STRATEGIC ANALYTICS

Diversification Benefit Calculations for Retail Portfolios

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Strategic Analytics Today

$1+ trillion in assets being analyzed in > 25 countries

Clients include leading retail lenders worldwide including:

- Capital One
- Discover
- HBOS
- HSBC
- Lloyds TSB
- SunTrust
- US Bank
- Wells Fargo

Used to analyze all retail and consumer lending products:

- Mortgage
- Home equity lines and loans
- Auto loans
- Cards
- Personal lines and loans
- Student loans
- Small business loans

Domain Expertise

Industry Risk Performance Studies

Scenario-based Forecasting

Portfolio Stress Testing

Economic Capital Modeling

Product and Services Overview

Service & Software Packages

SA's services and software are bundled to suit to clients' modeling requirements.

Retail and Mortgage Risk Services

- Scenario-based Forecasting
- Portfolio Stress Testing
- Forecast Volatility Analysis
- Topaz / Eclipse Industry Risk Studies
- LookAhead Forecaster Software

Retail and Mortgage Finance Services

- P&L Forecasting
- Economic Capital Modeling
- Diversification Benefits Modeling
- Portfolio Optimization

End-User Software Applications

SA provides end-user software applications to satisfy the most advance requirements.

LookAhead™

Scenario-based Forecasting Software

- LookAhead Power Station
- LookAhead Expert
- LookAhead Forecaster

TrueCapital™

Economic Capital Modeling Software

PossiblePaths™

Monte Carlo Scenario Generation

Agenda

- Diversification Concepts
  - What structure are we correlating?
  - What variables are we correlating?
  - How do we define diversification?
- Correlations between retail loans
  - The Monte Carlo view of correlation
  - The Distributional view of correlation
    - Synthetic Indices
    - Normal approximations
    - Copulas
- Correlations between retail and the rest of the bank.
  - The Distributional view is required.

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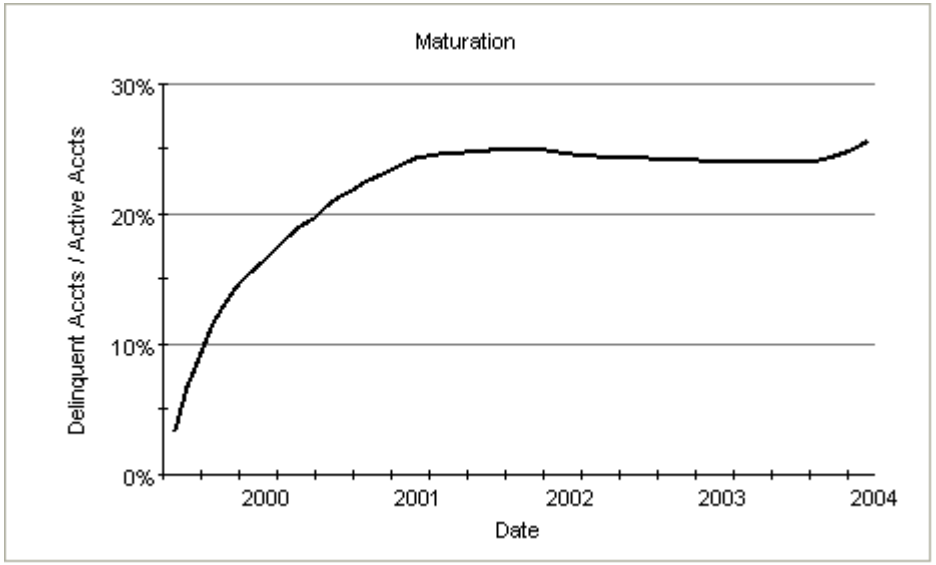
The Dynamics of Retail Portfolios

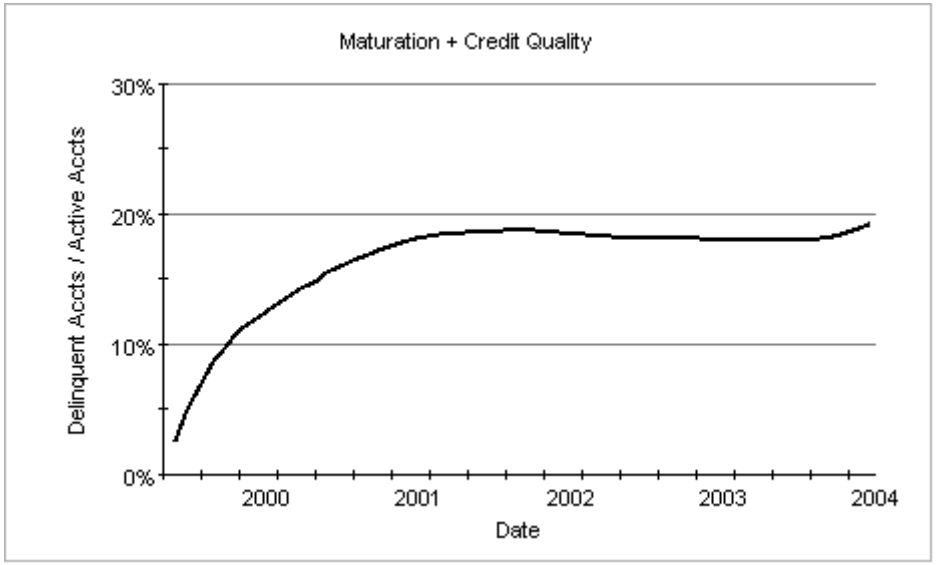
Components of Portfolio Performance

- Vintage Lifecycle



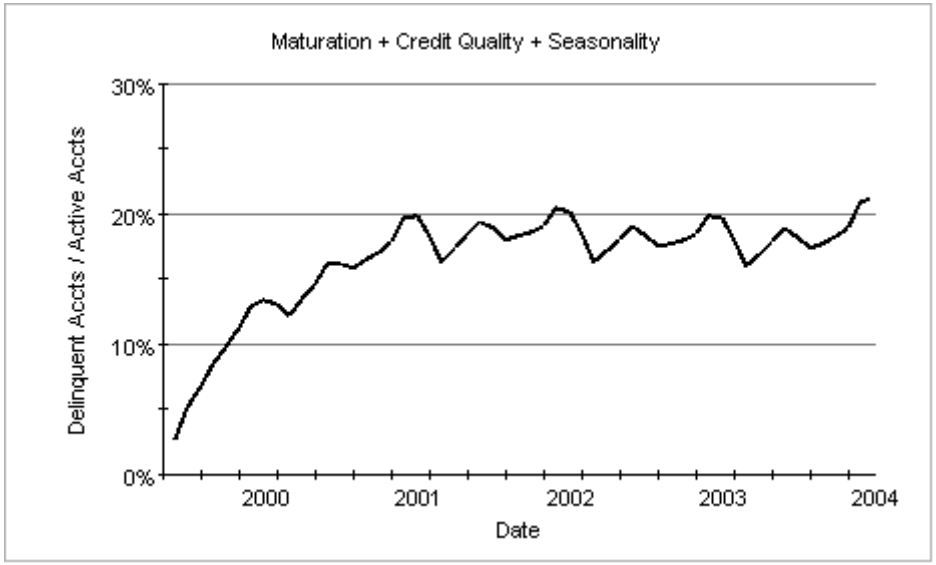
Components of Portfolio Performance

- Vintage Lifecycle
- Credit Quality



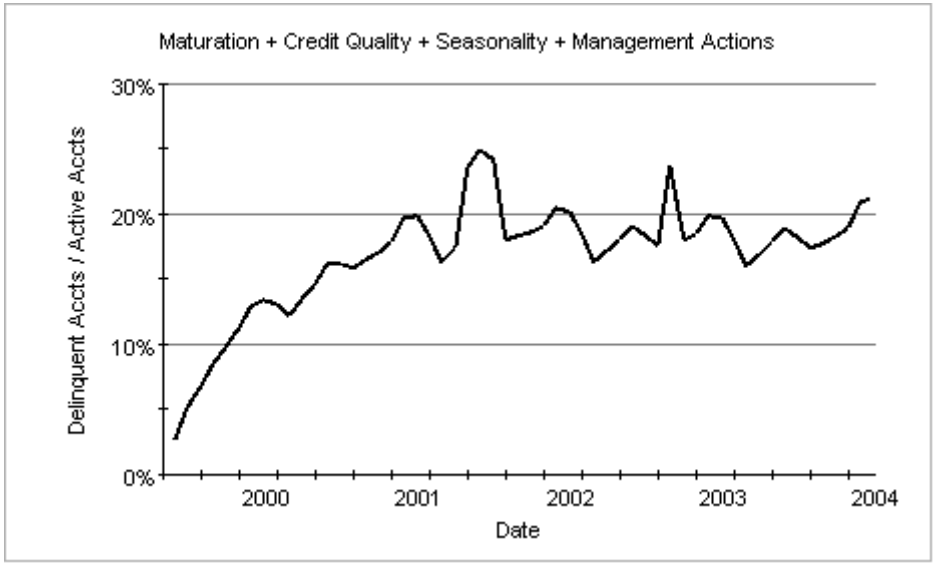
Components of Portfolio Performance

- Vintage Lifecycle
- Credit Quality
- Seasonality



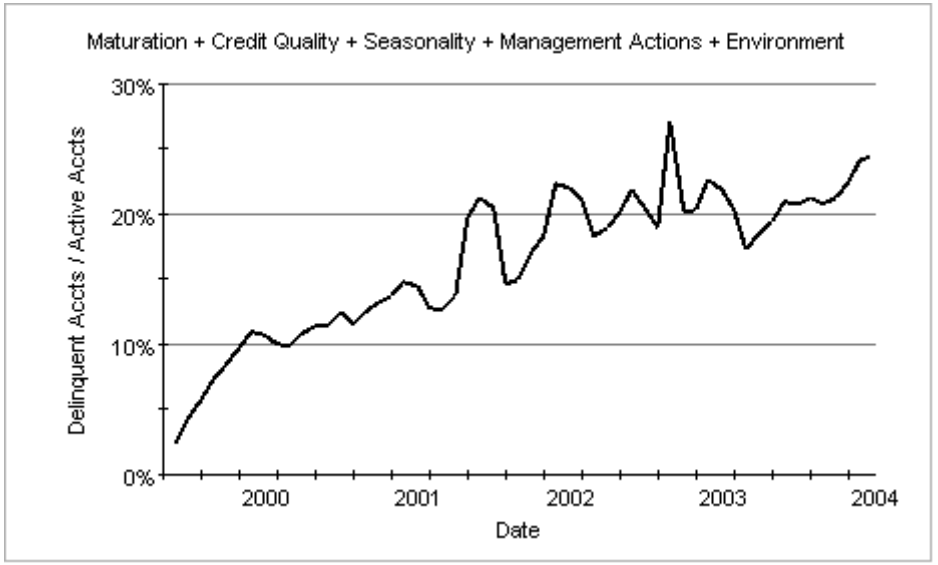
Components of Portfolio Performance

- Vintage Lifecycle
- Credit Quality
- Seasonality
- Management Actions



Components of Portfolio Performance

- Vintage Lifecycle
- Credit Quality
- Seasonality
- Management Actions
- Macroeconomic & Competitive Environment



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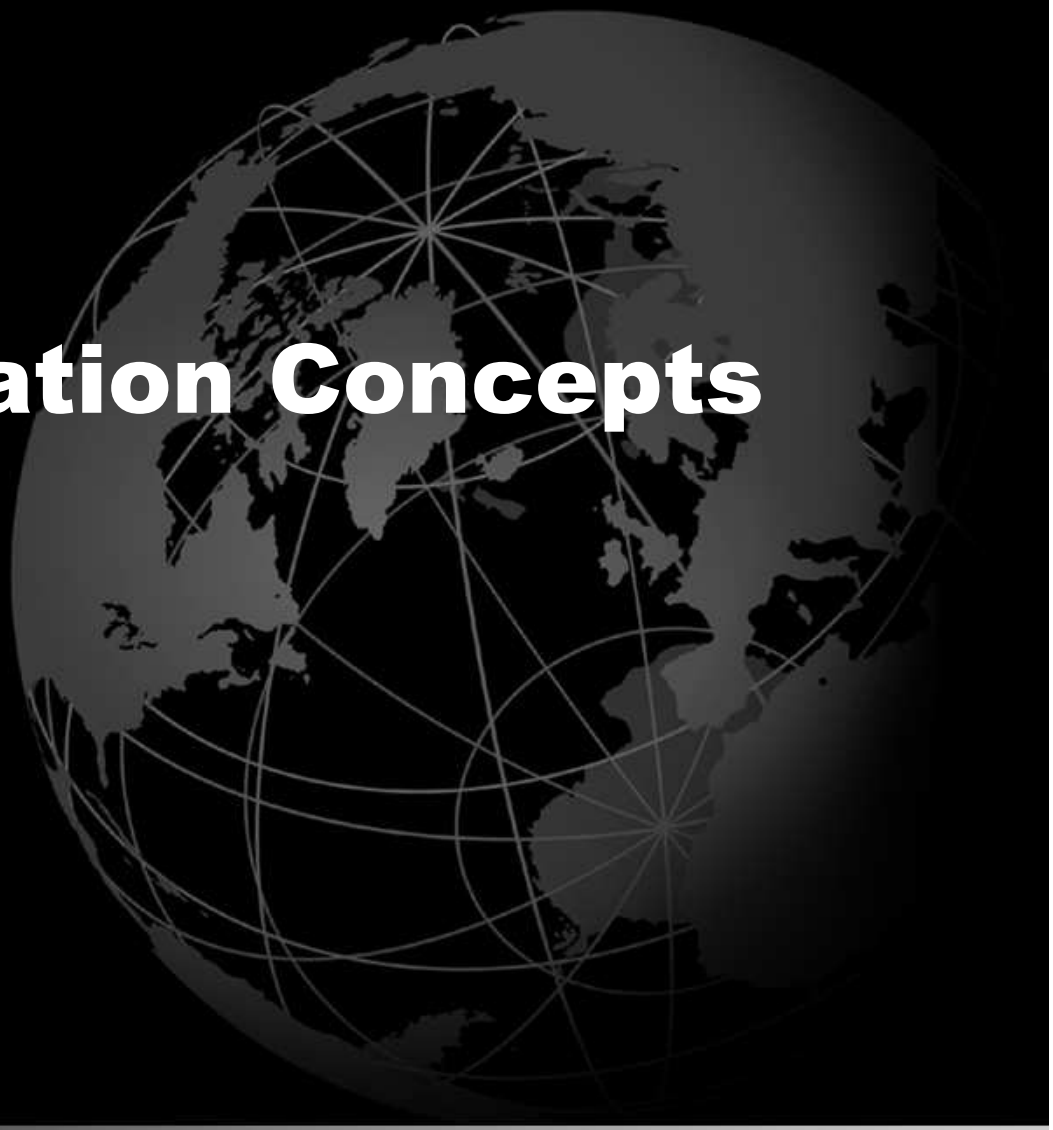
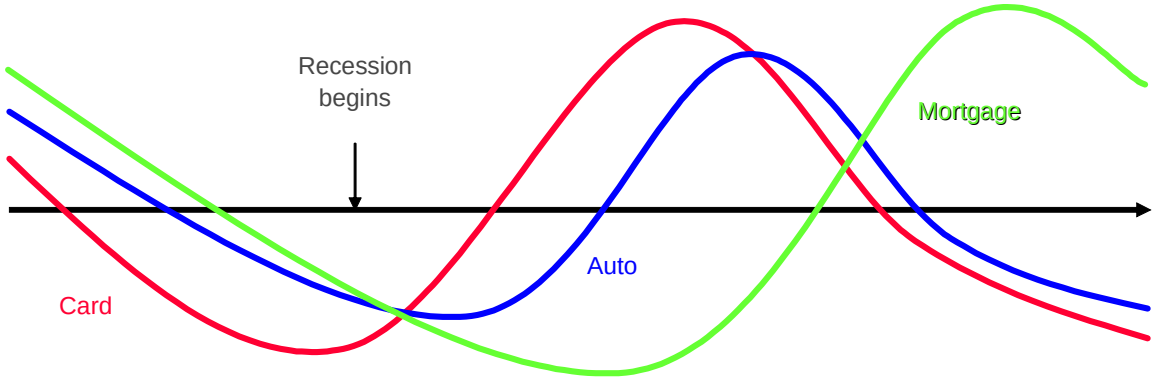
Diversification Concepts



The Concept of Diversification

- We want to hold capital, adjusted for whether all extreme capital needs will occur simultaneously.



Assuming normal distributions…

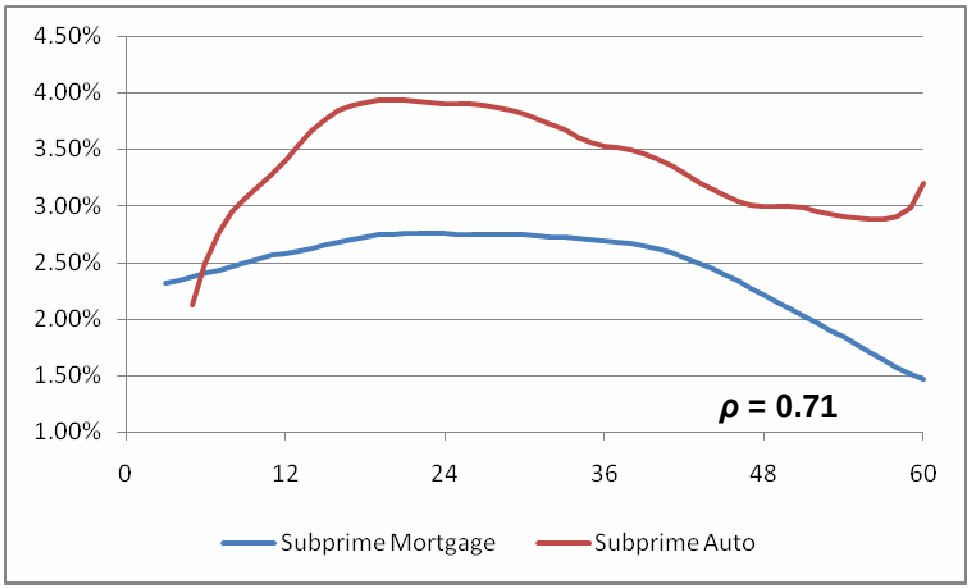
- With perfect correlation: $C_{Bank} = C_{Card} + C_{Auto} + C_{Mortgage} + \cdots$
- With partial correlation: $C_{Bank} \leq C_{Card} + C_{Auto} + C_{Mortgage} + \cdots$
- With no correlation: $C_{Bank} = \sqrt{C_{Card}^{\ 2} + C_{Auto}^{\ 2} + C_{Mortgage}^{\ 2} + \cdots}$

Sources of Correlation

- What correlations do we wish to consider?
  - Originations Volume
  - Originations Quality
  - Macroeconomic Impacts

Correlation Due to Originations Volume

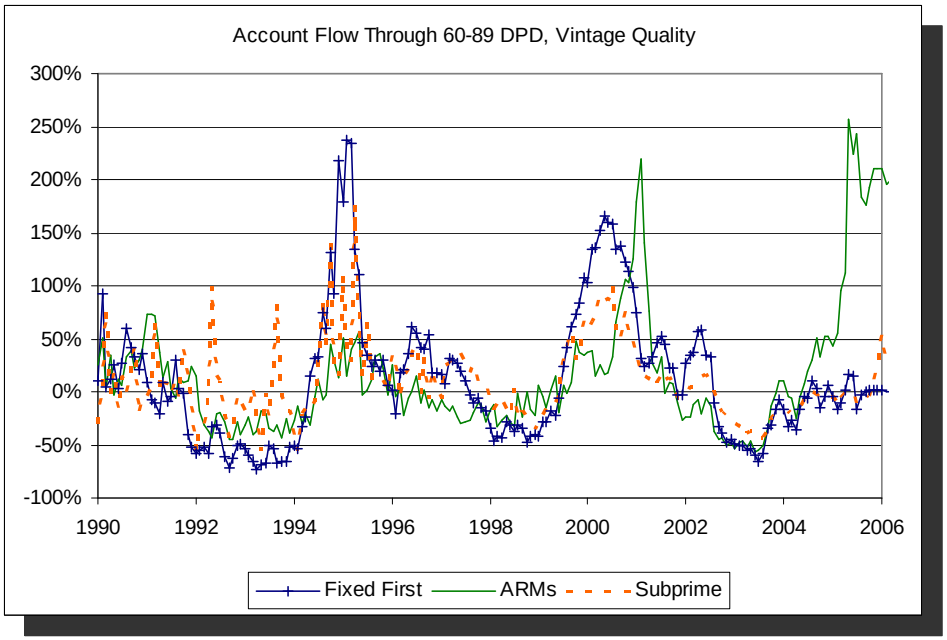
- Retail loan vintages will be strongly correlated just due to lifecycle effects



- Consequently, a burst of originations in two products will make them appear correlated.

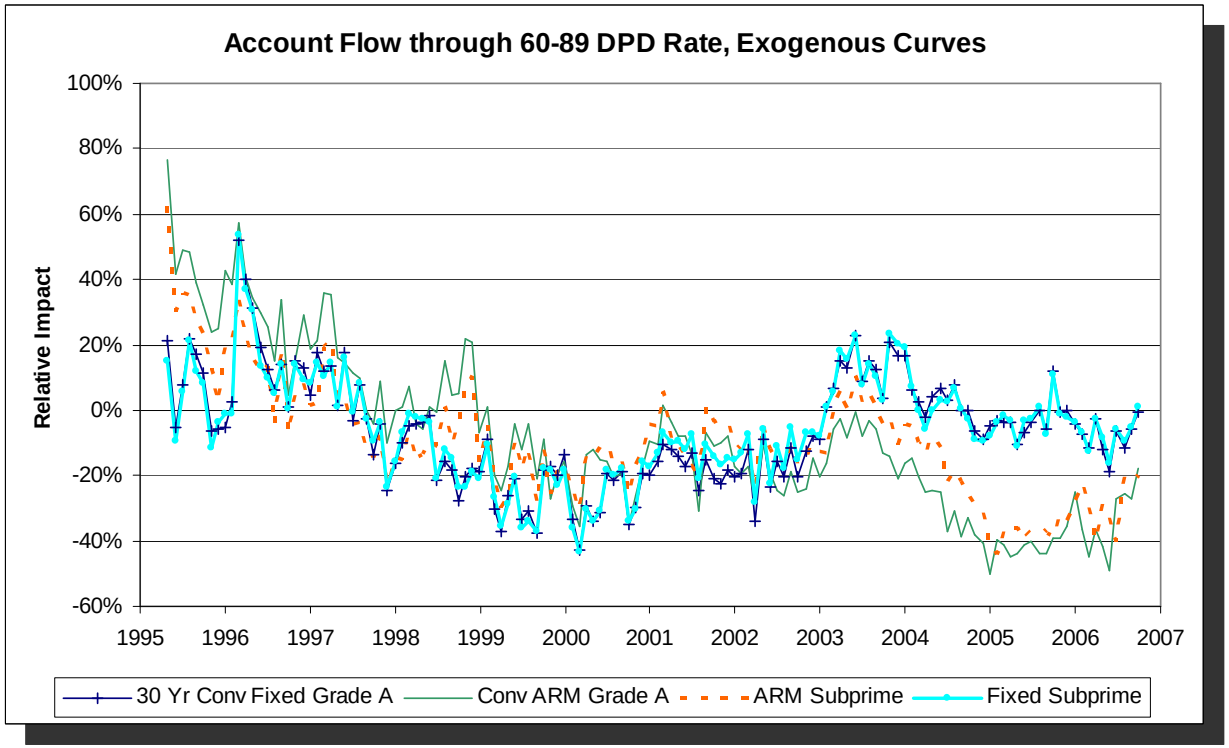
Correlation Due to Originations Quality

- Originations quality varies with time, in apparent response to macroeconomic conditions.
- However, anecdotal evidence suggests that it is the portfolio management's response to macroeconomic conditions that can, but need not necessarily, create the correlation.
- The current US mortgage crisis is being felt simultaneously in auto and card in most portfolios, because of quality correlations.



Correlation Due to the Economy

- We see strong similarities across products in response to the same economic environment.



Which Correlations to Include?

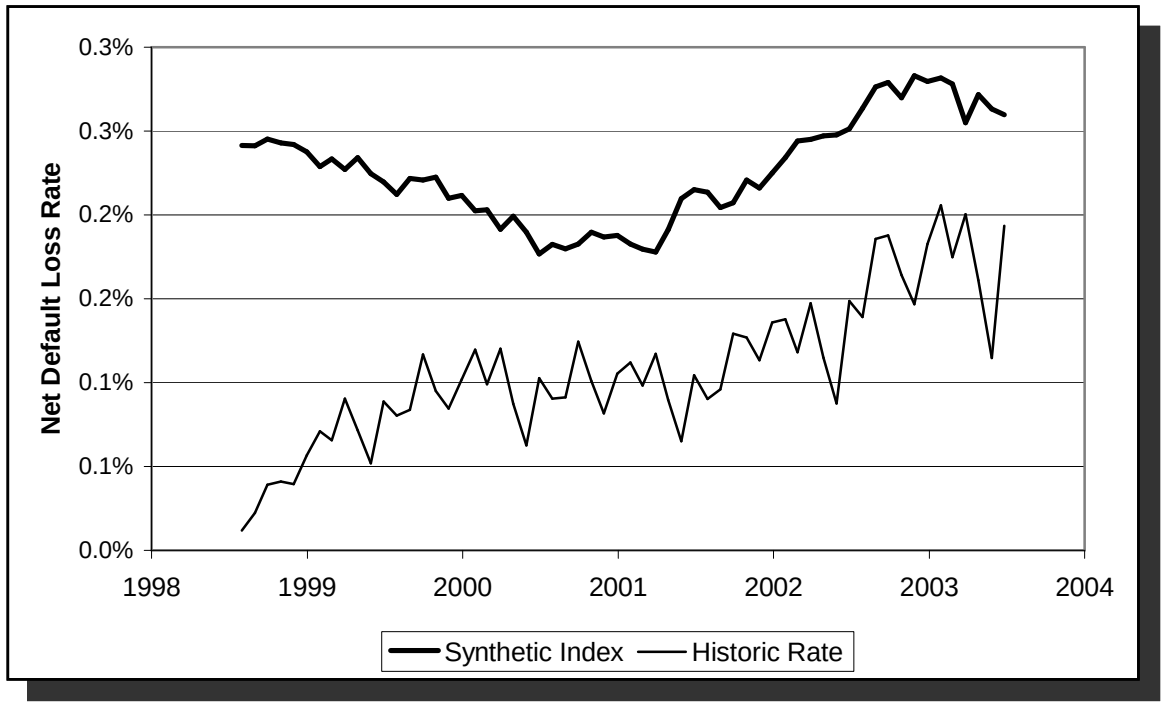
- Depending on out decisions, dramatically different answers are possible:

A.	**Volume Quality Macroeconomic**	**Use full loss time series**
B.	**Quality Macroeconomic**	**Create a synthetic loss time series eliminating volume effects**
C.	**Macroeconomic**	**Create a synthetic loss time series eliminating volume & quality effects**

- Between retail products, scenario-based forecasting + Monte Carlo simulation is more accurate.
- Integrating with the rest of the bank is where the problems arise, and the need for Synthetic Indices.

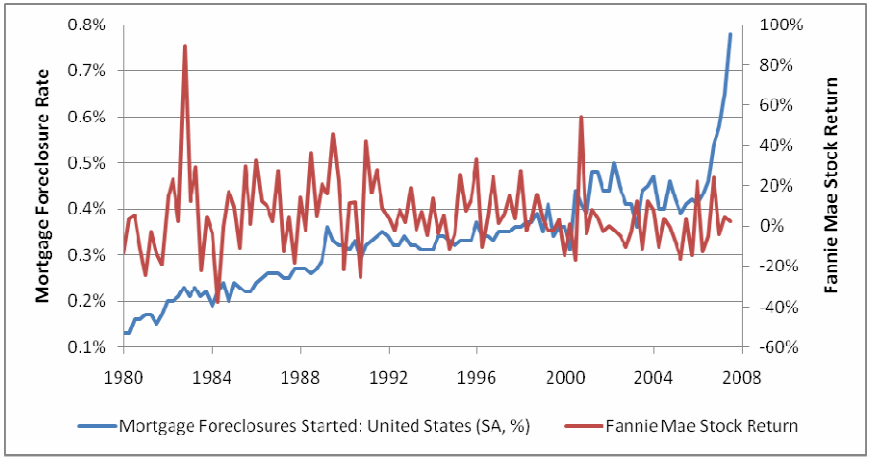
A Synthetic Index Comparison

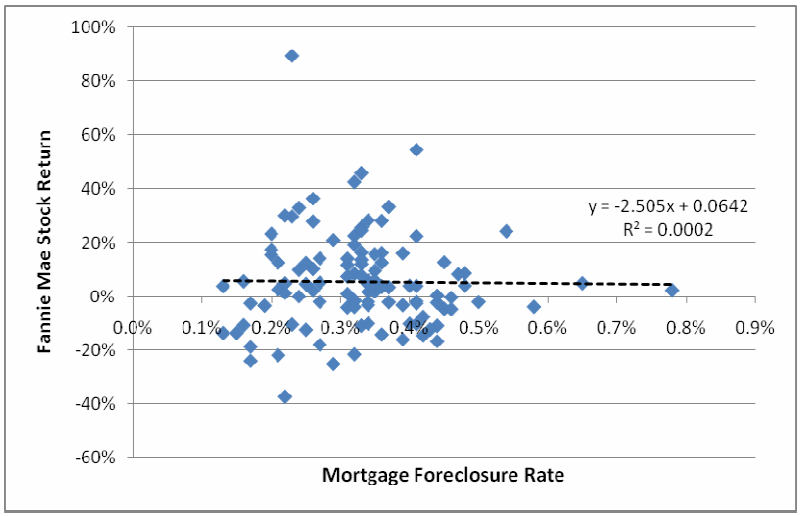
- New product or segment launches (thin) highlight the problem of correlation due to originations volume.
- A Synthetic Index (thick) can strip away those effects.



What Variables Are We Correlating?

- Retail portfolio losses are not equivalent to market returns.





- Retail portfolio return series show much less correlation between products than do retail portfolio loss series.
- If we consider only losses, it must at least be Net Default Loss Rate, not just Default Account Rate.

How Do We Define Diversification?

…or correlation?

- Are we correlating over the next 12 months, or to a recessionary event?
- Do we want to measure overall correlation, or only extreme event correlation?

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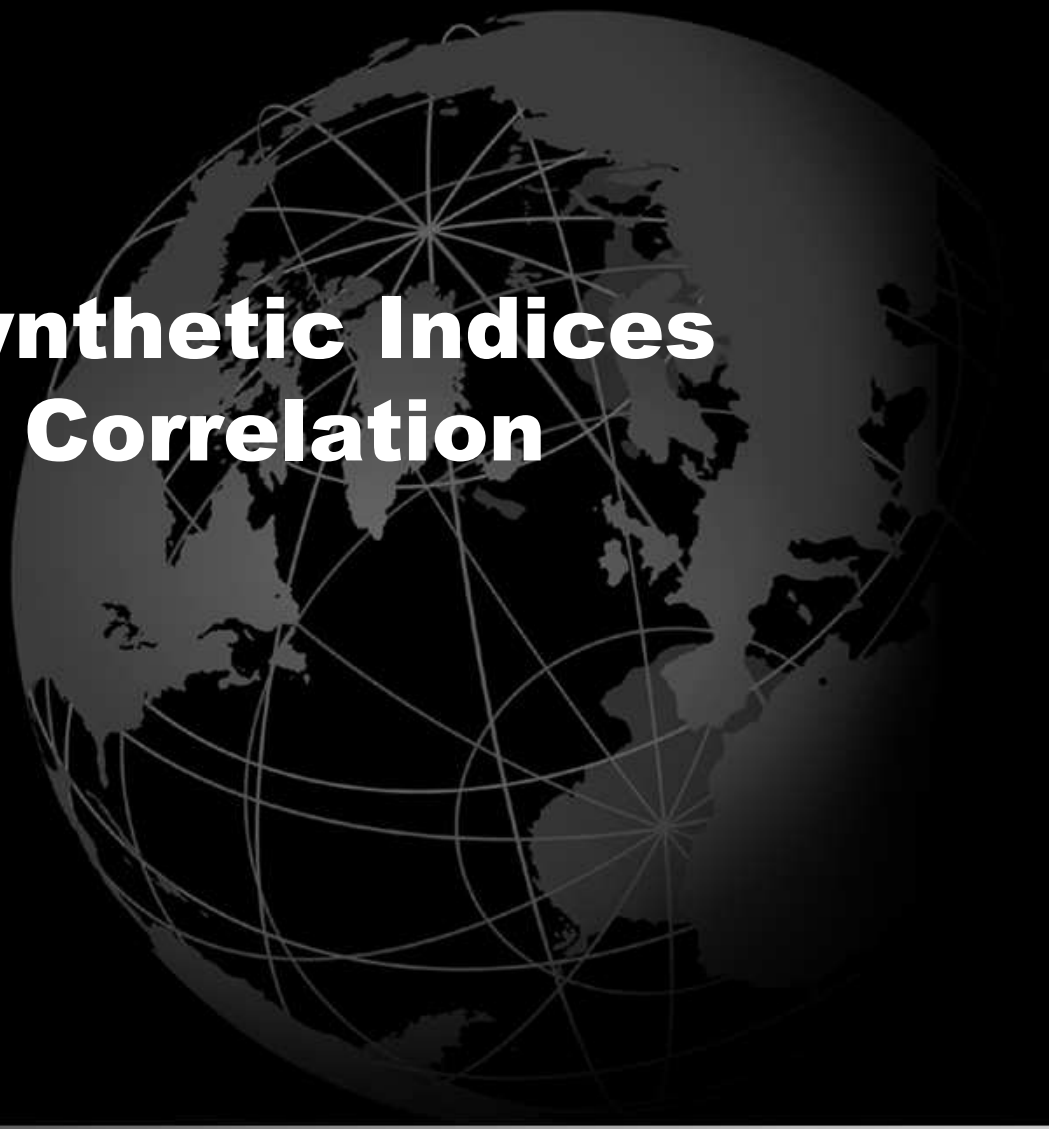
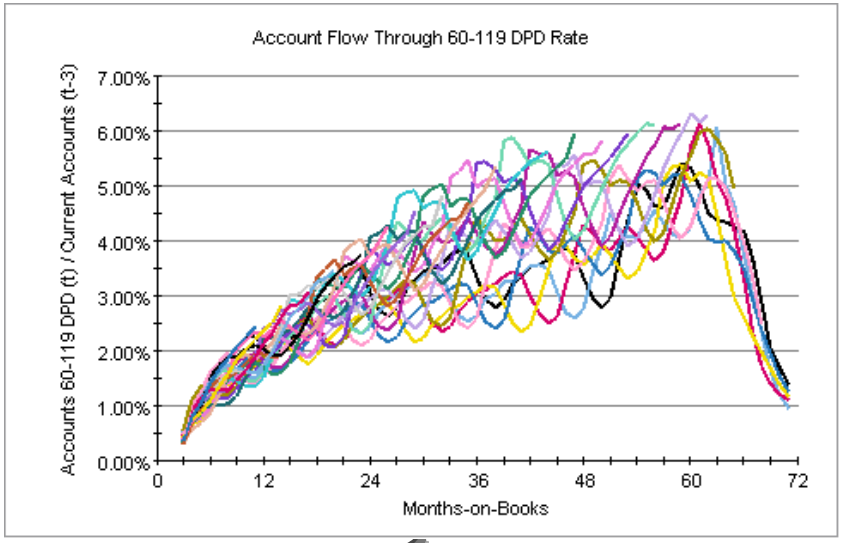
Creating Synthetic Indices to Measure Correlation

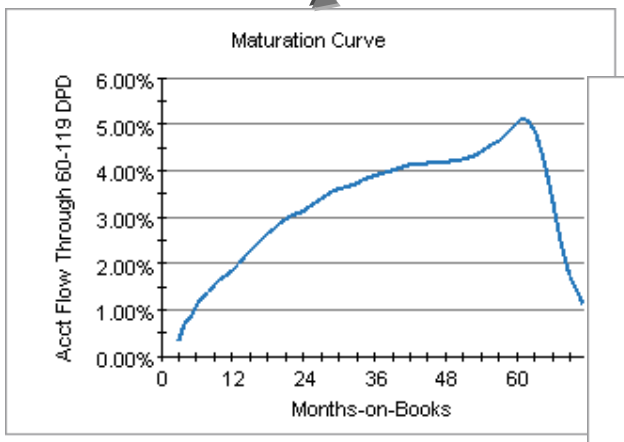


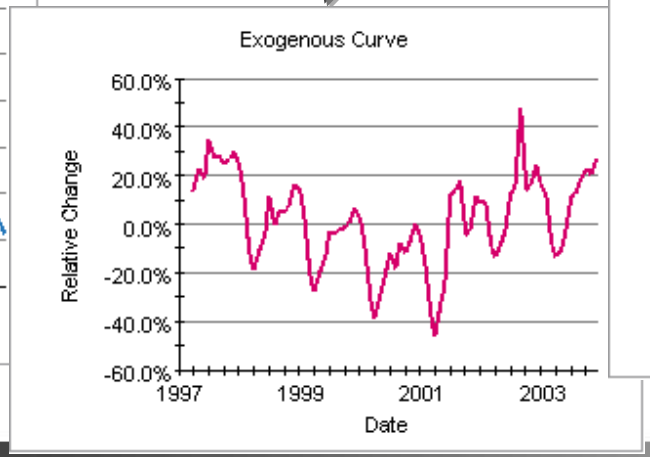
Dual-time Dynamics (DtD)

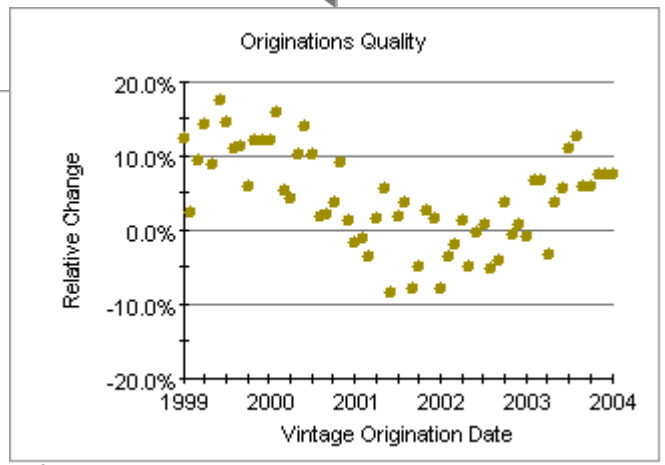
- **Maximum Likelihood Estimates of the following functional form:**

$$r(a,v,t) = \beta(v)e^{f_m(a)}e^{f_g(t)}$$



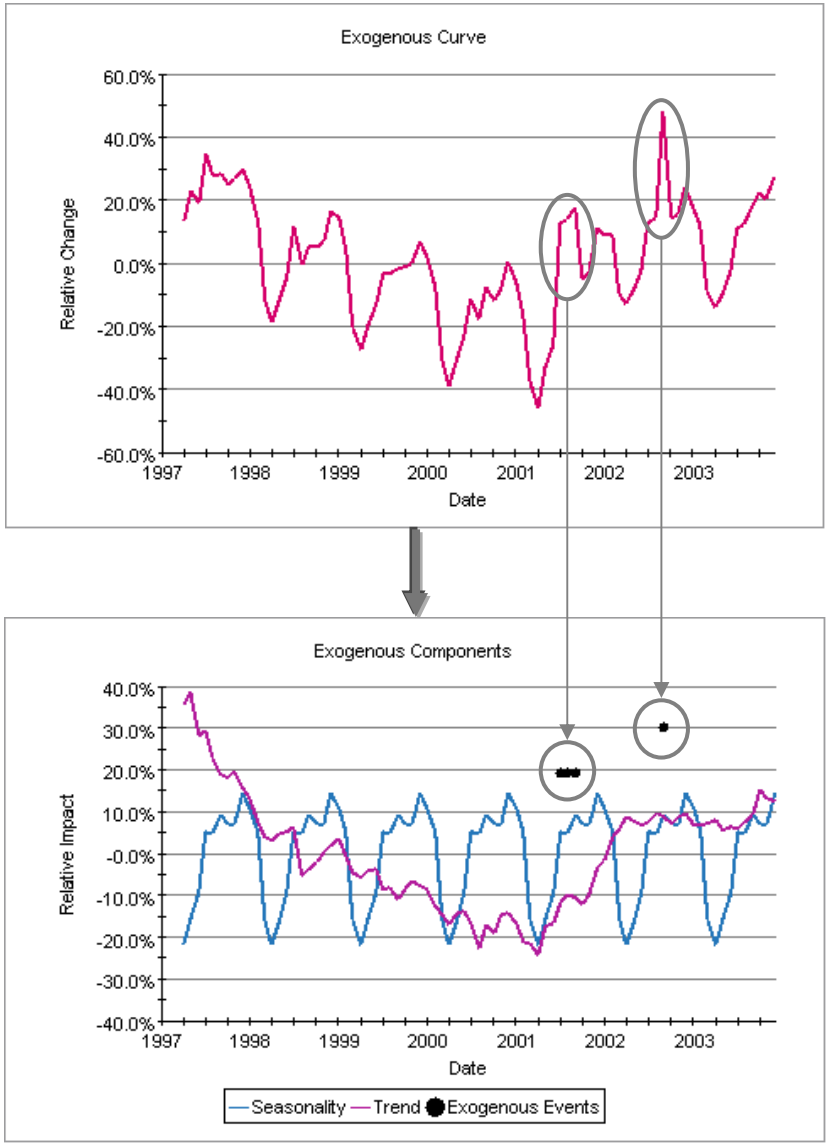






Decomposing the Exogenous Curve

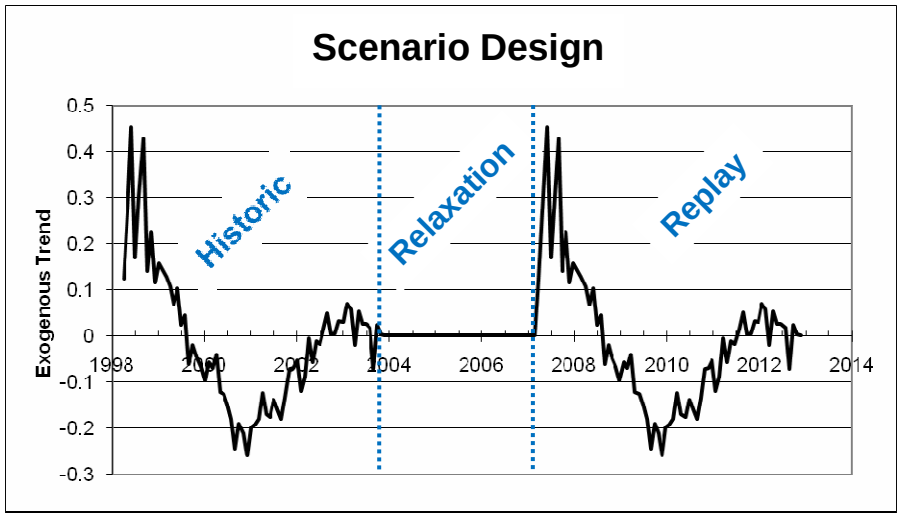
- The exogenous curve measures the relative impact of external factors upon intrinsic consumer dynamics
- e.g. “20% higher delinquency than would have been expected from the maturation process”
- To ascertain cause-and-effect, the exogenous curve is further decomposed into seasonality, trend (usually macroeconomic impact), and events (management actions).



Computing Synthetic Indices

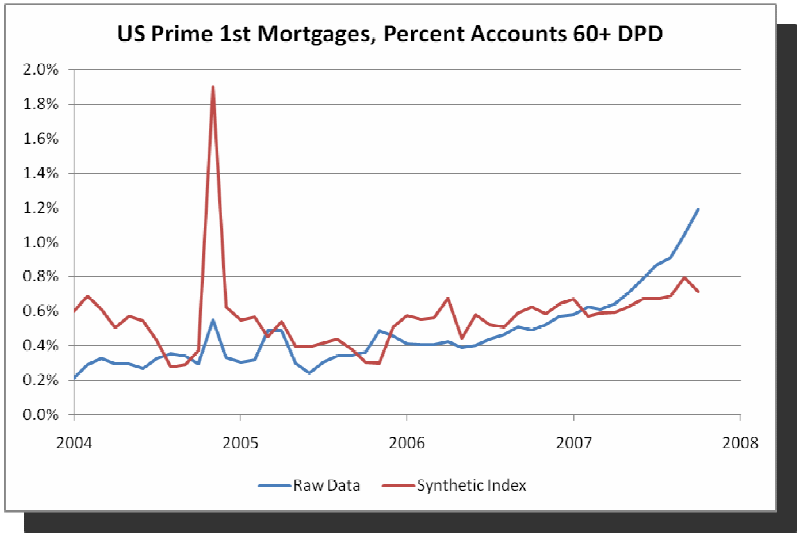
- The following steps can be done with any scenario-based forecasting system that separates environmental and vintage quality effects:

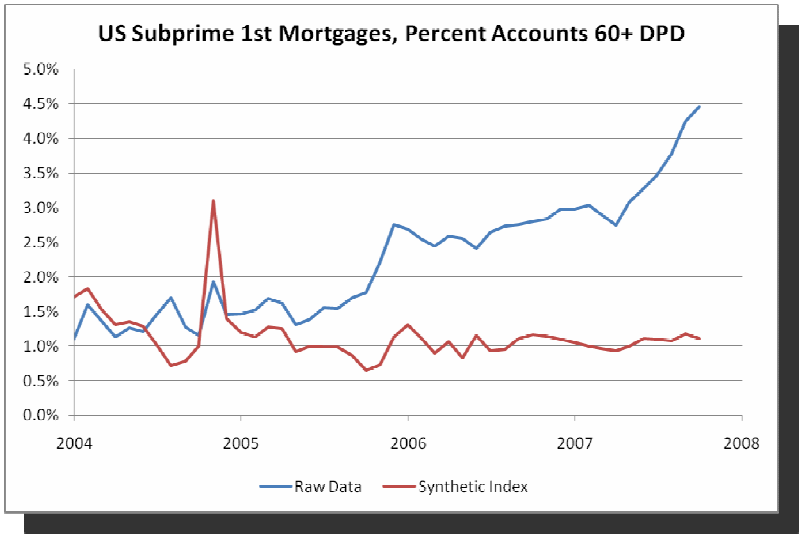
1. **Forecast through the "Relaxation" period with steady originations volume and quality and steady-state environment.**
   - **The Relaxation period should extend until the target variable, e.g. loss rate, has attained a steady-state.**
2. **Forecast through the "Replay" period with continued steady originations, but replay the historic environment.**
3. **Shift the Replay period back in time to align with the historic period being replayed.**



Examples

- Recent US Mortgage data was analyzed.
- The environment was measured historically and a scenario designed as described in the previous slide.
- The resulting re-forecast of delinquency rates is shown below.





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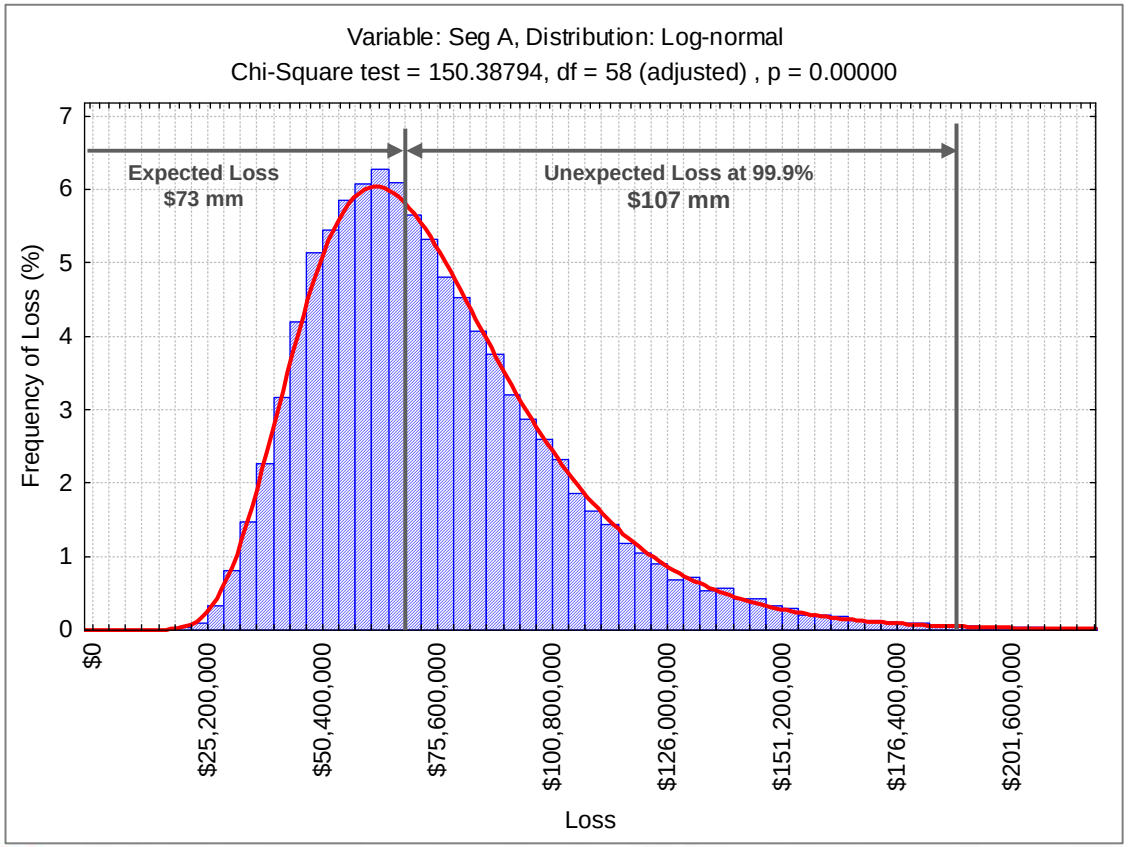
Creating & Combining Distributions

Economic Capital Distributions

- Experimentally, we find the loss distributions to fit exceptionally well to LogNormal overall, but with extra weight in the tail.
- A LogNormal assumption seems to underestimate the 99.9% point in the tail by 5% to 10%.



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Combining Distributions

From most accurate to least accurate…

1. Embed the cross-correlation structure directly in the scenario generation when computing capital via Monte Carlo.

$$L_{p,s} = f_p\left(E_s, I_{p,s}\right),\ L_s = \sum_{p=1}^{N_p} L_{p,s}$$

In the above formula, $L_{p,s}$ is the loss forecast for product p given scenario s. E_s are common factors capturing cross-product correlations. $I_{p,s}$ are idiosyncratic, product-specific factors.

The net capital can be computed from the distribution of net loss L_s.

Combining Distributions

2. Fit NIG functions to the distribution of Log($L_{p,s}$), compute a covariance matrix $\sigma_{i,j}$ from the Synthetic Indices, and combine distributions via an NIG Copula.

   "The Normal Inverse Gaussian Distribution for Synthetic CDO Pricing," A. Kalemanova, B. Schmid, and R. Werner, Aug 2005, risklab germany working paper.

3. Normal or LogNormal distributions are easily combined via

$$\sigma_{net}^2 = \sum_{i=1}^{n} \sum_{j=1}^{n} \rho_{ij} \sigma_i \sigma_j$$

where ρ_{ij} is the correlation matrix and σ_i^2 are the variances of the distributions.

Correlation under Stress

- Is “Stress Correlation” the same as overall correlation?
  - Do retail losses converge during extreme economic stress?
- “Stress Correlation” is unlikely to apply across all bank products simultaneously, but could certainly be an issue for retail.
- The interproduct correlations appear to be stable up to “ordinary” recessions. We lack data to test beyond that point.
  - May not appear true if raw loss time series are correlated, because of the compounding effects of originations policies.

Conclusions

- We can solve the problem of spurious correlation due to coincident marketing activities.
- We can solve the combination of correlated distributions with fat tails.
- We do not have sufficient data to fully address the issue of “stressed correlation”.