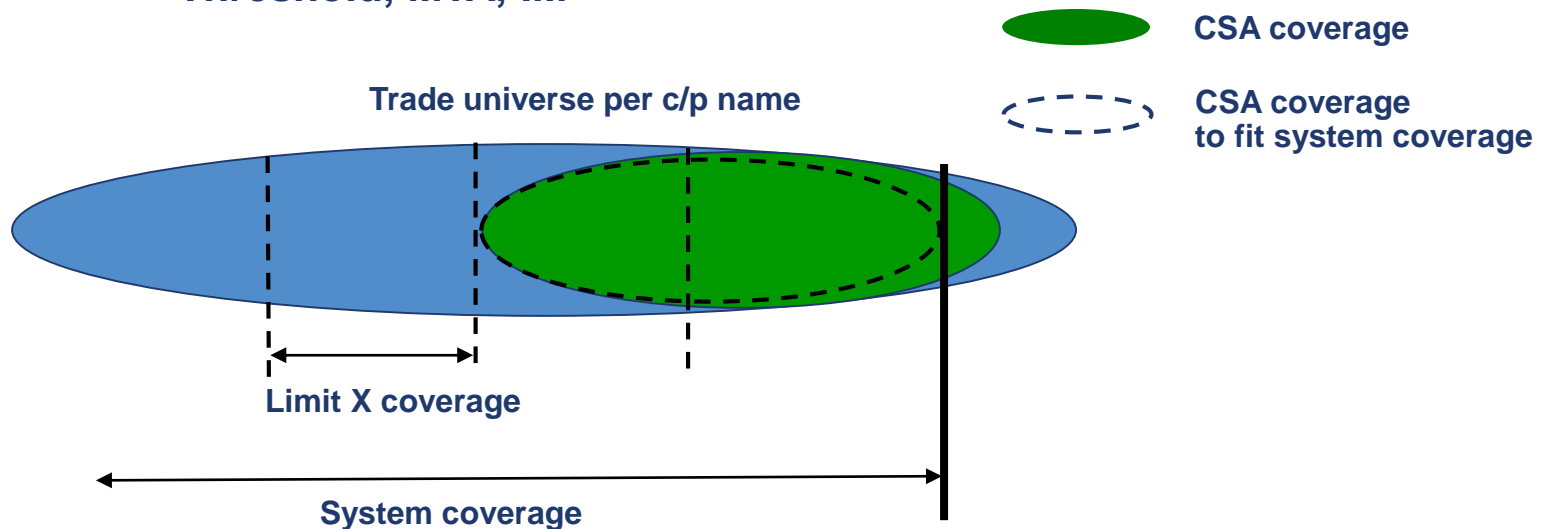
Bank is (almost) cashflow neutral - “all in, all out” and “nothing in, nothing out” should be consistent in predictive power

Group IV Legal and limit framework intrudes...

“Predict - record - compare with (Front Office or internal) realisation”

If the realisation is “real world”: FO PV vs.. actual collateral

- CSA is cross product, but can be partial in cover
- Limit is cross product, but can be partial in cover
But not the same part!
- We can slice and dice 10 day move, but not
Threshold, MTA, IM



- We need collateral allocation algorithm – still counts as “real world”?
- Limit names to fully enclosed by CSA? – solves system coverage problem, but not at limit or sub-entity level

Group IV Legal and limit framework intrudes...

*System prediction vs.. the system or simplify coverage assumption
("model" FO collateral)*

1. Recursion problem
2. Model error problem
3. Coverage error

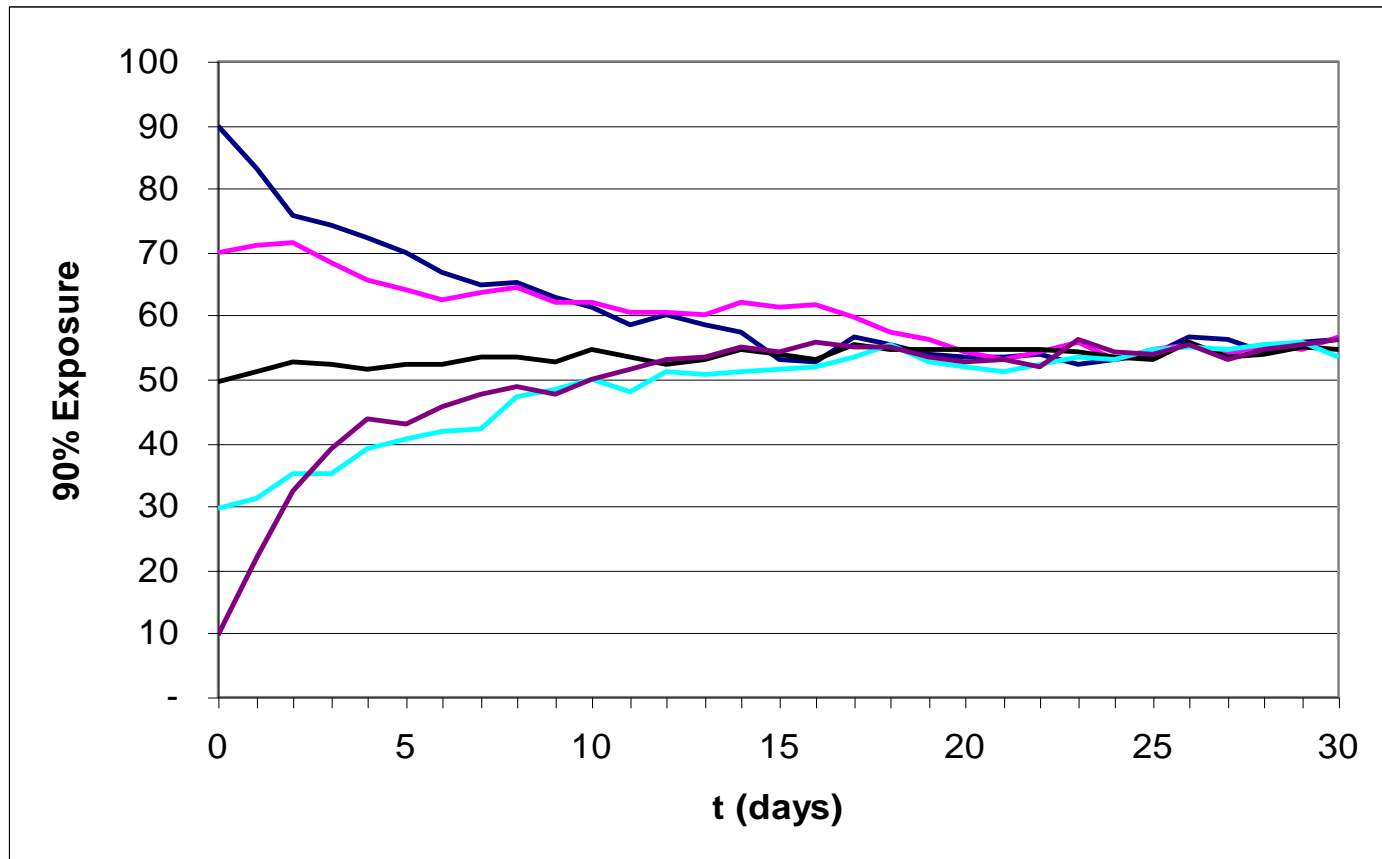
Recursion problem

- What collateral do we have today?
 - Depends on yesterday: legally entitled - path dependent due to MTA
- Use simplifying assumption for day 0:
 - For prediction
 - For realisation
 - "conservative" assumption creates bias
 - simplifying (no MTA) realisation - model error
 - "full" realisation - create historic path of model calculated collateral
 - "Full" realisation covers risk of ideal world of always fulfilled legal obligations on deals within system coverage

Group IV Legal and limit framework intrudes...

*System prediction vs.. the system or simplify coverage assumption
("model" FO collateral)*

- Recursion problem – long term prediction as benefit?
 - Starting conditions lose importance



MTA is set is 5x daily portfolio volatility

Group IV Legal and limit framework intrudes...

2. Model error problem

MTA cover is required by Basel II, but even if neglected:

- Received – agreed – legally entitled: stochastic difference due to time lag, operational differences, disputes
- operational differences, disputes – do we want to reflect and backtest operational risk in credit risk system?
- regulators – legally entitled is not enough

3. Coverage error

still a problem ...

- both real and internal collateral coverage – ‘slice and dice’ problem for MTA, Threshold, IM. Even if a bank is prepared to tolerate error in limit framework, regulators need a separate a study at least for regulatory capital impact