Implementing an AMA for Operational Risk

May 19, 2005

Federal Reserve Bank of Boston

A Discussion of Quantitative Models for Operational Risk: Extremes, Dependence and Aggregation

Daniel J. Brown

Jonathan T. Wang

Northern Trust

Agenda

I. Introduction to Northern Trust

II. Northern's Early Modeling Efforts for Operational Risk

III. Northern's LDA-EVT Model (v.1.0):

Some Learnings and Some Questions to Consider

IV. Closing Notes – Using EVT in a Basel II Framework

I. Introduction

Northern Trust Profile (as of 12/31/2004)

- Market Risk: minimal
- Credit Risk:
  - $18B Loans, $19B Off-Balance Sheet
    - Very high quality portfolio – net charge-offs average 0.11% of outstanding loans (1995-2004)
  - $9B Securities
  - $45B Total Assets
- Operational Risk
  - Non-interest revenue is over 70% of total revenue
  - $2.6 Trillion Assets Under Administration
    - $572B Under Management
  - Over 10M market transactions executed in 2004

Northern Trust - Operational Risk Environment

- Strong process management culture
  - Management focus has traditionally been on controls
    - Result is low loss rates
    - But not a lot of development of sophisticated quantitative analytics prior to Basel II implementation efforts
- World Wide Operations
  - Corporate strategic focus on par with income generation
- Well established loss reporting structure
  - Detailed loss database in place since 1999
  - Board of Directors focus – Business Risk Committee

II. Northern's Early Modeling Efforts For Operational Risk

Operational Risk Modeling Efforts

- A learning process that has provided many insights
  - Development effort uncovered issues, problems, alternatives
- Focus of Efforts:
  - Simple but flexible solutions that could grow as we learned
    - Started with simple spreadsheet model, knowing it would be throw-away
    - Developed simple approaches first, then evolved models or developed alternate approaches
  - Concentrated on the big pieces
    - *de minimis* or one-off solutions for small exposures
- Parallel communications effort
  - Inform and educate Senior Management

Development Efforts - A Chronological Account

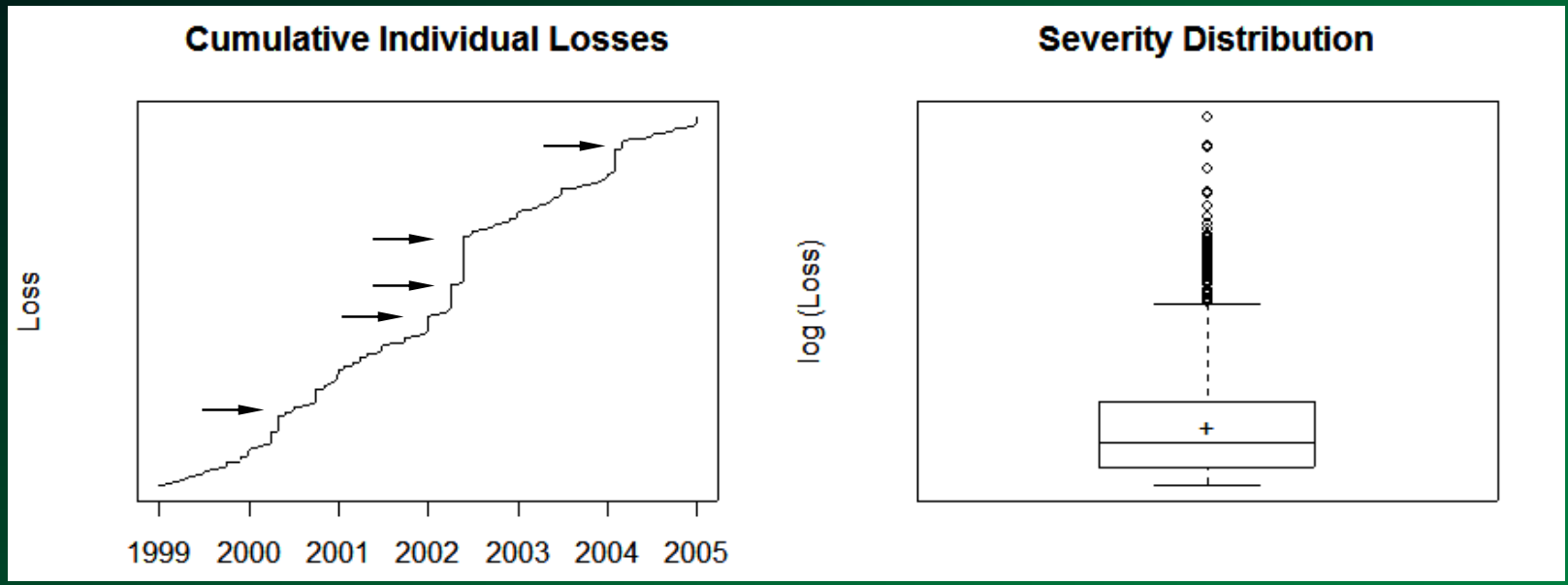
- Basic LDA model
  - Internal data only - Poisson frequency, empirical sampling for severity
  - Extended models to use modeled severity distributions (lognormal, etc.)
- Inclusion of external data - issues
  - Filtering the data - Which external losses apply to Northern Trust?
  - Scaling or adjusting the data for:
    - Size of operations
    - Quality of Control Environment
    - Time (inflation effects)
  - How much weight should be given to external data?
    - 'Adventures in Probability Space'
  - Explored various techniques – some were legitimate
    - 'Stratified' Sampling, Regression 'Extension', Credibility Theory

Lessons from External Data Modeling

- Results were highly sensitive to assumptions
  - Approaches required too much judgment, seemed arbitrary
- Scaling was critical, yet extremely difficult
- External data, even scaled, have powerful effect on loss distribution and capital
- Some techniques could be too complex to explain to Senior Management and Board Members
- At the time, other banks were finding similar challenges

III.a. Northern's LDA-EVT Model (v.1.0): Some Learnings

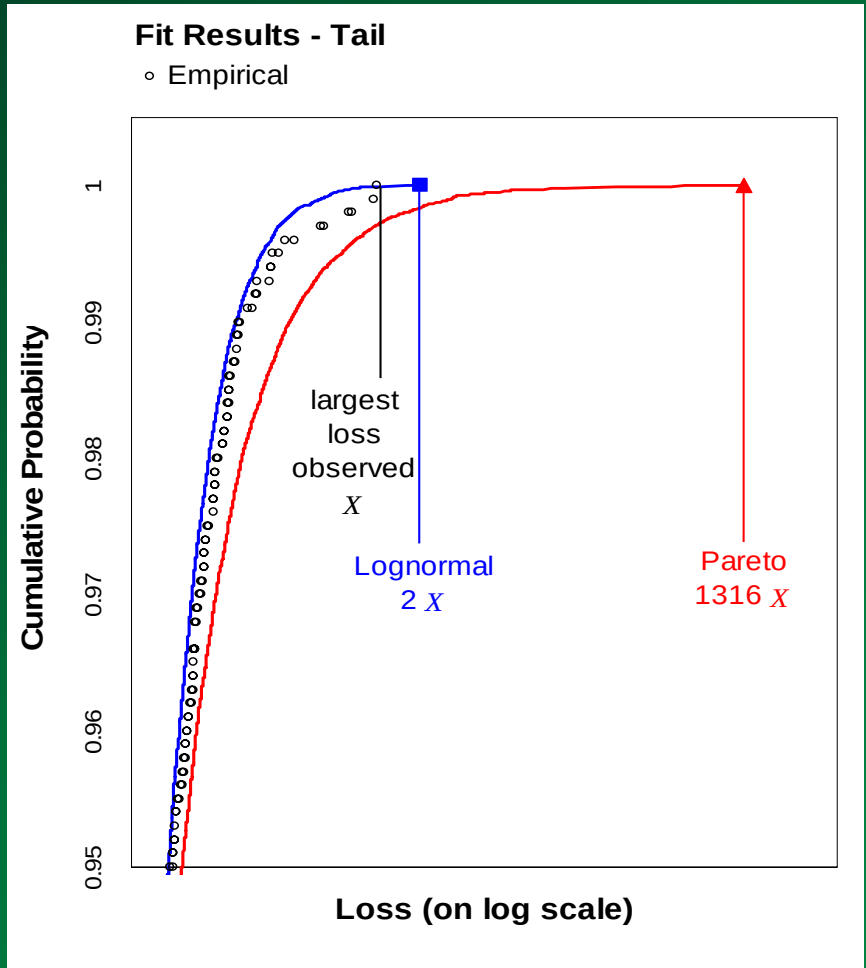
Exploratory Data Analysis



- Operational loss data appear to follow heavy-tailed distributions
  - Mostly small losses mixed with a few large losses (→)
  - Data points span many orders of magnitude
  - Largest loss is 35 SD's away from mean

Exploratory Data Analysis, continued

- No single distribution fits well over the entire data set
- Particularly the tail
  - Lognormal *underfits*
  - Pareto *overfits*
  - Not shown: other thin- and heavy-tailed distributions



Risk and Uncertainty in Monetary Policy

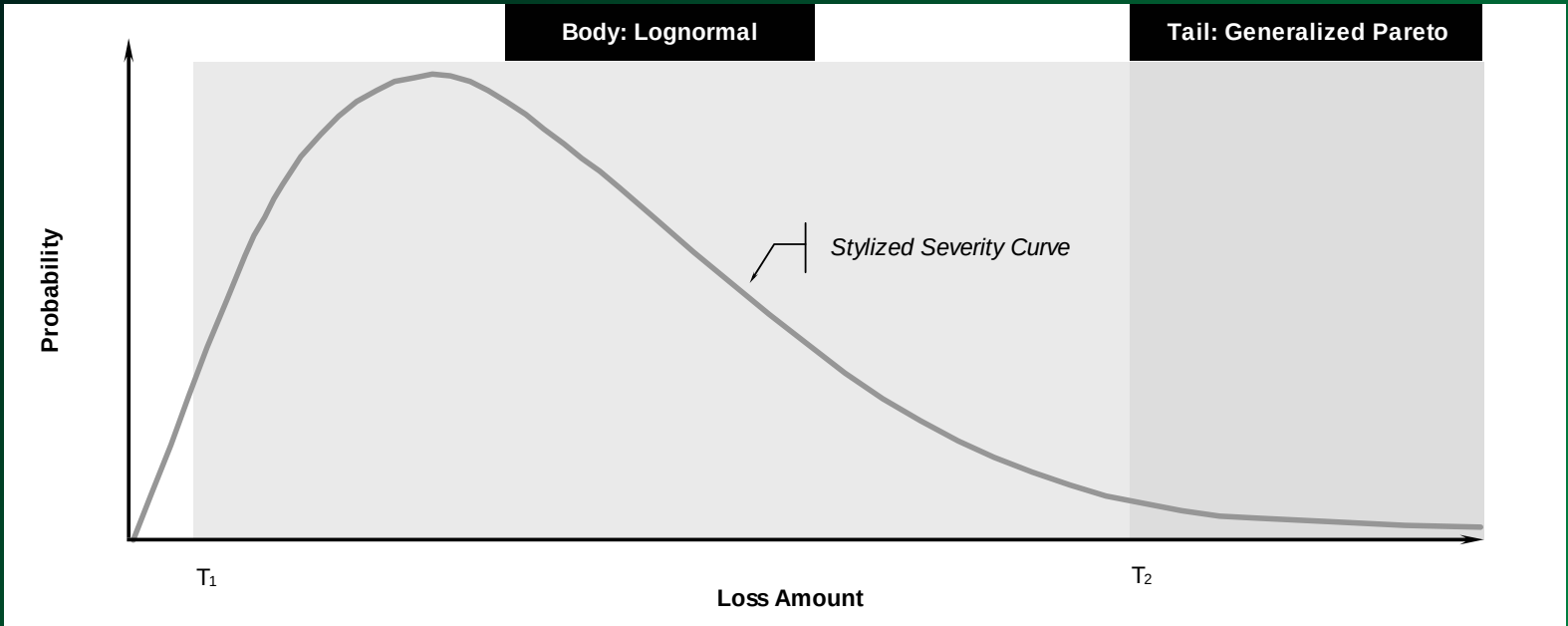
"Every model, no matter how detailed or how well designed, conceptually and empirically, is a vastly simplified representation of the world that we experience with all its intricacies on a day-to-day basis.

…We often fit simple models only because we cannot estimate a continuously changing set of parameters without vastly more observations than are currently available to us.

…In pursuing a risk-management approach to policy, we must confront the fact that only a limited number of risks can be quantified with any confidence. And even these risks are generally quantifiable only if we accept the assumption that the future will, at least in some important respects, resemble the past."

Remarks by Alan Greenspan
At the Meetings of the American Economic Association
January 3, 2004

Northern's LDA-EVT Model (v.1.0)
An Overview



- Internal data only
- T_1 = Internal data collection threshold
- T_2 = Tail threshold determined using EVT
  (more on T_2 later)

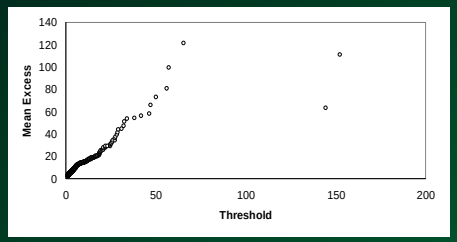
- Model separately
  - Body (Poisson-Lognormal)
  - Tail (Poisson-GPD)
- Top of house
  - No distinctions by loss type
  - 90% losses in EDPM *

** EDPM: Execution, Delivery and Process Management*

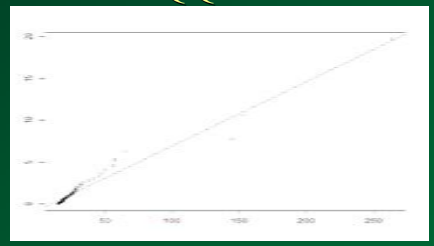
Tail Threshold Selection Process

- On the one hand, EVT comes with a suite of analytical tools

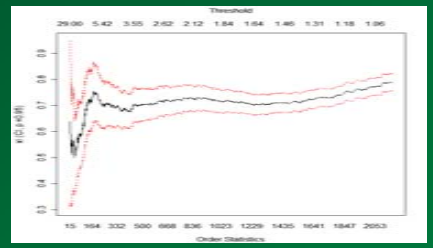
Mean Excess Plot



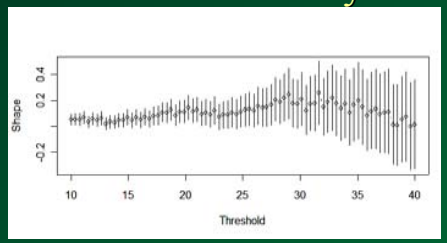
QQ Plot



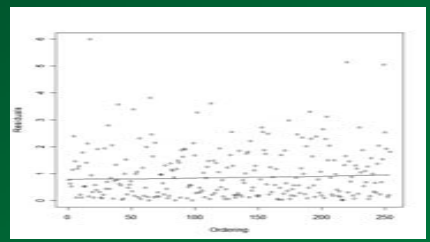
Hill Plot



Parameter Stability Plot



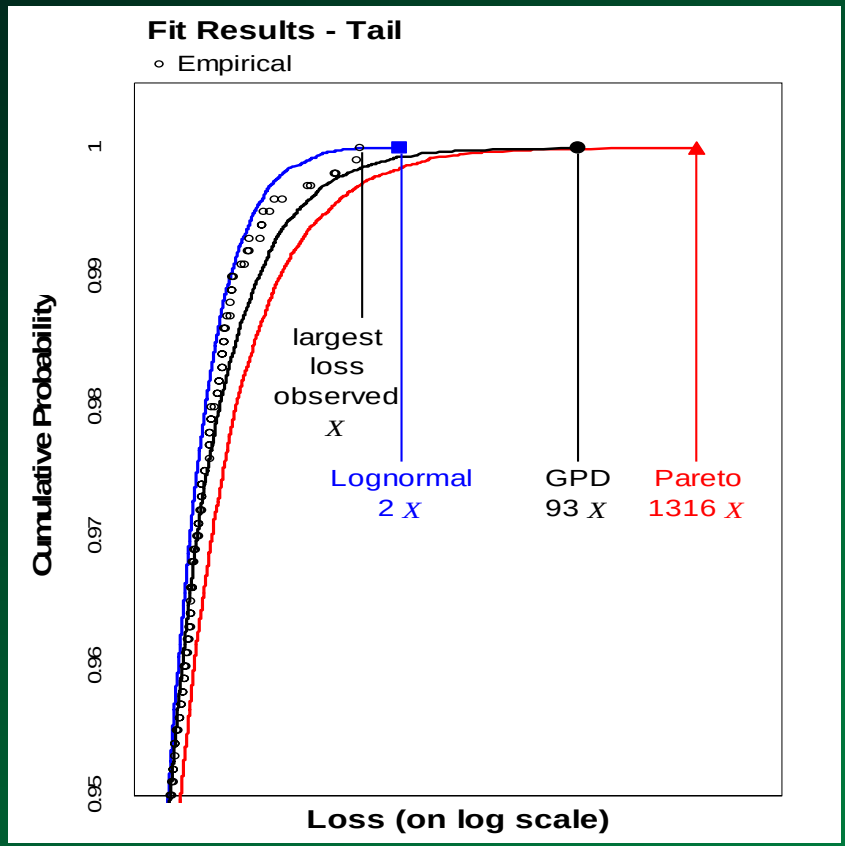
Residual Plot



- On the other hand…
  - Not a trivial exercise
  - Particularly when there is more than one appropriate tail threshold
  - Requires skilled interpretation of plots
  - Should not be examined in isolation
- 'Optimal' tail threshold best reconciles bias and variance

Some Results of LDA-EVT Modeling

- GPD outperforms every distribution tested



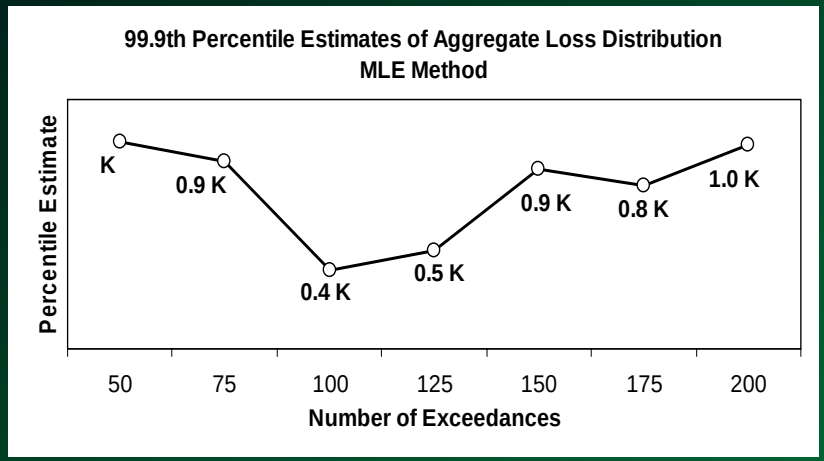
- As to Aggregate Loss Distribution, Unexpected Loss (UL) is 15 times greater than Expected Loss (EL)

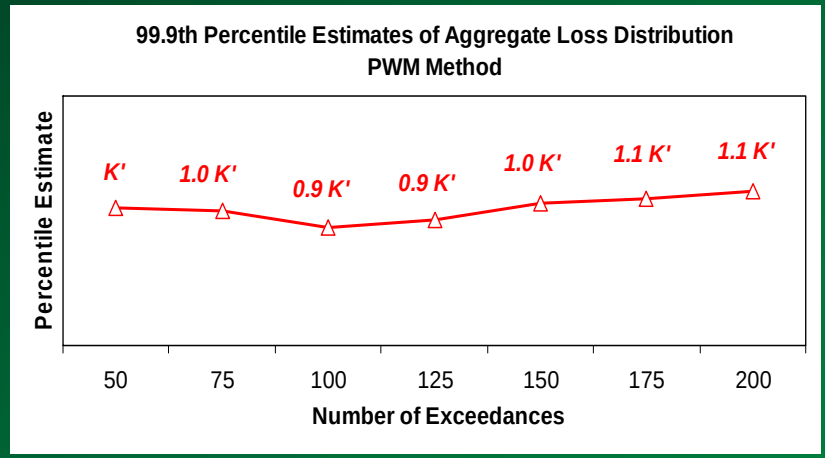
	Op Risk as % of MRC (1)
Basel's Expectation	12%
QIS-4 Results	
Exponential	2%
Lognormal	5%
Pareto	18531%
EVT Approach	***35%***

(1) MRC: Minimum Regulatory Capital

III.b. Some Questions to Consider

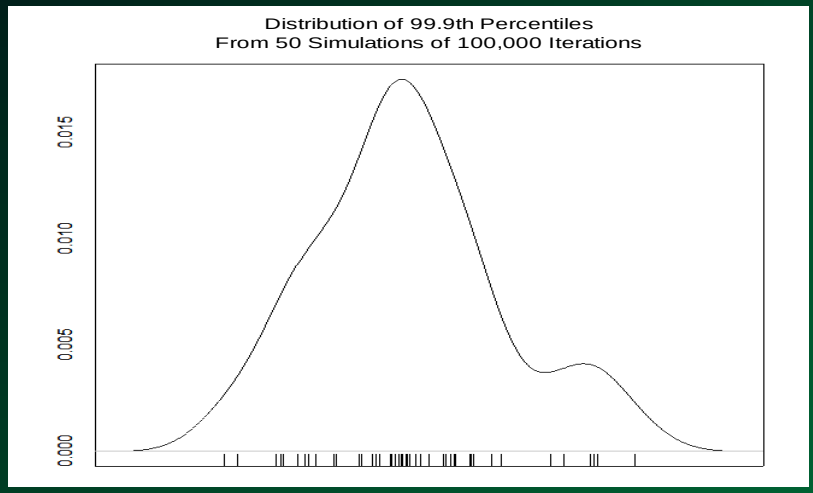
Maximum Likelihood Estimator (MLE) *vs.* Probability Weighted Moments (PWM)

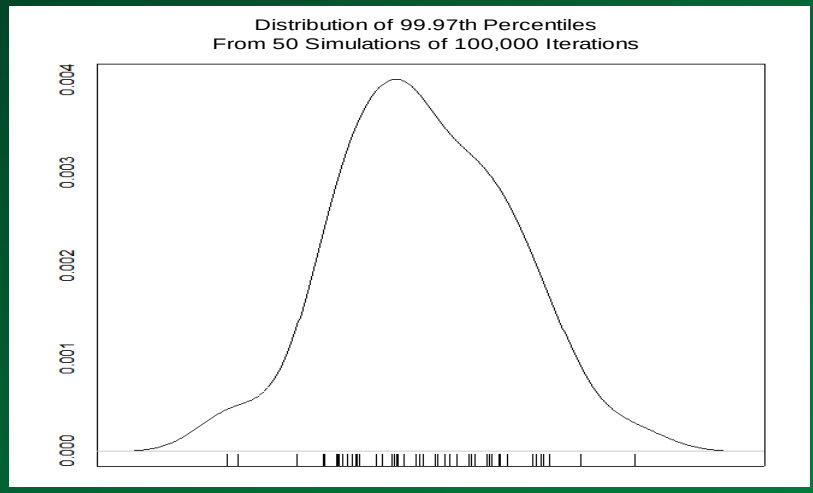




- Capital using MLE appears to be more sensitive to tail threshold than using PWM
- A conundrum: A higher capital estimate as a result of excluding the largest loss
  - An answer: The exclusion of the largest loss slightly changes the overall characteristics of the data set. As a result, the previously chosen 'optimal' tail threshold is no longer deemed optimal. The new 'optimal' tail threshold corresponds to more exceedances; hence a higher capital estimate.
- What are (or should be) the guidelines around which method to use?

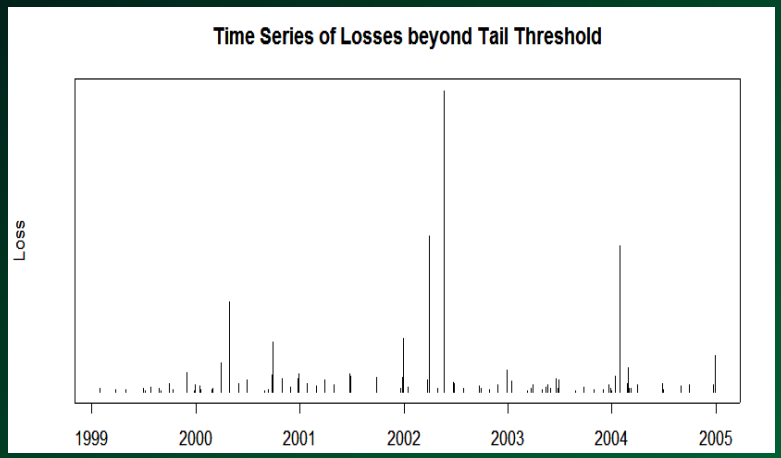
Robustness

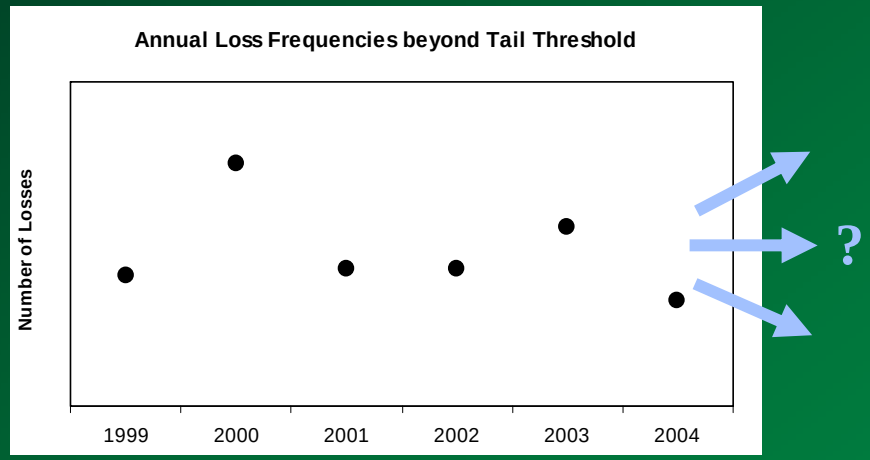




- Aggregate loss distribution is obtained through simulation
  - 100,000 iterations
  - 99.9th percentile is estimated (for regulatory capital)
- Due to randomness, estimate is expected to be different for each simulation
- Simulation is repeated 50 times to allow for randomness
  - Distribution of 50 simulated 99.9th percentiles seems wide-ranging
    - Maximum higher than minimum by about 30%
    - Even further spread for 99.97th percentile (for economic capital), about 60%
- What should be an acceptable level of robustness in dealing with heavy-tailed distributions?

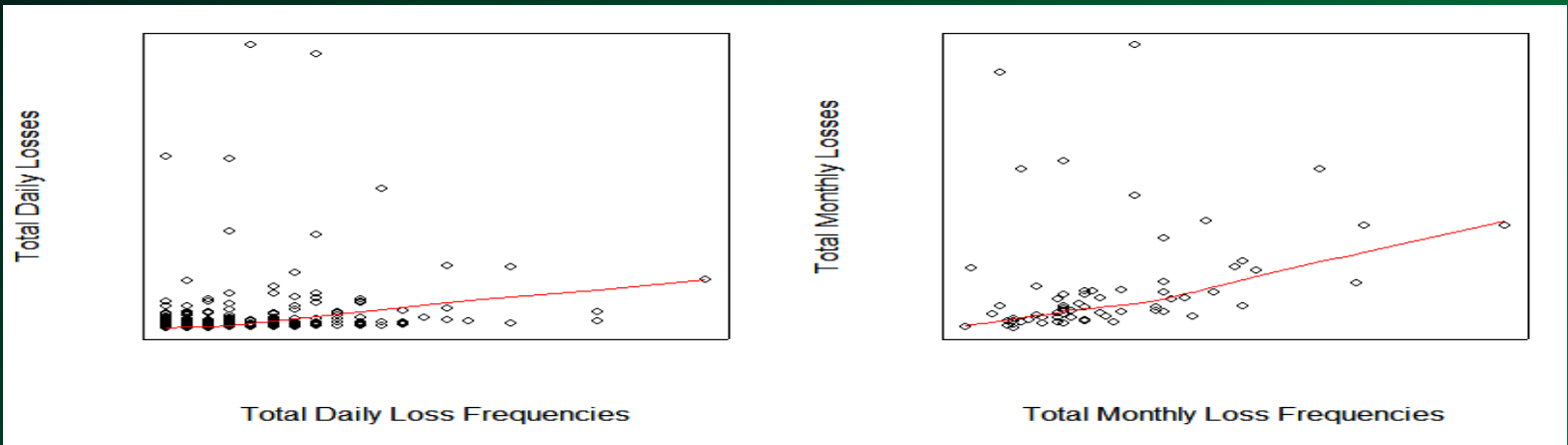
Stationarity





- Operational losses beyond tail threshold appear to be non-stationary, in the absence of formal analysis:
  - Loss frequencies are (also) irregularly spaced in time
    - But the presence of seasonality / cyclicality is not apparent
  - Loss frequencies seem to trend downward, only slightly
    - But the time period is relatively short
- More data are needed, in order to:
  - Obtain a proper understanding of event generating process
  - Appropriately model non-stationarity
- How different would capital be when non-stationarity is taken into account?

Dependence



- No evidence of dependence between frequency and severity
  - Typically largest total-daily (-monthly) losses consist of one large loss combined with small losses
- Literature suggests the use of copulas for describing the interdependence between large losses of different business units/loss types
  - What are (or should be) the guidelines that would help to determine the most appropriate copula (Clayton, Gumbel, Frank)?
  - How sensitive is capital to copula?
  - Is capital more sensitive to copula or to marginal distribution?
  - May be quite some time before this one can be fully addressed from a practical standpoint
    - Particularly for institutions with a somewhat homogeneous business/loss portfolio

IV. Closing Notes

Closing Notes

- Techniques for modeling operational risk are developing very quickly
  - The learning curve seems to be growing taller even as we climb it
- For Northern, EVT-based modeling (v.1.0) produces reasonable though significant results
  - More robust, defensible than models using only internal data or a mix of internal and filtered external data
  - Plan to use EVT as one of several capital modeling approaches
- Still some tough issues to address
  - Stability of model results (especially as new data are added)
  - Explaining the modeling approach to Senior Management, Board of Directors
  - Incorporating the Qualitative Adjustments – RCSA, KRIs, Scenario Analysis
    - … and still maintaining the quality of the modeling effort
  - Allocating top of house capital – to business units, products, customers

Connection with Emerging EVT Approaches

- Correlations do not play a large role in modeling at this point
  - Northern Trust pretty close to mono-line
- Time impacts are noticeable
  - See value in time adjustments for backtesting
  - But foresee issues in applying time adjustments to forward-looking capital
    - Expectation of conservativism in Basel II
- Capital allocation
  - Currently determining 'marginal capital impacts' by excluding parts of the organization
  - Paper presents promising alternate techniques to address this issue
    - Embedding, Superpositioning, and Thinning
    - But it will be quite some time before we have enough data to use such approaches
- Overall, the approaches described in the paper open up several paths for exploration and development

Thank You

References

1. Bensalah, Y. (2000), 'Steps in Applying Extreme Value Theory to Finance: A Review'.

2. Coleman, R. (2002), 'Op risk modelling for extremes'.

3. Coles, S. (2001), An Introduction to Statistical Modeling of Extreme Values, Springer.

4. Corrandin, S. (2002), 'Economic Risk Capital and Reinsurance: an Extreme Value Theory's Application to Fire Claims of an Insurance Company'.

5. Danielsson, J. and de Vries, C. (2002), 'Where do Extremes Matter?'.

6. Danielsson, J., de Haan, L., Peng, L, and de Vries, C. (1999), 'Using a Bootstrap Method to Choose the Sample Fraction in Tail Index Estimation'.

7. de Fontnouvelle, P., DeJesue-Rueff, V., Jordan, J., and Rosengren, E. (2003), 'Using Loss Data to Quantify Operational Risk'.

8. Di Clemente, A. and Romano, C. (2003), 'A Coupla-Extreme Value Theory Approach for Modelling Operational Risk'.

9. Diebold, F., Schuermann, T., and Stroughair, J. (1998), 'Pitfalls and Opportunities in the Use of Extreme Value Theory in Risk Management'.

References, continued

10. Ebnöther, S., McNeil, A., and Antolinex-Fehr, P (2001), 'Modelling Operational Risk'.

11. Embrechts, P., Kaufmann, R., and Samorodnitsky, G. (2002), 'Ruin theory revisited: stochastic models for operational risk'.

12. Embrechts, P., Lindskog, F., and McNeil, A. (2001), ' Modelling Dependence with Copulas and Applications to Risk Management'.

13. Embrechts, P., Resnick, S., and Samorodnitsky G. (1996), 'Extreme value theory as a risk management tool'.

14. Fabien, F. (2003), 'Copula: A new vision for economic capital and application to a four line of business company'.

15. Këllezi, E. and Gilli, M. (2002), 'Extreme Value Theory for Tail-Related Risk Measures'.

16. McNeil, A. (1996), 'Estimating the Tails of Loss Severity Distributions using Extreme Value Theory'.

17. McNeil, A. (1999), 'Extreme Value Theory for Risk Managers'.

18. McNeil, A. and Saladin, T. (1997), 'The Peaks over Thresholds Method for Estimating High Quantiles of Loss Distributions'.

References, continued

19. Melchiori, M (2003), 'Which Archimedean Copula is the right one?'.

20. Mirzai, B. (2001), 'Operational Risk Quantification and Insurance'.

21. Parisi, F. (2000), 'Extreme Value Theory and Standard & Poor's Ratings'.

22. R Development Core Team (2004). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org.

23. Romano, C. (2002), 'Calibrating and Simulating Copula Functions: An Application to the Italian Stock Market'.

24. Smith, R. (2003), 'Statistics of Extremes, with Applications in Environment, Insurance and Finance'.