Nomura Securities International, Inc.
Equity Quantitative Analytics

Risk Models For Changing Markets

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Risk Measurement in Turbulent Times

- **Turbulent times put particular stress on risk models**
  - Higher systematic risks
  - Common fat-tail events within shifting volatility regimes
  - Structural changes at various levels of granularity
- **Some (relatively) new technologies help address that**
  - Random Matrix Theory for clean correlations from limited data
  - Non-normal volatilities
  - Hierarchical model aggregation
- **We will briefly discuss those, with some applications**

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Problem: Selecting Factors

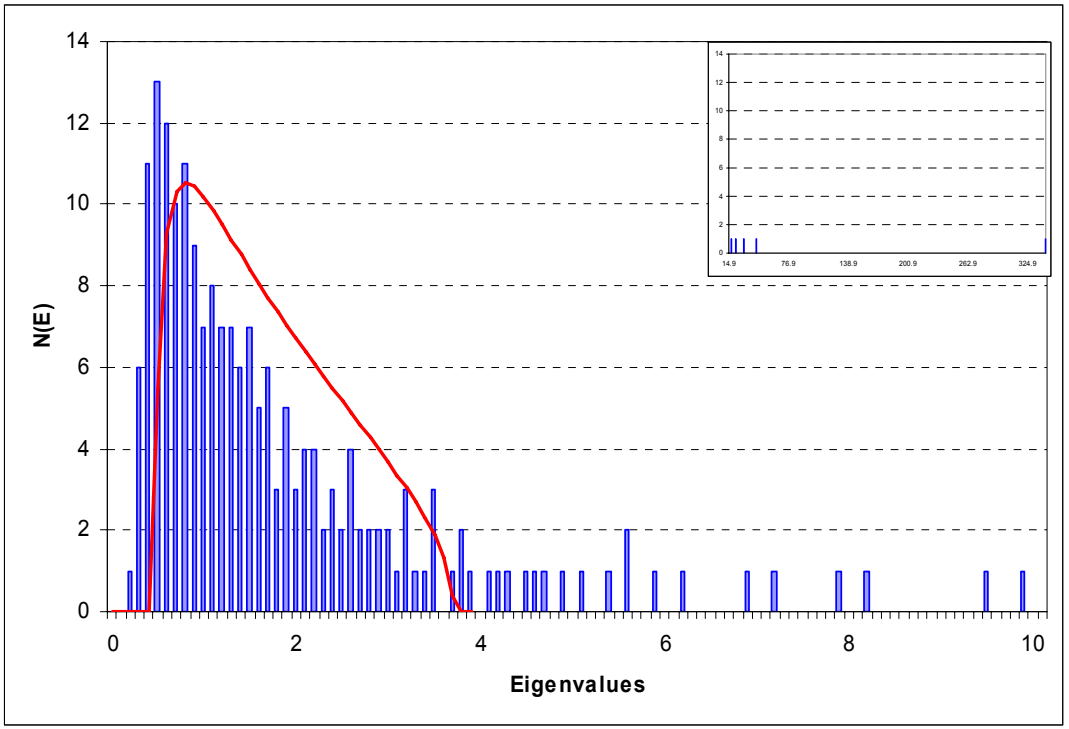
- **Risk models separate systematic from idiosyncratic risk**
  - Systematic risk expressed in common factors

- **It is important to be able to do this separation *dynamically***
  - The number (and nature) of active factors changes with the market's tone
  - Yet most risk models use static criteria to identify common risk
    - Fixed number of factors, or systematic risk as fixed fraction of total risk…

- **How can we determine how many factors are active at any given time?**
  - We need a "t-test" to determine would-be factor validity

Solution: Comparison with Random Matrices

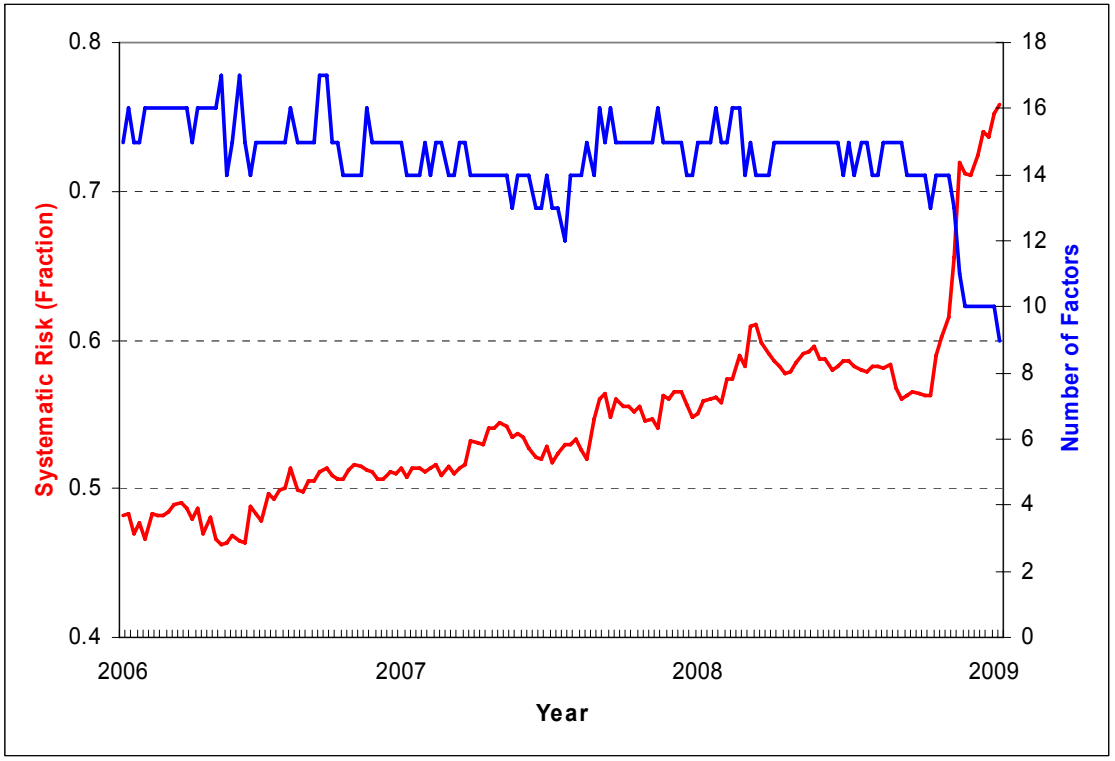
- **Random Matrix Theory provides a "t-test"**
  - Among would-be factors, we keep only those that stick out from the "noise"
  - "Noise" is a covariance (or correlation) matrix that is "random"
  - Principal component spectrum of random matrices found by math or simulation



Source: Nomura Securities International, Inc.

Application: How Many Factors Drive The Market?

- **Factor counting provides a running measure of market nervousness**
  - Factor analysis on moving windows yields a time series of factor counts
  - In times of crisis, systematic risk rises and the number of factors drops



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Problem: Preserving Local Structure in a Global Model

- **Risk modeling can be done on many scales**
  - Sectors, countries, regions, globally
- **It is important to do this *consistently***
  - We want to preserve fine structure within a broader framework
  - We want to keep risk numbers the same regardless of scale or context
  - But we also want to keep no more factors than necessary
- **How can we combine risk models consistently?**
  - Adopt a bottom-up approach

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Solution: A New Hierarchical Construction Process

- Take two factor models: $R_1 = R_1^{sys} + \varepsilon_1$ and $R_2 = R_2^{sys} + \varepsilon_2$
- Stack the systematic parts $\begin{bmatrix} R_1^{sys} \\ R_2^{sys} \end{bmatrix}$ and do PCA analysis to explain the already de-noised returns

Sector 1 $\oplus$ **Sector 2** $\oplus \ldots \oplus$ **Sector *N*** $\Rightarrow$ **Country Model**

Country 1 $\oplus$ **Country 2** $\oplus \ldots \oplus$ **Country *N*** $\Rightarrow$ **Regional / Global Model**

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Application: How Different Are Different Countries and Sectors Risk-wise?

US Sectors	Factors
Communications	6
Consumer Cyclical	6
Consumer Non-cyclical	7
Diversified	3
Energy	4
Financial	6
Industrial	6
Materials	6
Technology	3
Utilities	5
US Composite*	15

Source: Nomura Securities International, Inc.

Americas Countries	Factors
US	15
Canada	9
Brazil	5
Chile	4
Peru	3
Colombia	3
Argentina	2
Mexico	2
Americas Composite*	31

Source: Nomura Securities International, Inc.

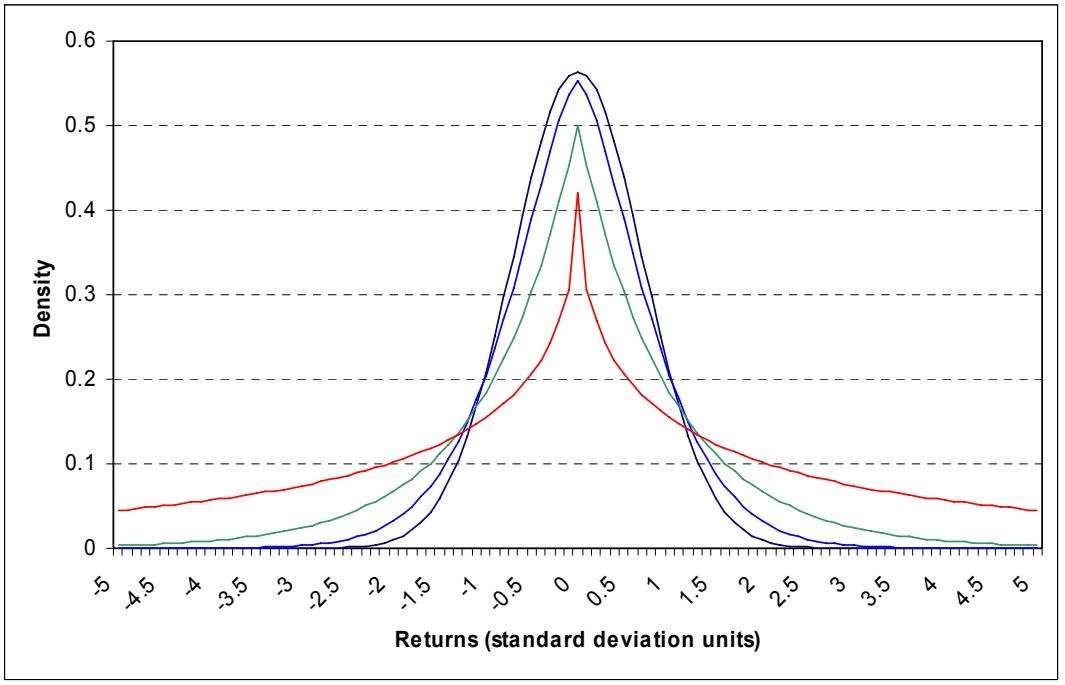
**Data as of 02/23/09*

Problem: Fat Tails

- **Normal distributions are notoriously poor in handling extreme risk**
  - Extreme events happen far more frequently than normal distributions would predict
  - Such misrepresentation of risk can lead to catastrophic losses
- **It is important to understand that changing volatility and fat tails are related**
  - Weighing recent events more improves risk estimates
  - But unless non-normal measures are used, extreme risk is still underestimated
- **How can we incorporate fat tails into factor-based risk models?**
  - Focus on estimating “true” volatility

Solution: Non-Normal Volatilities

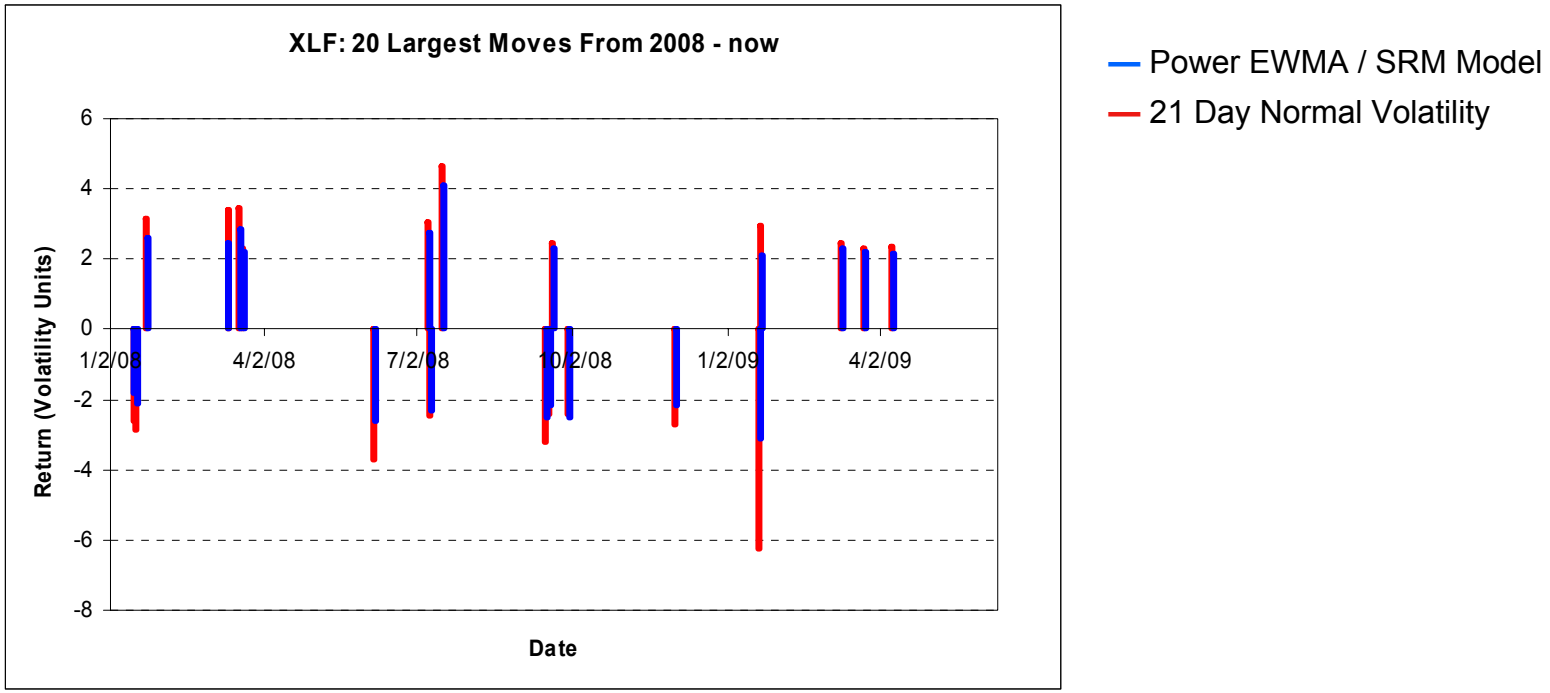
- Estimate volatilities using appropriate non-normal distributions
- Power Exponential family is a convenient choice
  - The degree of thickness of the tail can be controlled with α ; $f(x) \propto \exp\left(-\left|\frac{x}{\sigma}\right|^{\alpha}\right)$
- Combine with EWMA - estimation to get "Power-EWMA"



Source: Nomura Securities International, Inc.

Application: Extreme Risk Management

- **With compensation for fat tails, the predicted VaR conforms more closely to actual returns**
  - Since 2008 the XLF has exceeded 99% VaR (normal) on 9 days vs. 3½ expected
  - Average loss on such days was 37% above normal VaR with a max of 170%
  - In contrast, 99% Power-EWMA VAR was exceeded only 4 times, with an average loss of only 15% above VaR, rising to no more than 33%



Source: Nomura Securities International, Inc.

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From Theory To Practice

- **Nomura's Statistical Risk Model (SRM) suite incorporates these features**
  - Factor selection using random matrix priors, fat tails, hierarchical construction
  - 76 countries, 50,000 equities
  - Multiple horizons: 3 months, 1 month
- **Like most of Nomura's analytical utilities, it is available in TradeSpex™**
  - Web-based analytical platform
  - Risk, Optimization and Pre/Post-Trade Analysis
- **If you are interested in further discussion, we would love to hear from you**
  - We also have a white paper on our model

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