What are the Essential Features of a Good Economic Scenario Generator?

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What is an Economic Scenario Generator

- An ESG generates all the financial economic and macro-economic variables necessary for risk management.
- Produces a forward looking simulated global economy of financial markets including the pricing of derivatives and alternative assets.
- The simulated global economy manifests as a distribution of possible economic futures.
- Simulation engenders unexpected, but plausible outcomes critical to assessing risk.
- An ESG is not a predictive tool.

What is an Economic Scenario Generator

- Model parameterization should induce distributions and dynamics that reflect not just the salient features of the benchmark, but also novel behavior.
- The random aspects of the simulation enable us to capture plausible scenarios that have not yet been observed.
- Those are the unexpected outcomes critical to assessing risk.

Components of the Process: A Good ESG

- Coverage of critical financial variables such as: interest rates, total return, and macro variables.
- Coverage of a broad range of asset classes.
- Dynamic relationships between these variables are captured.
- Models can be estimated and calibrated using benchmark financial data.
- Models can be fully validated.

Measuring the Performance on an ESG

- In order to assess the performance of an ESG, one must understand and measure a vast array of empirical facts.
- One must be able to judge the relationships among the financial economic variables produced by the ESG against what is understood in the historical record.
- Let us look at some of the interesting empirical facts.

US Large Cap Equity Daily Returns

- **Testing portfolio protection strategies like CPPI requires daily returns.**

Data vs. the average 80 year simulation

Daily returns S&P 500 1926 - 2005

	Data	SVJ	GBM	
Mean	0.02%	0.02%	0.02%	
StdDev	1.2%	1.2%	1.2%	
Skew	-0.5	-0.5	0	
XS-Kurtosis	21	18	0	
Jumps exceeding				
-4.50%	90	71	2	
-7%	24	28	0	←
-9%	9	16	0	←
1987 > -20%	1	0.1	0	←

With GBM these are virtually impossible events.

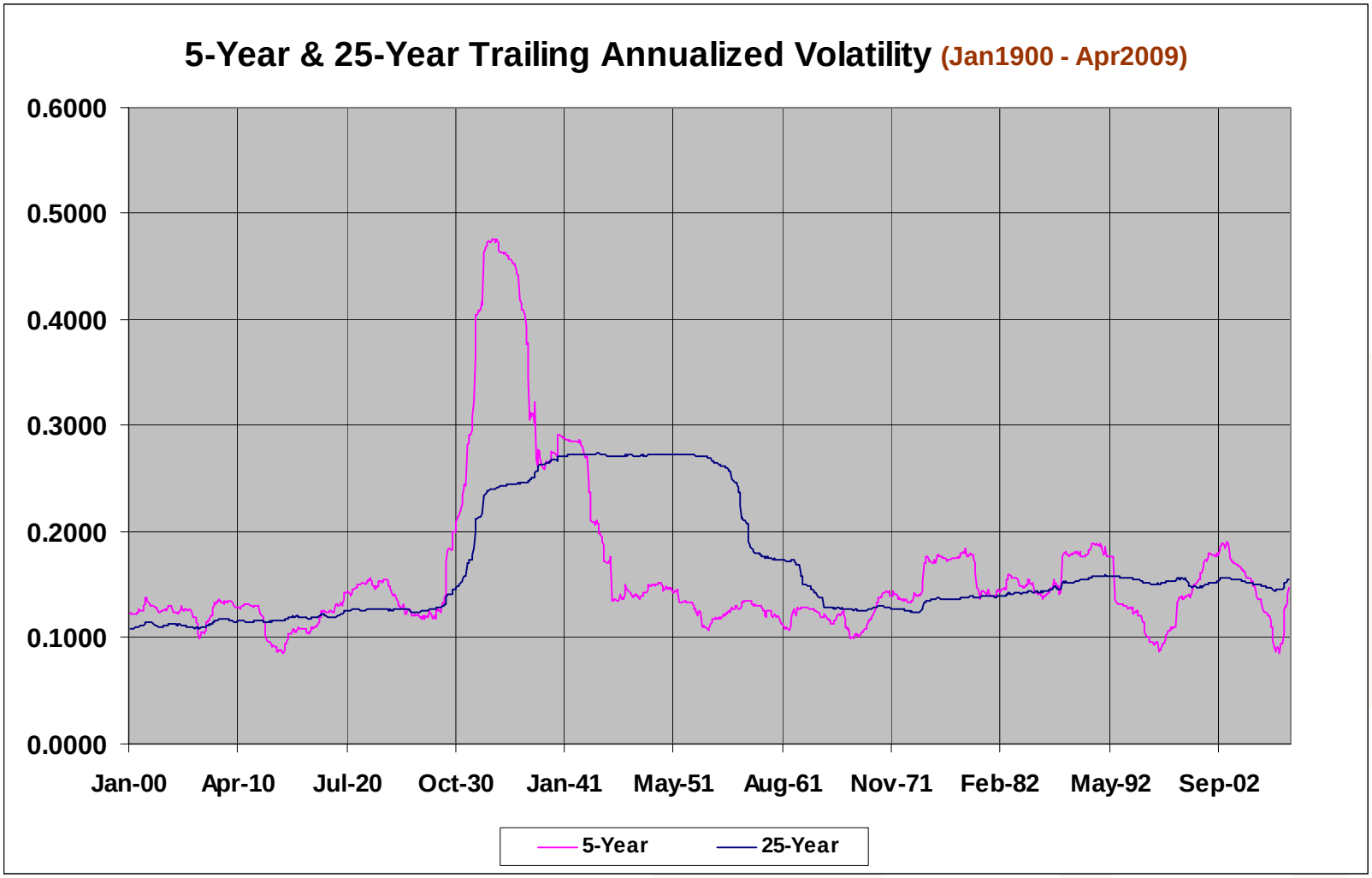
The "Volatility Question" for Equity

The historical record shows a broad range of average volatility levels.

	Standard Deviation	Annualized Volatility
Jan26 - Dec36	0.09848375	0.34115772

	Data Ending April, 2009	
	Standard Deviation	Annualized Volatility
March, 1871	0.04821870	0.16703447
January, 1900	0.05177234	0.17934465
January, 1926	0.05569653	0.19293845
January, 1946	0.04217329	0.14609255
January, 1960	0.04332166	0.15007064
January, 2000	0.04667281	0.16167937

The “Volatility Question” for Equity



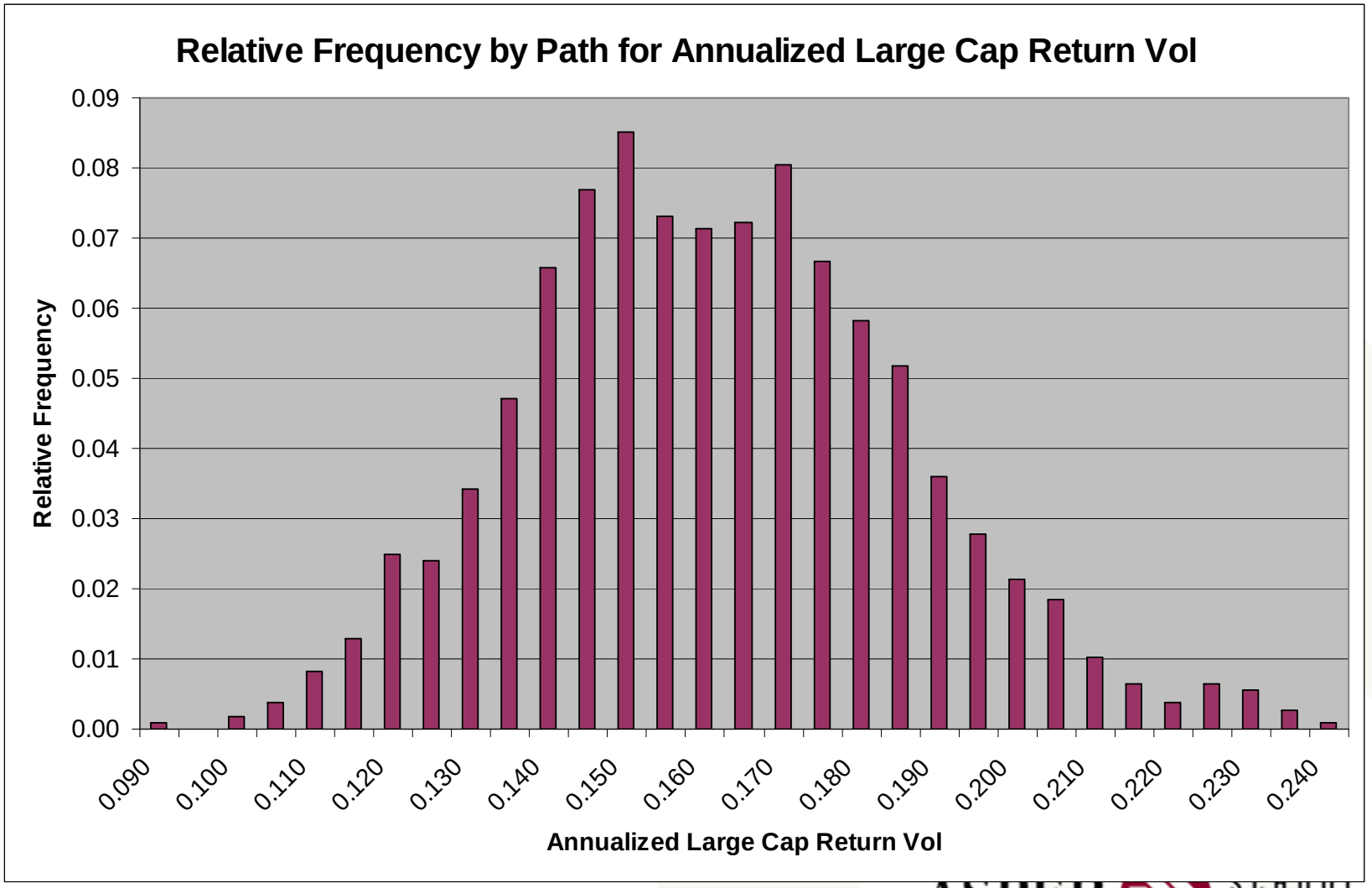
The "Volatility Question" for Equity

The following statistics are characteristic of an SVJ model large cap calibration.

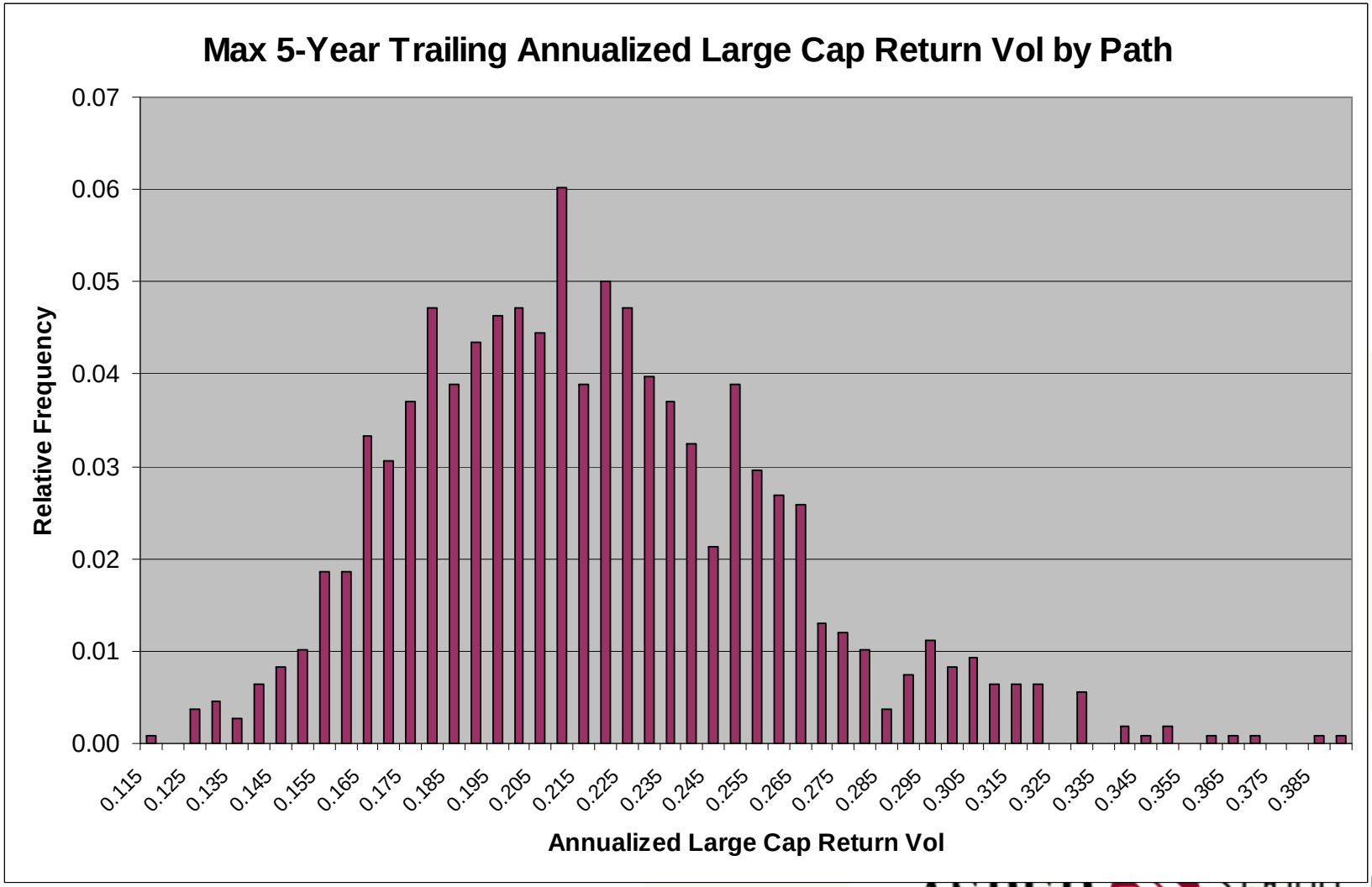
All Simulated Data	
Standard Deviation	0.080488
Monthly Standard Deviation	0.046470
Annualized Standard Deviation	**0.160976**

	Volatility Averages over Paths
Min	**0.087192**
Max	**0.236134**
Average	**0.158971**

The “Volatility Question” for Equity



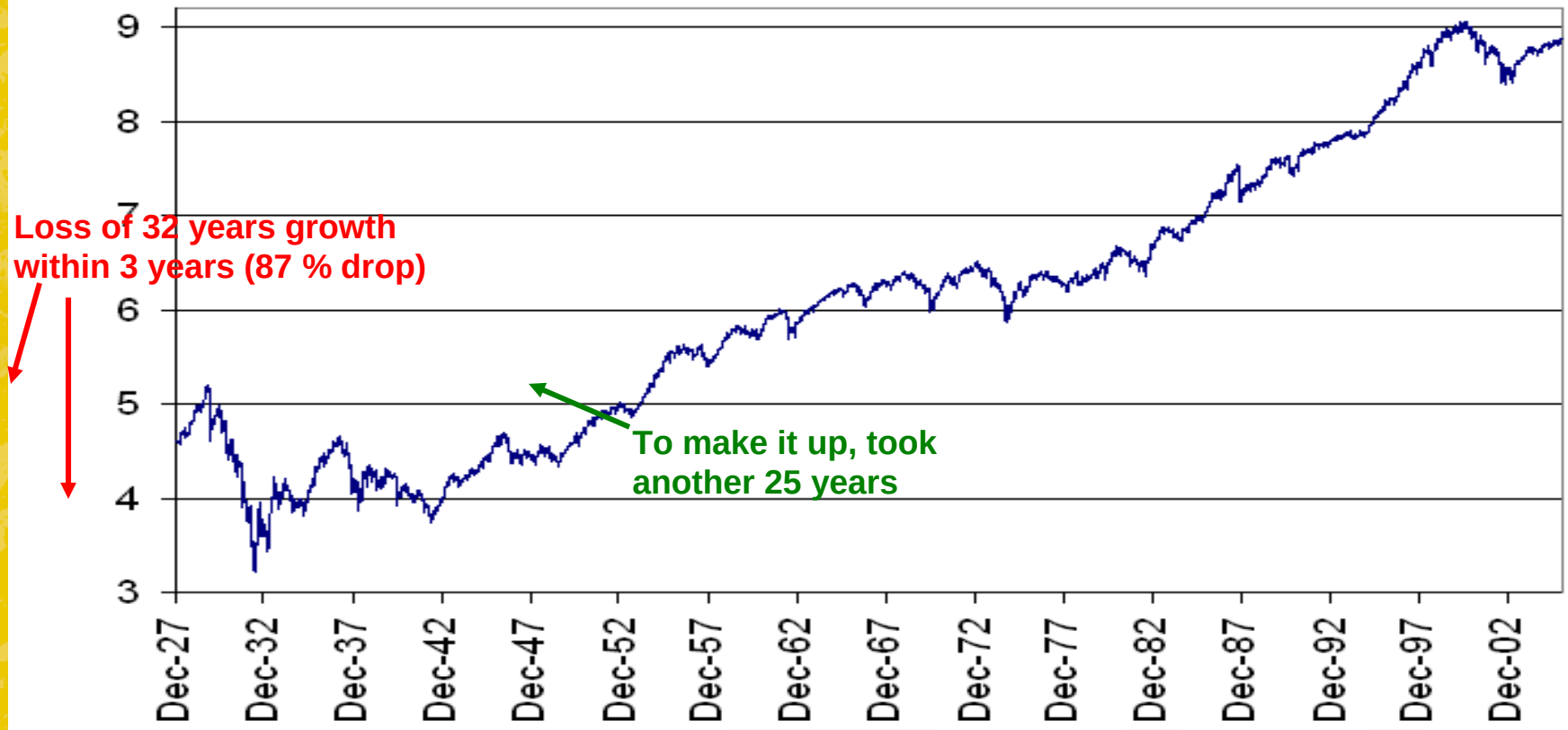
The “Volatility Question” for Equity



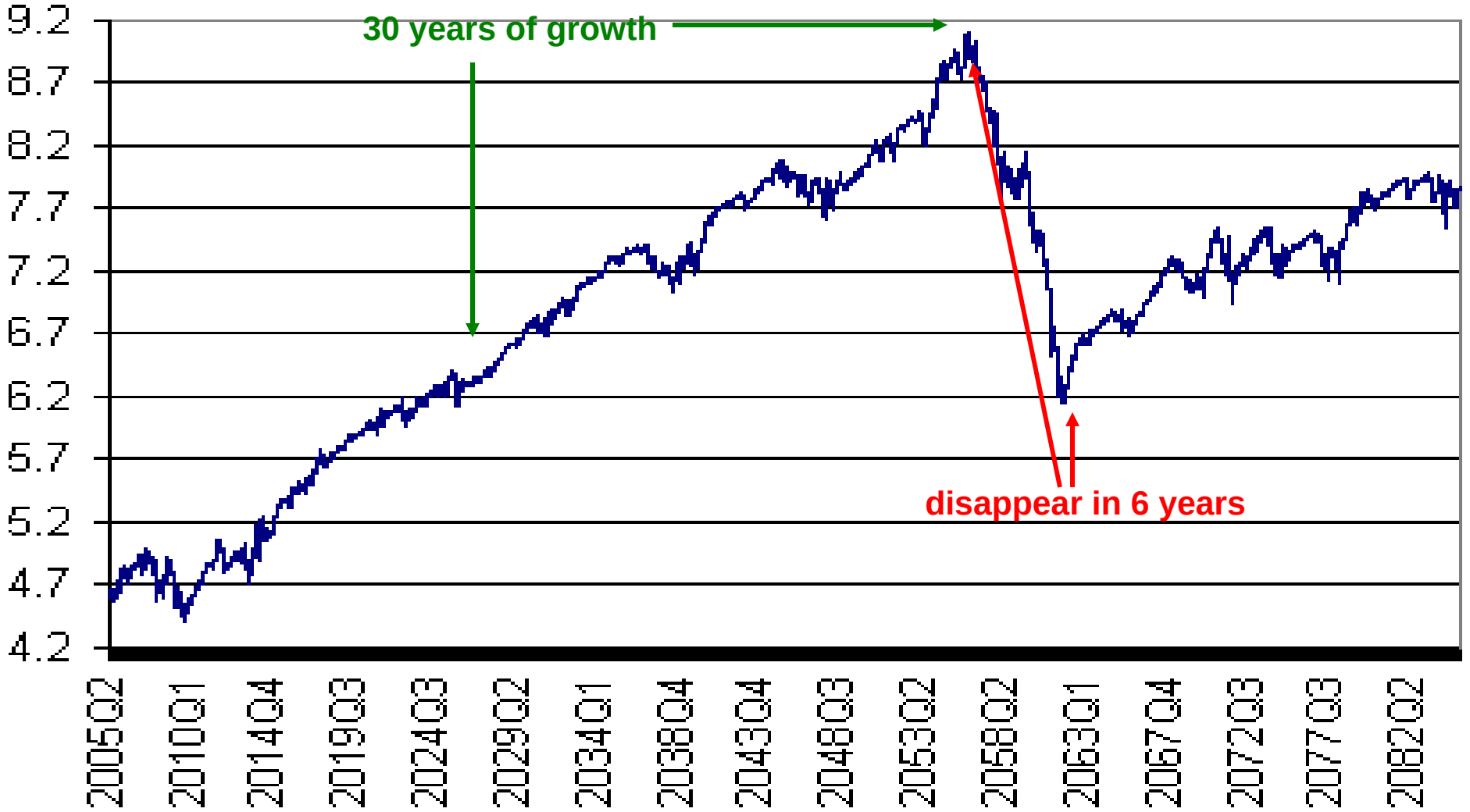
Pathwise Behavior versus Averages

- Reminder of a common error:
  - Average mean and variance are not a measure of the diversity of events that can emerge on a path (scenario.)
  - Average behavior suppresses individual behavior.
  - A scenario is the development of one possible coherent economy over time.
  - It is pathwise behavior that matters when assessing investment programs and risk management.

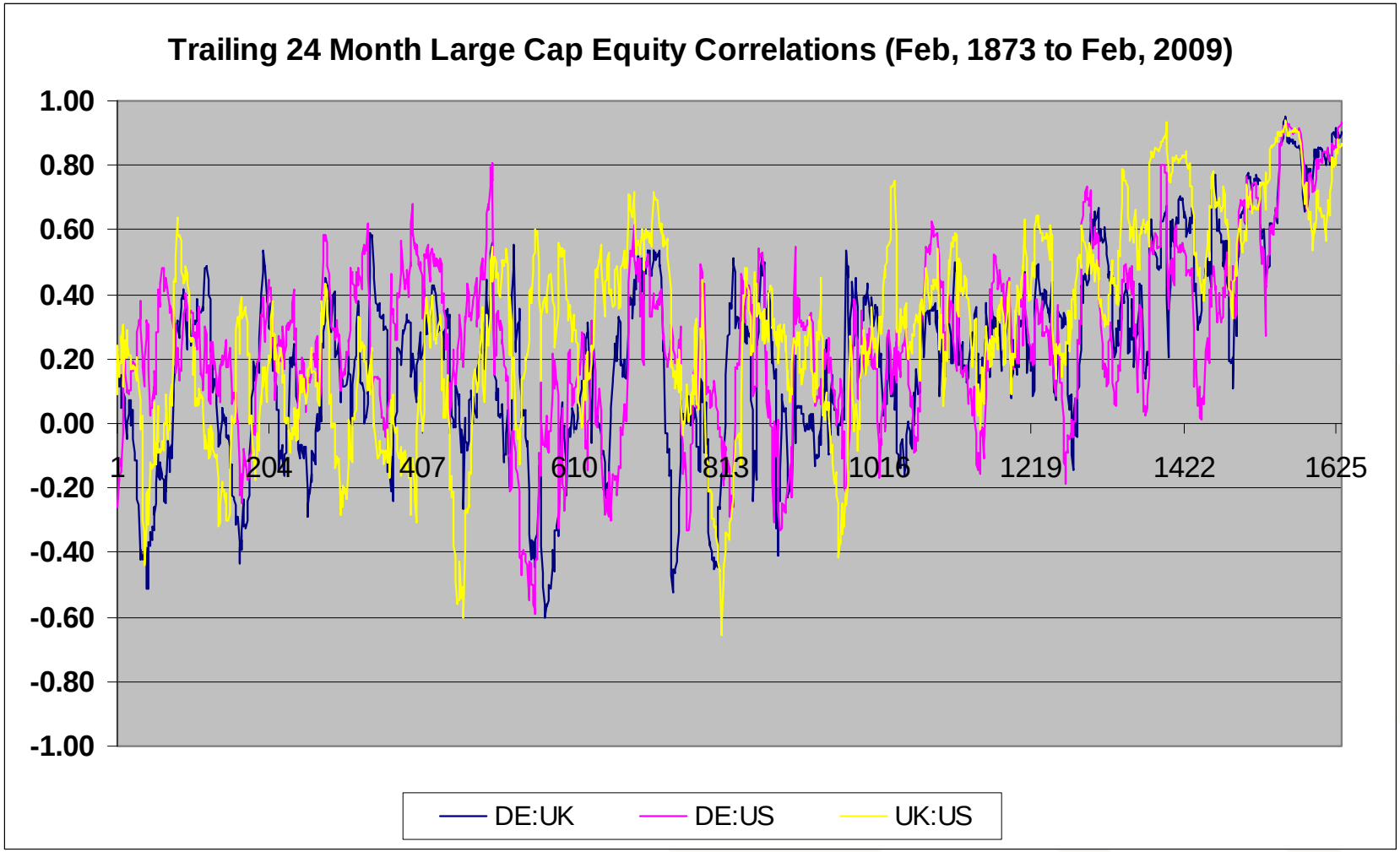
Historical S&P 500 Log Level Data for the Period 1926 - 2005



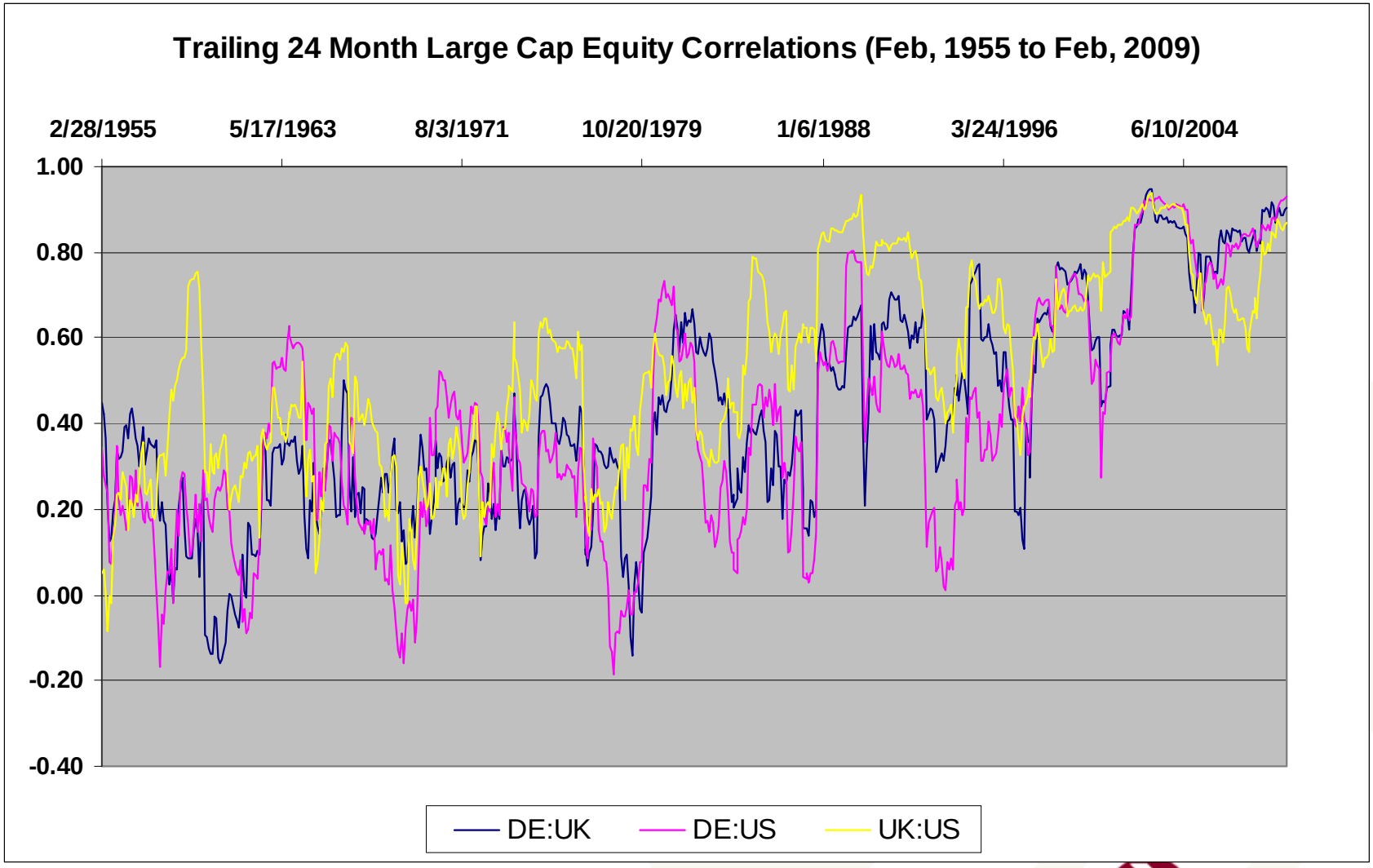
80 Years Simulated S&P 500 (Log Scale)



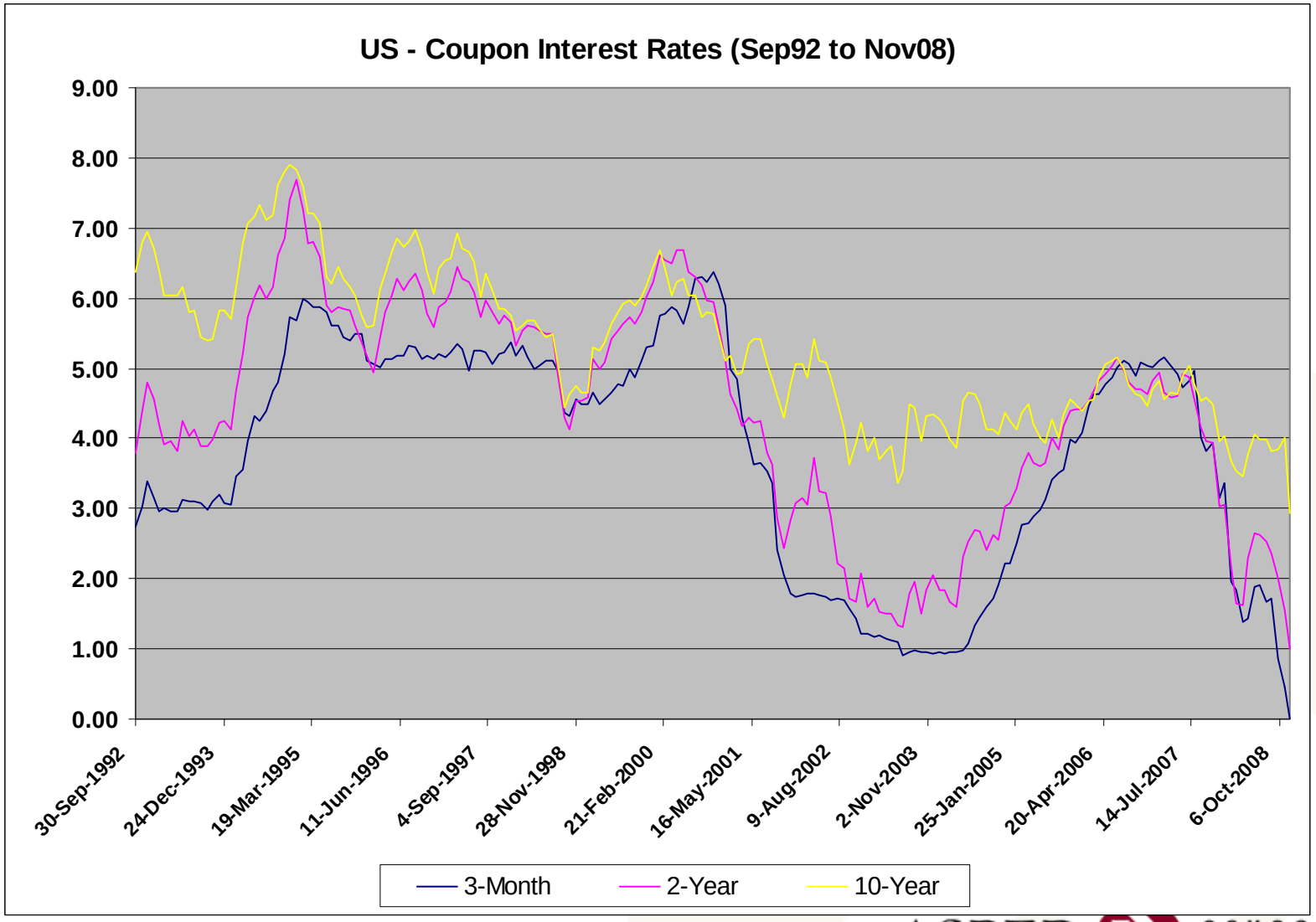
Global Equity Modelling



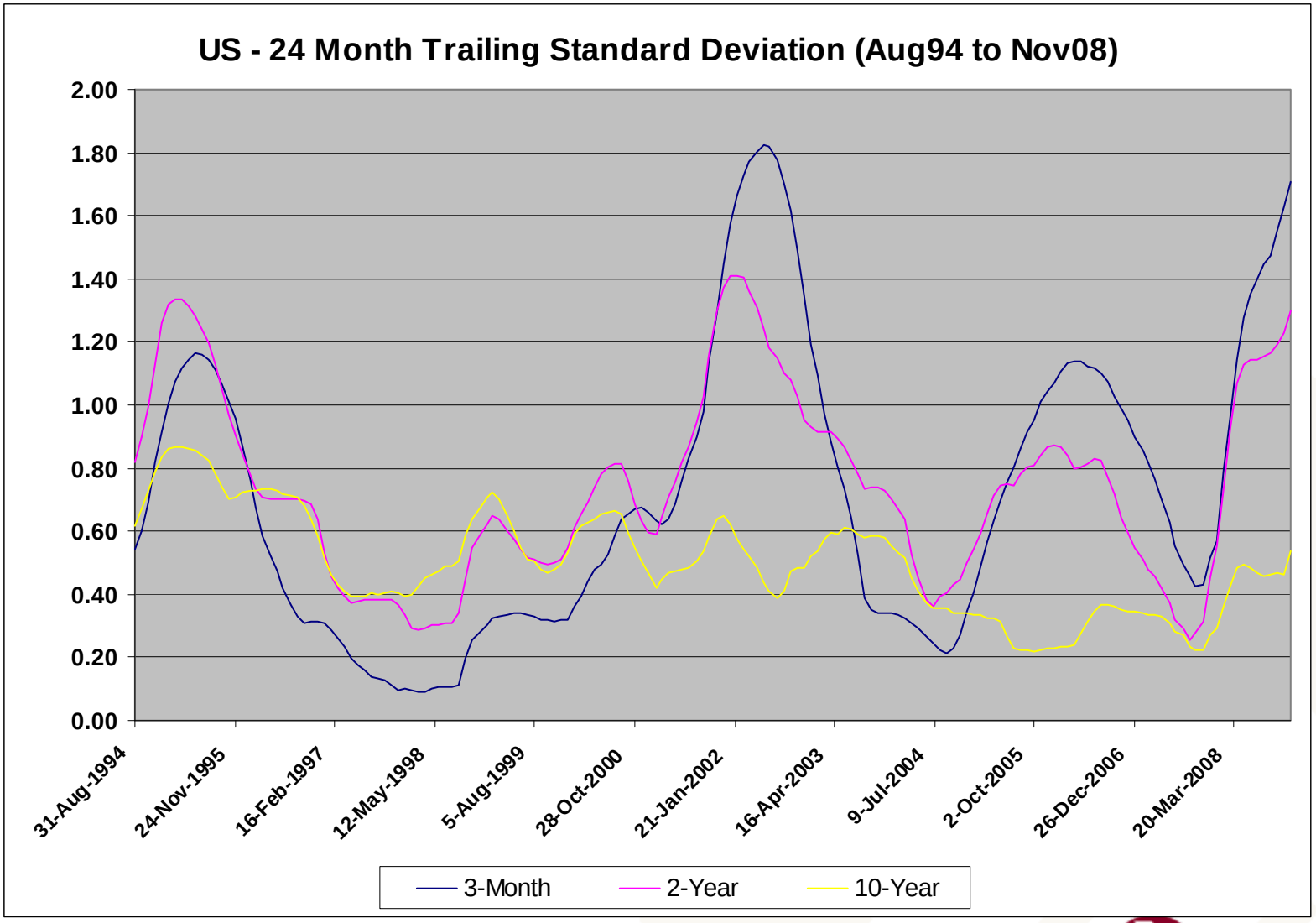
Global Equity Modelling



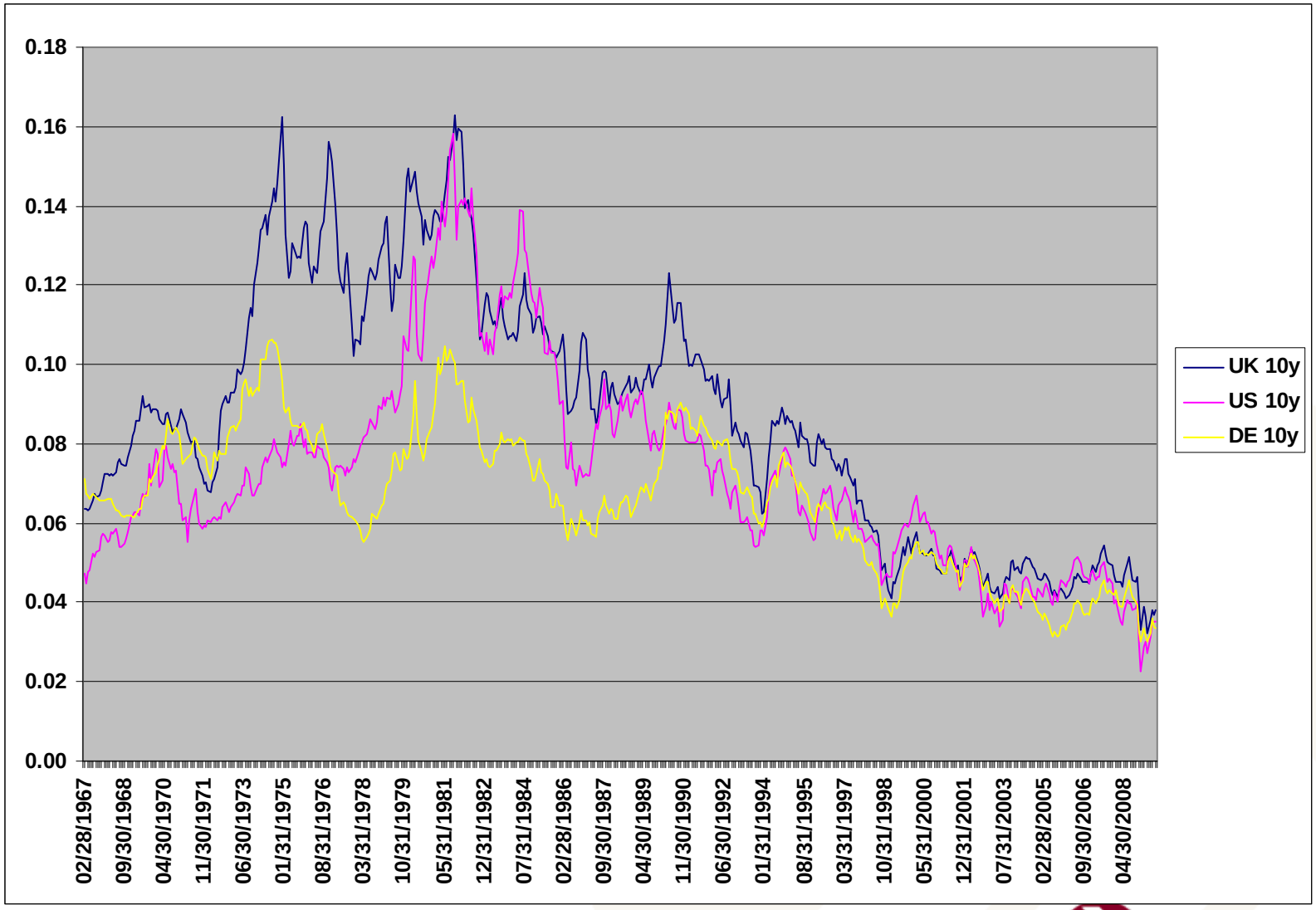
Interest Rate Levels



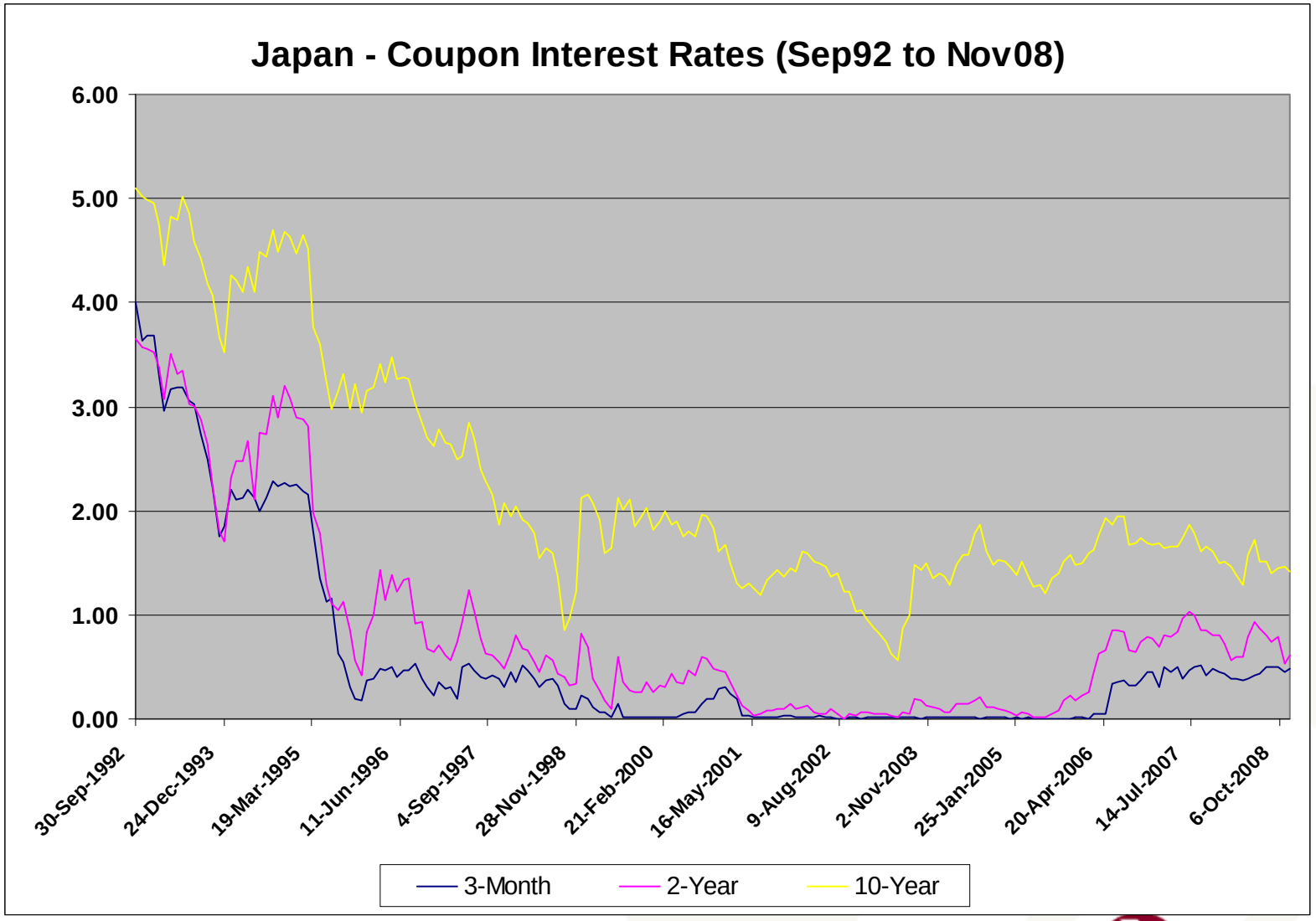
Interest Rate Volatilities



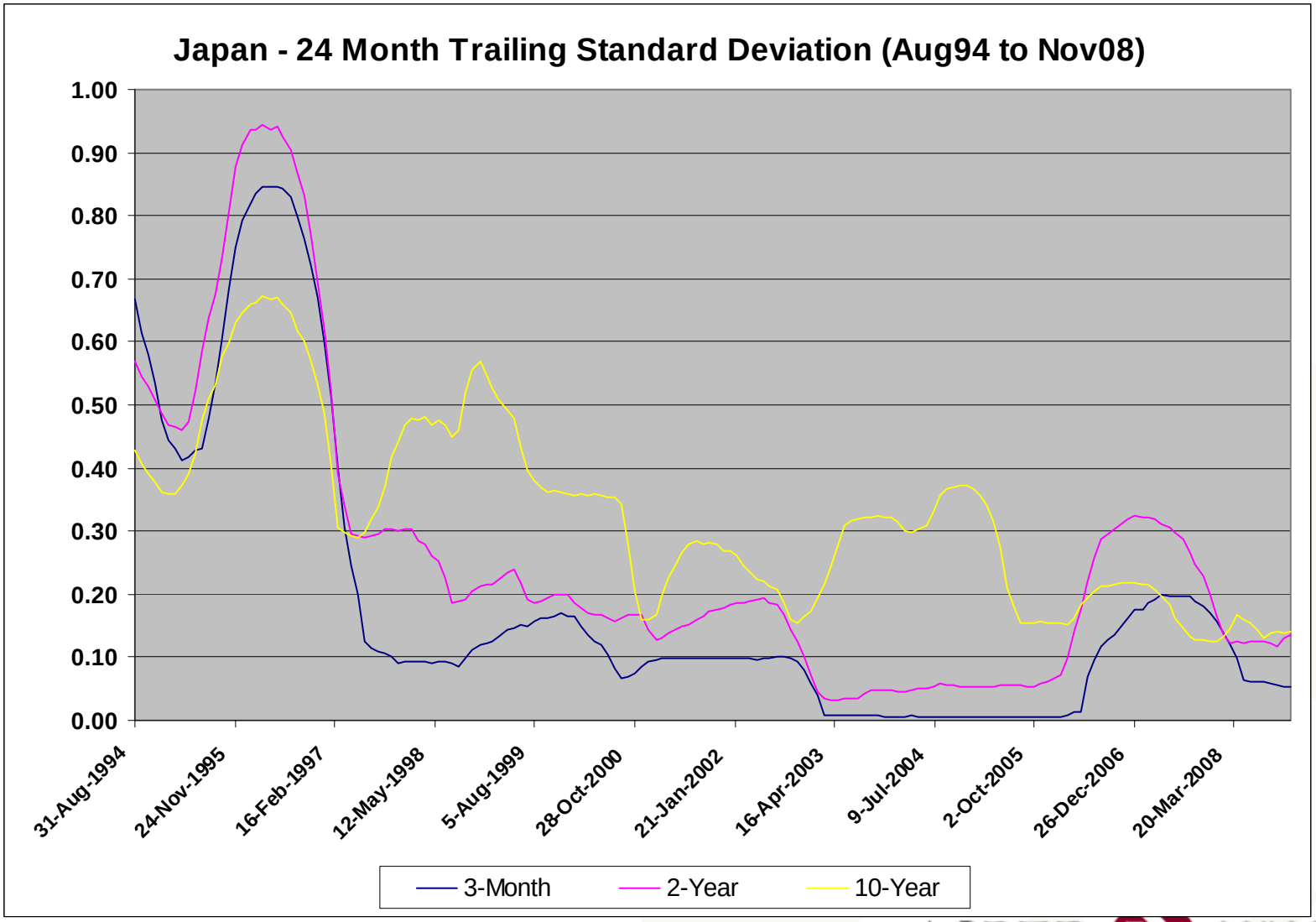
Global Interest-Rate Movements



Japan Interest Rates



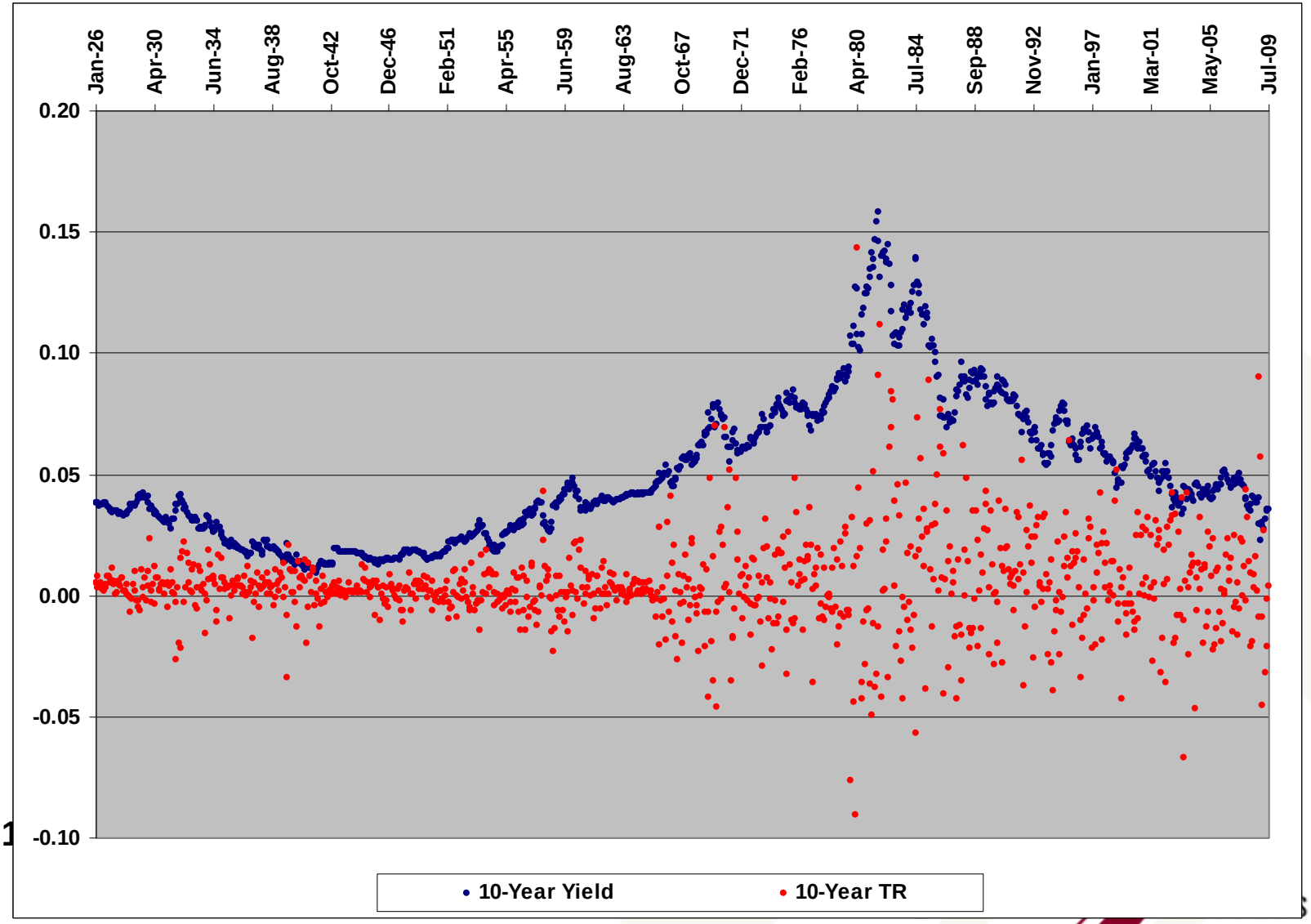
Japan Interest Rate Volatility



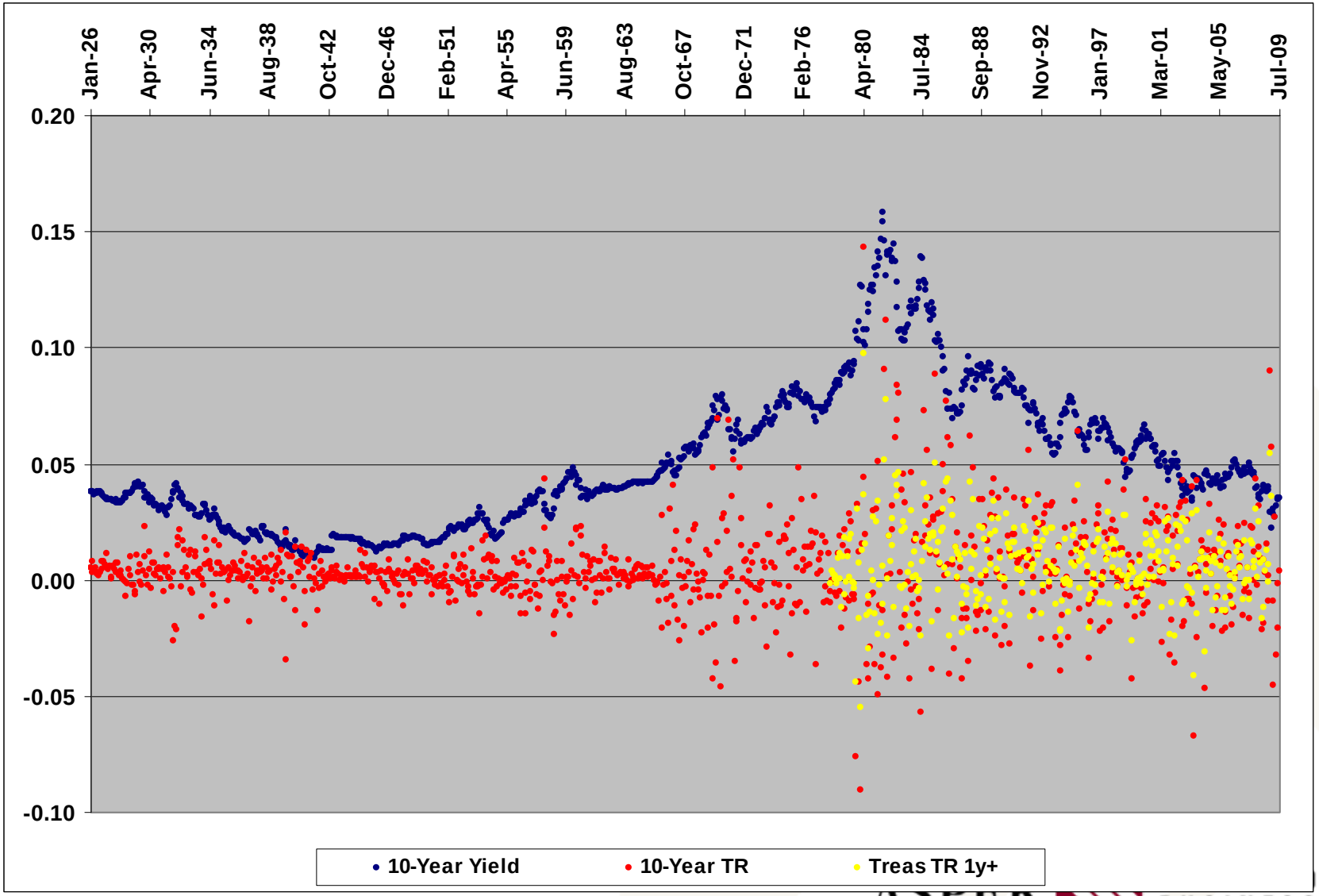
Market Relationships

- There is danger in building in “ideas” about market behaviour that are not thoroughly vetted.
- Some have advocated the “conventional wisdom” that bond yields have something to do with bond returns. (Starting points vs. equilibrium levels matter but …)
- Let’s have a look at what history tells us.

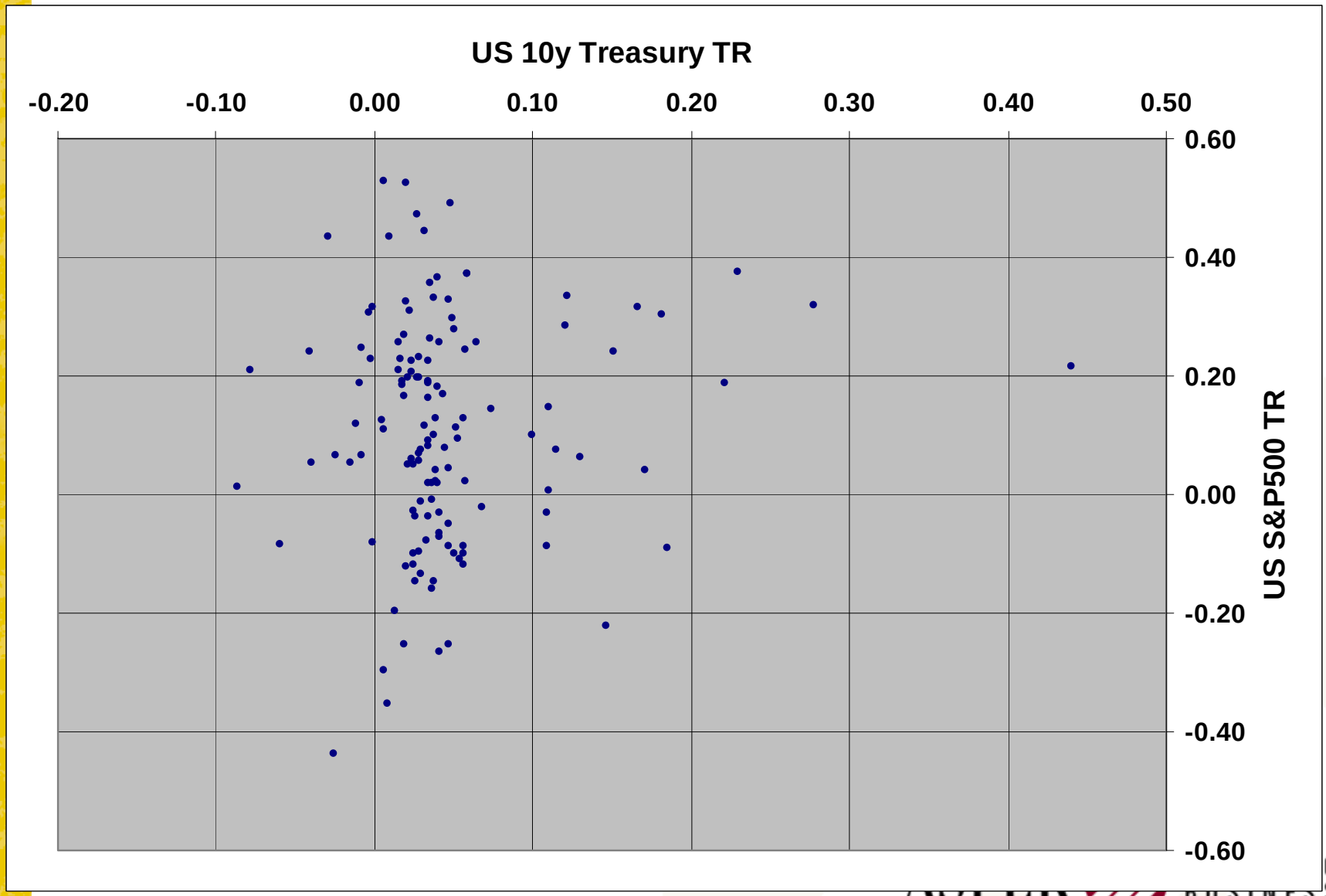
Market Relationships: Historical 1926-2009 US 10 year Treasury Yield and 10 year OTR Return



Market Relationships: Historical 1926-2009 US Same as Previous with a Treasury Bond Index



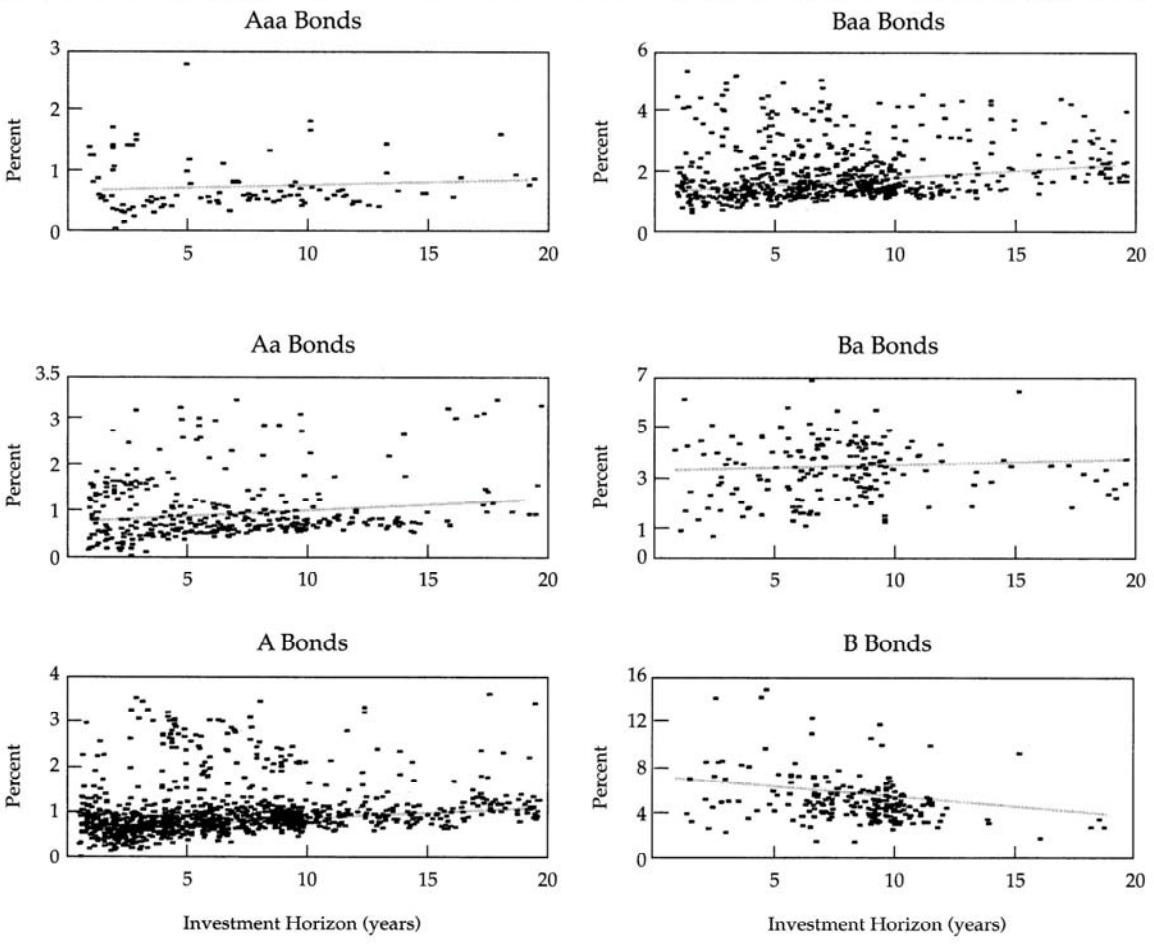
Annual (Cal Yr)US Trsy and Equity: 1871 - 2008



Empirical Facts: Spread Overlap

- Source: Fons: Using Default Rates to Model the Term Structure of Credit Risk
- Snapshot of Yield Spreads for Over 4000 US Issuers on September 30, 1993.
- Investment grade bonds exhibit a broad range of yield spreads by class at any point in time.
- Spreads overlap.

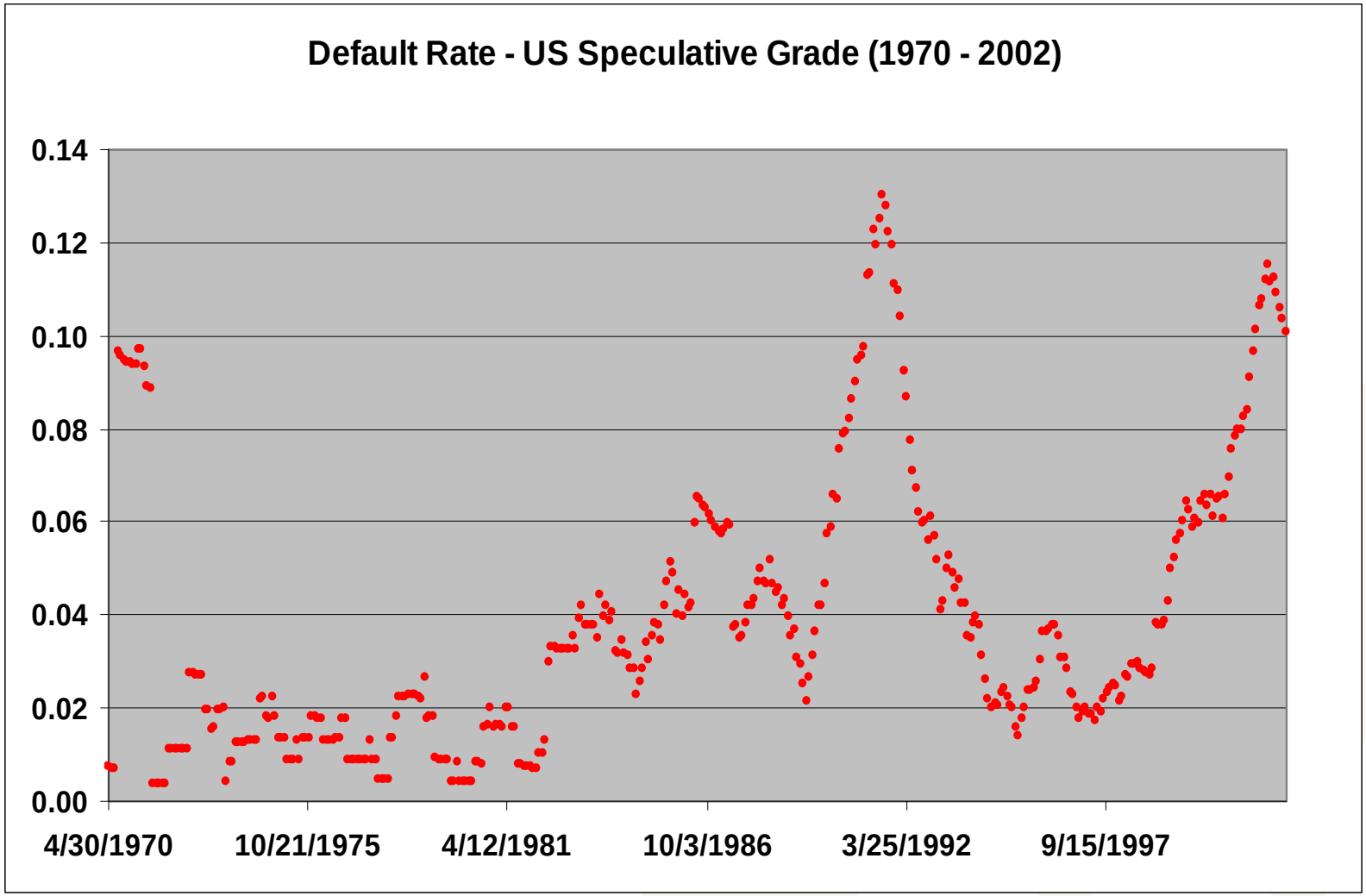
Figure 5. Market Spread by Maturity, Bonds of Various Ratings



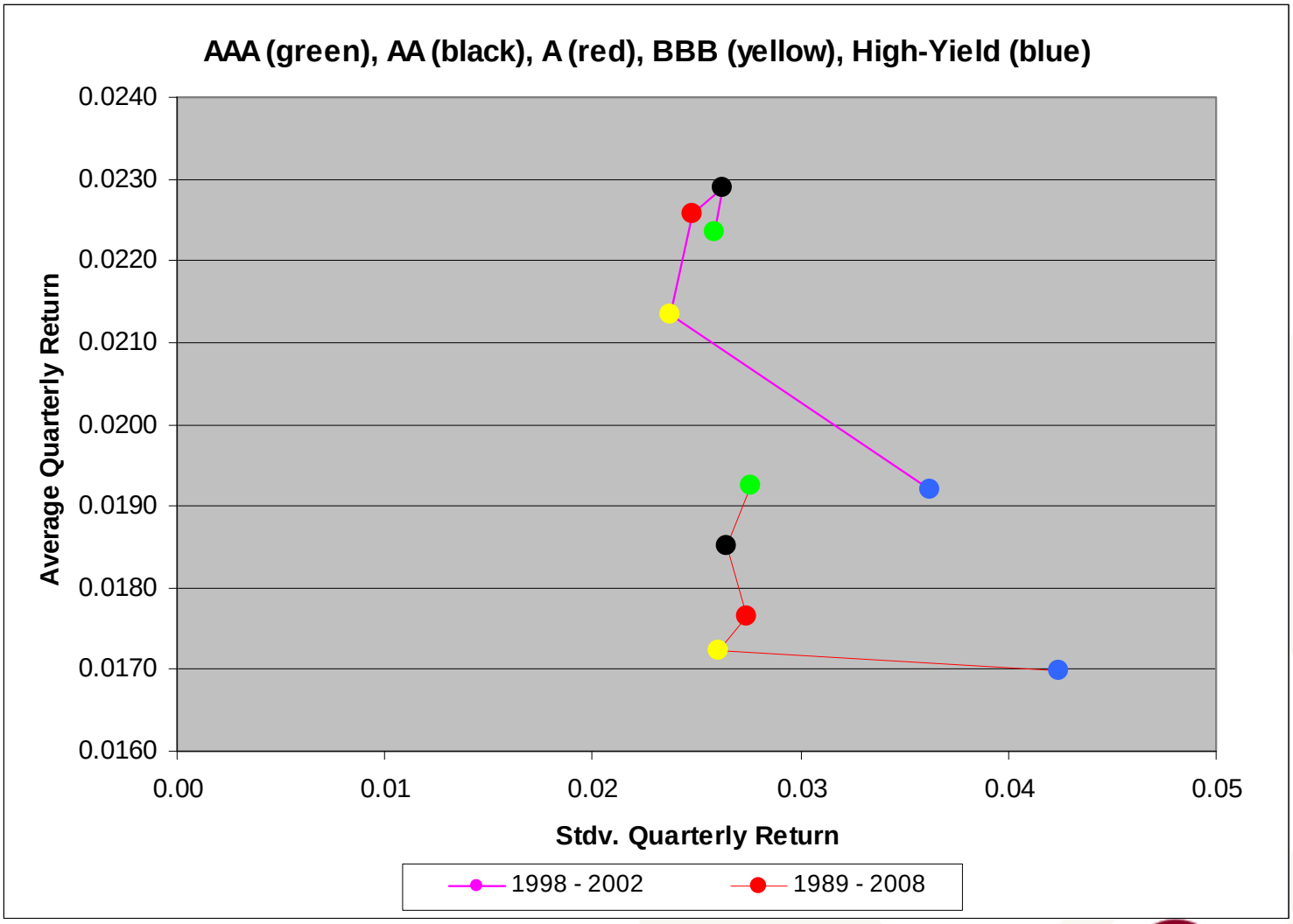
Empirical Facts: Default Rates

- Default rates exhibit clustering behaviour.
- Sudden changes in default behaviour are important risk factors in managing corporate bond returns.
- A good ESG must pick this up.

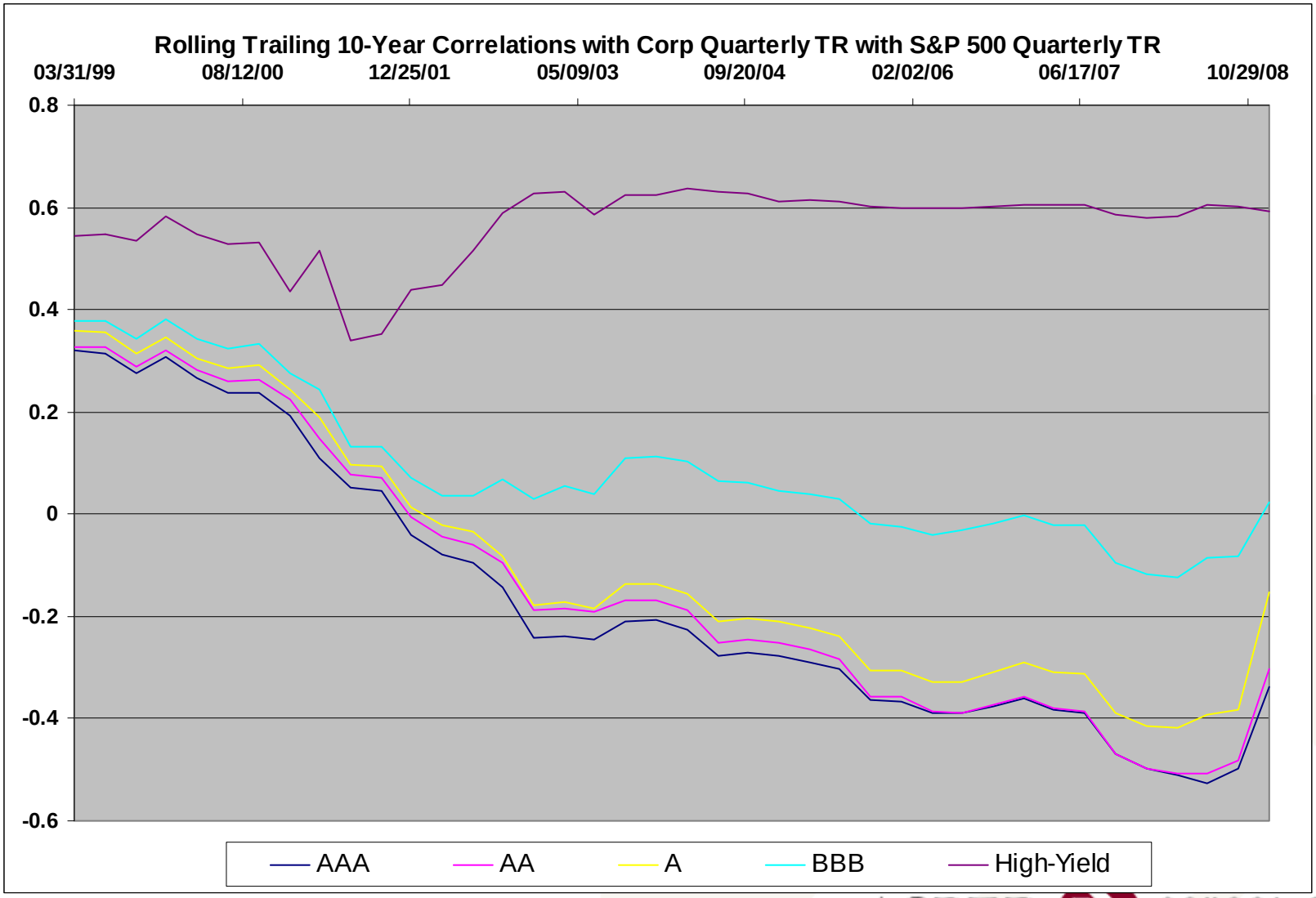
Empirical Facts: Default Rates Monthly Data



Corporate Bond Returns



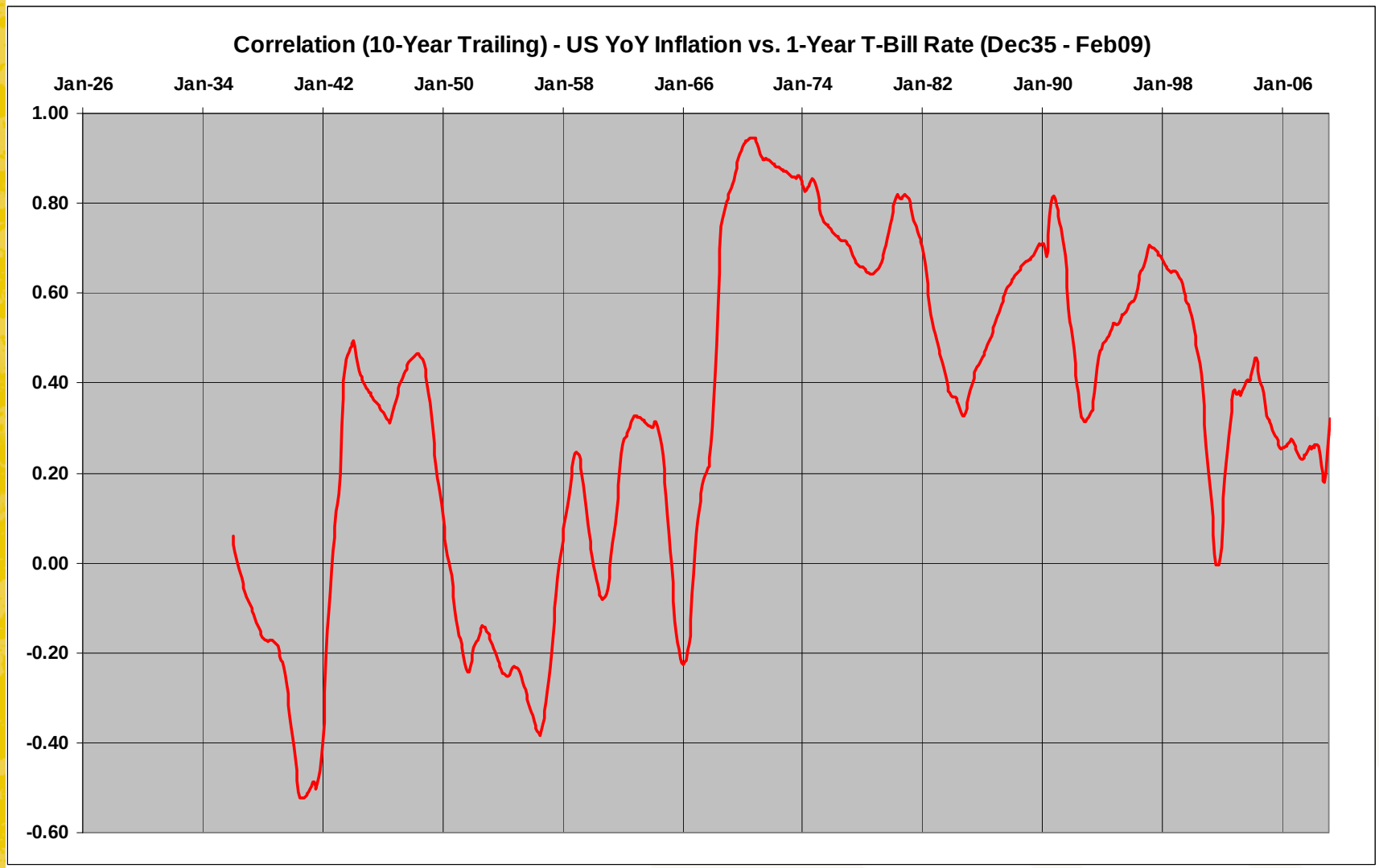
Corporate Bond Correlations



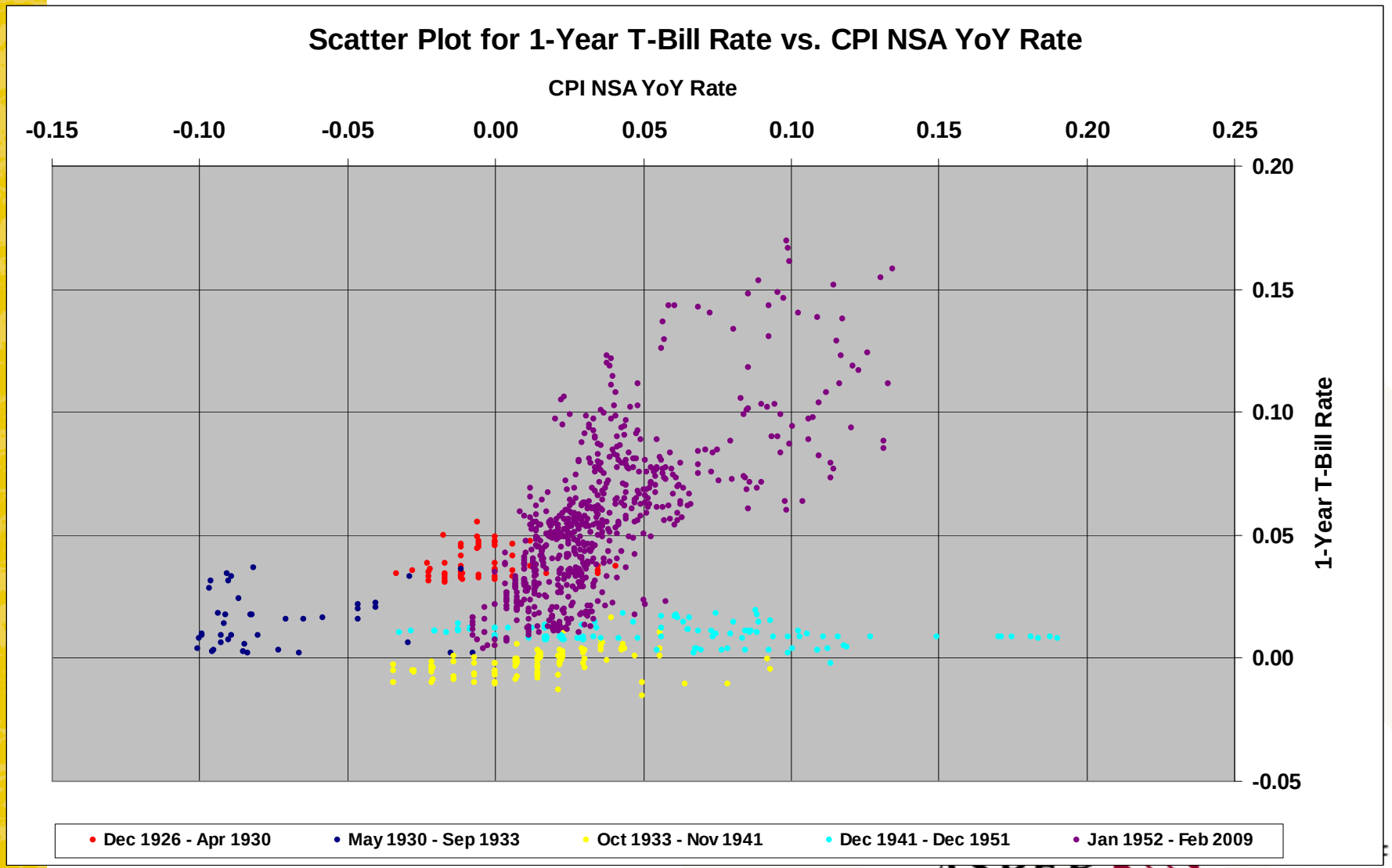
Inflation Models - Overview

- Inflation and expected inflation modeling is required for most insurance and pension applications. Ideally, an ESG provides both.
- Some applications require measures of several specific types of inflation beyond basic consumer price inflation. This may require the modeling of several inflation sub-indices.
- A link between Treasury yields and inflation must be respected.
- Seasonality effects must be accounted for.

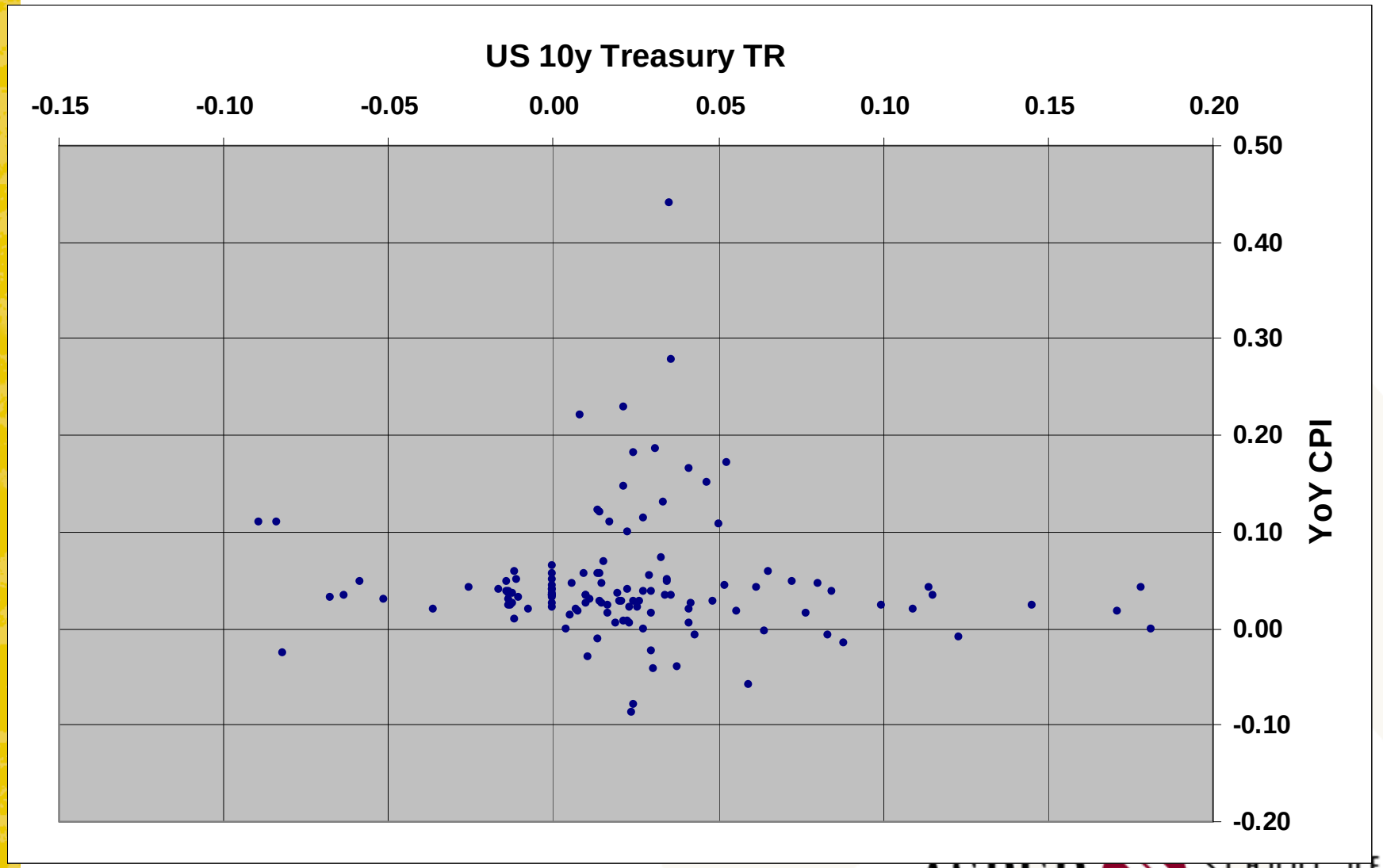
Inflation Models



Inflation Models



Annual (Cal Yr) US Trsy TR and CPI: 1876 - 2008



Inflation and the Real Term Structure

- Ideally, one should employ an arbitrage-free inflation model that, in addition to generating inflation, can:
  - Produce the real term structure of interest rates
  - Produce market expectations of inflation
  - Price inflation-linked bonds and derivatives
  - Coupled with an econometric model to produce inflation sub-indices
- The model should be flexible and efficient to estimate.

AAA Variable Annuity Guidelines (Equity)

1-Year

Overlapping Intervals

Percentile	Data	AAA Requirement
0.025	0.7277	0.78
0.050	0.7954	0.84
0.100	0.8728	0.90
0.900	1.3454	1.28
0.950	1.4107	1.35
0.975	1.4738	1.42

Non-Overlapping Intervals

Percentile	Data	AAA Requirement
0.025	0.7401	0.78
0.050	0.8041	0.84
0.100	0.8900	0.90
0.900	1.3434	1.28
0.950	1.3998	1.35
0.975	1.4699	1.42

5-Year v1

Overlapping Intervals

Percentile	Data	AAA Requirement
0.025	0.6593	0.72
0.050	0.8721	0.81
0.100	0.9762	0.94
0.900	2.4658	2.17
0.950	2.8031	2.45
0.975	3.0845	2.72

Non-Overlapping Intervals v1

Percentile	Data	AAA Requirement
0.025	0.9865	0.72
0.050	1.0451	0.81
0.100	1.0968	0.94
0.900	2.2339	2.17
0.950	2.3081	2.45
0.975	2.4562	2.72

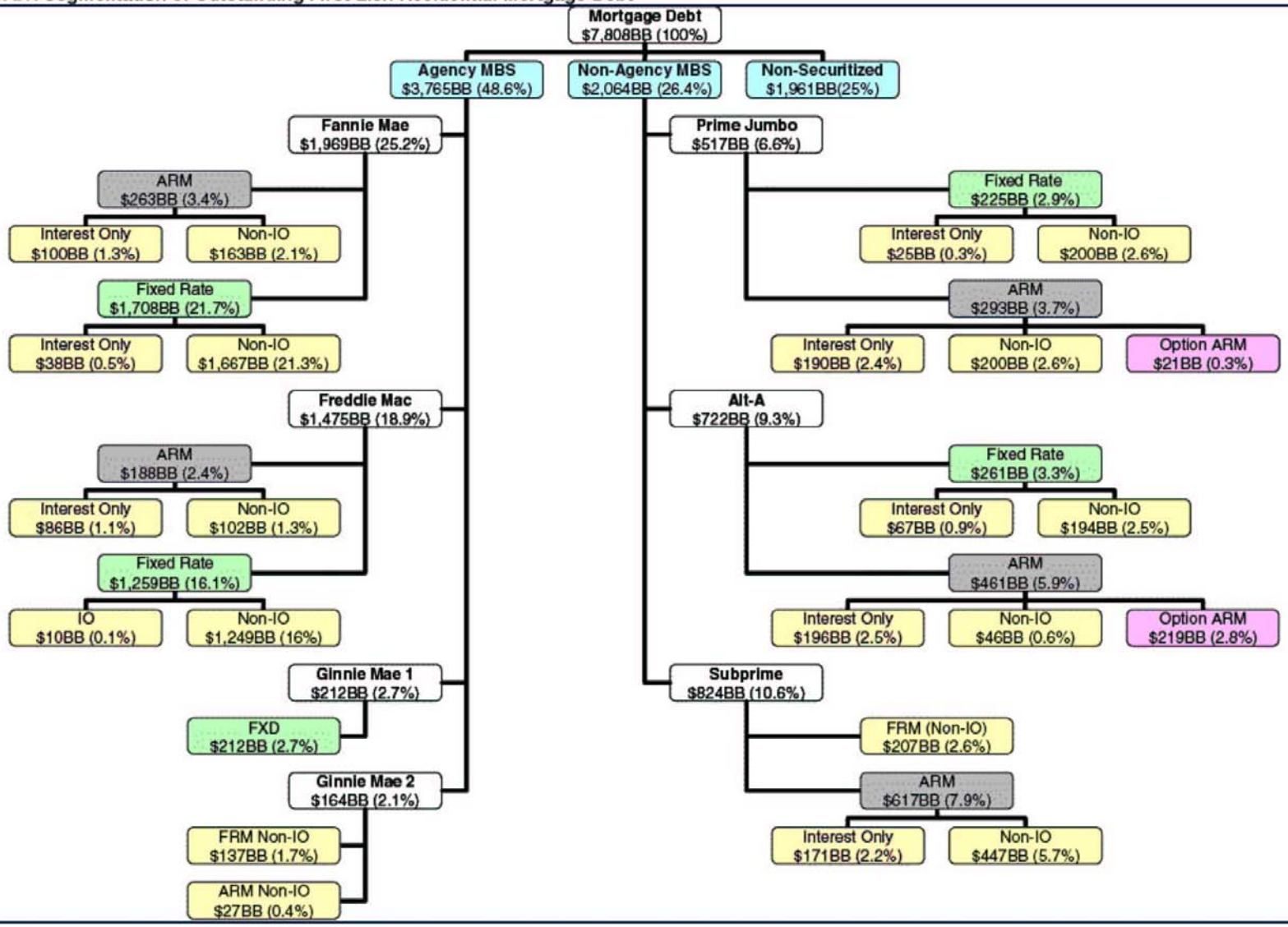
Non-Overlapping Intervals v2

Percentile	Data	AAA Requirement
0.025	0.7644	0.72
0.050	0.8918	0.81
0.100	1.0016	0.94
0.900	2.2213	2.17
0.950	2.6397	2.45
0.975	2.8256	2.72

What to Do About 2008?

- How does one take the lessons of 2008 and incorporate them into an ESG?
- A necessary first step is to understand the drivers of the events of 2008.
- What suite of economic variables can be used to explain the credit crunch?
  - Credit Spreads
  - Macroeconomic Variables
  - House Price Appreciation (HPA)

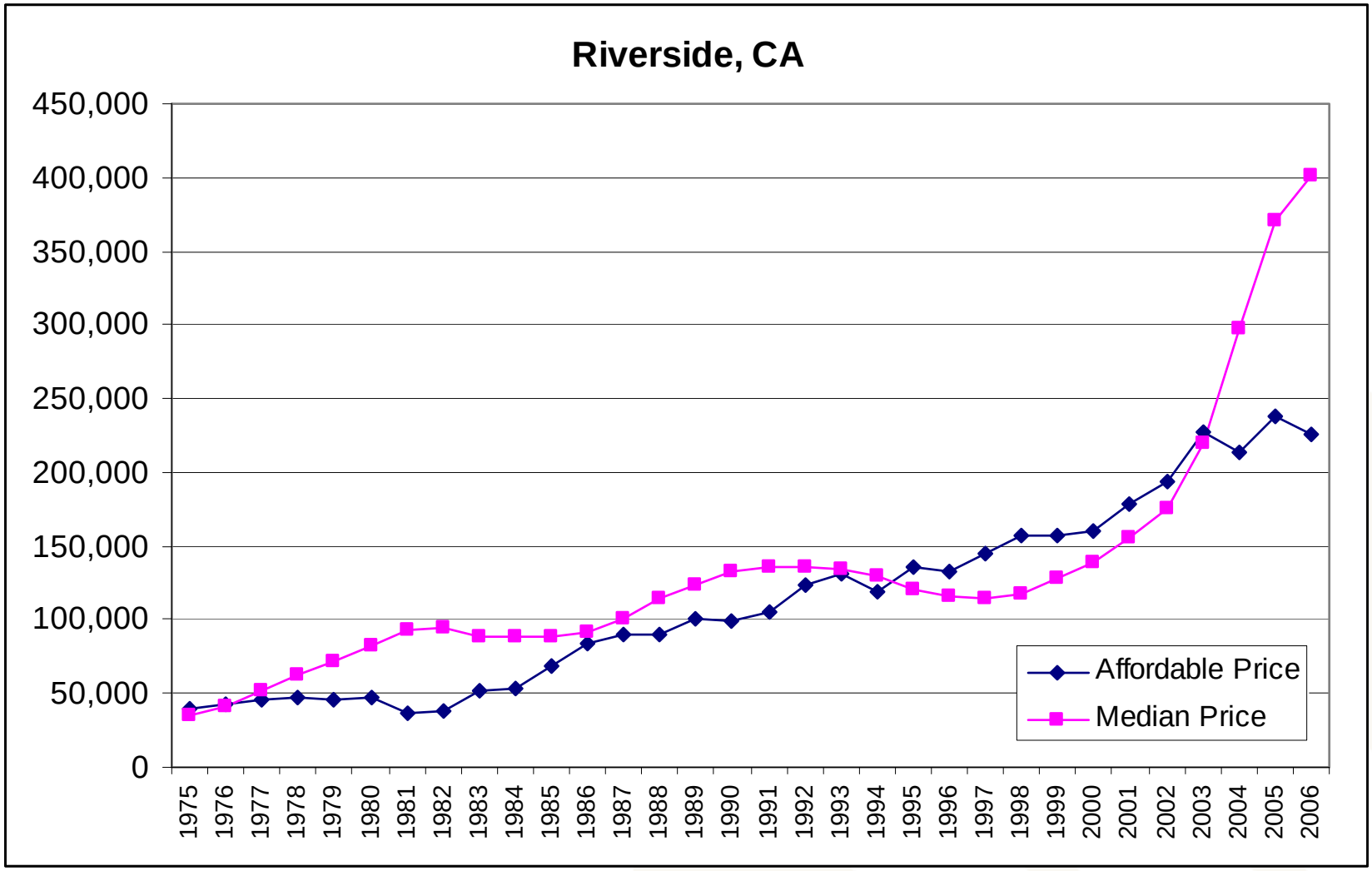
Exhibit 21: Segmentation of Outstanding First-Lien Residential Mortgage Debt



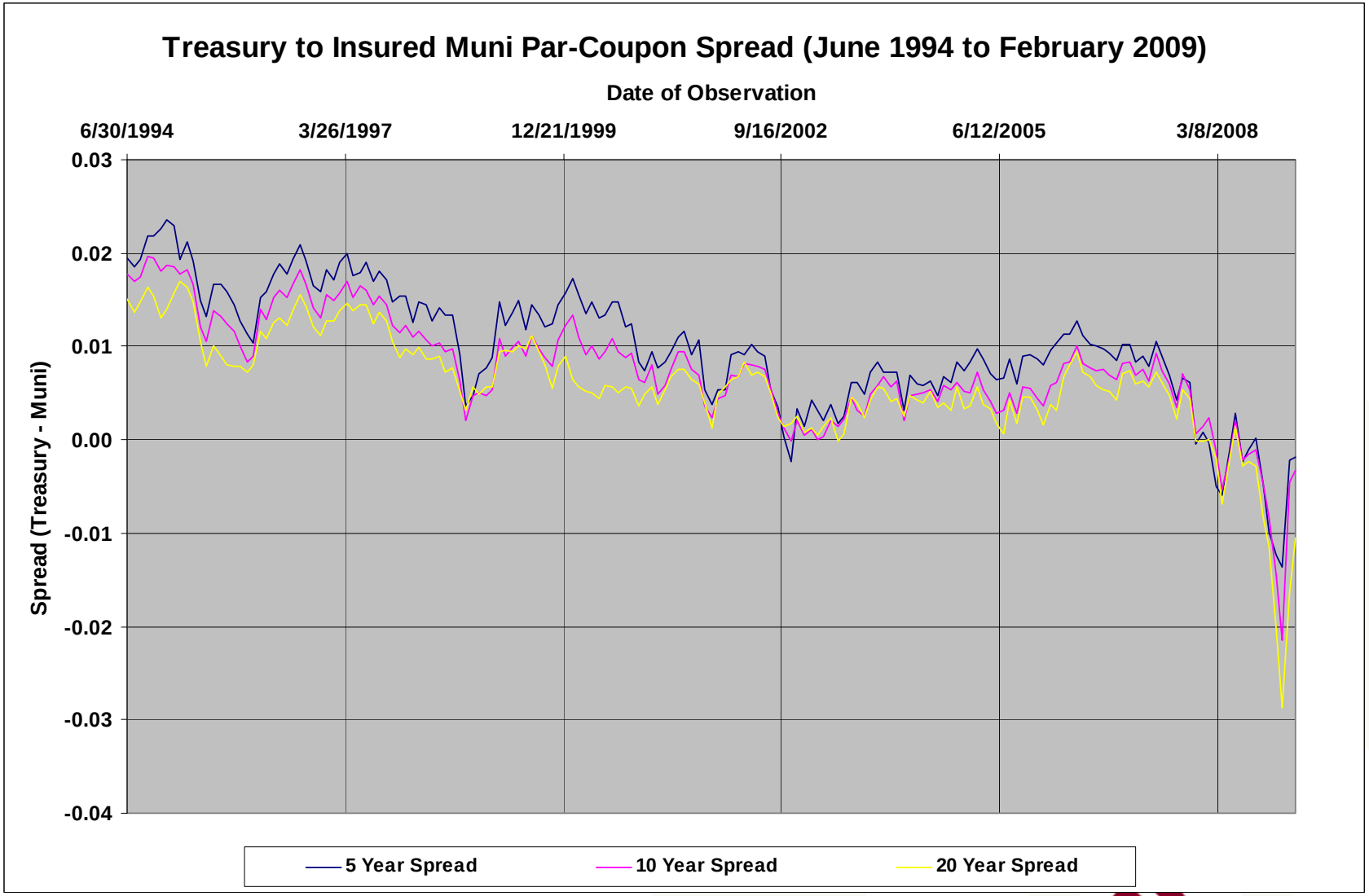
Assumptions: Securitization rate 75%; Loan Performance Reporting rate: Prime and Alt-A: 75%, Subprime: 65%

Source: Credit Suisse U.S. Mortgage Strategy

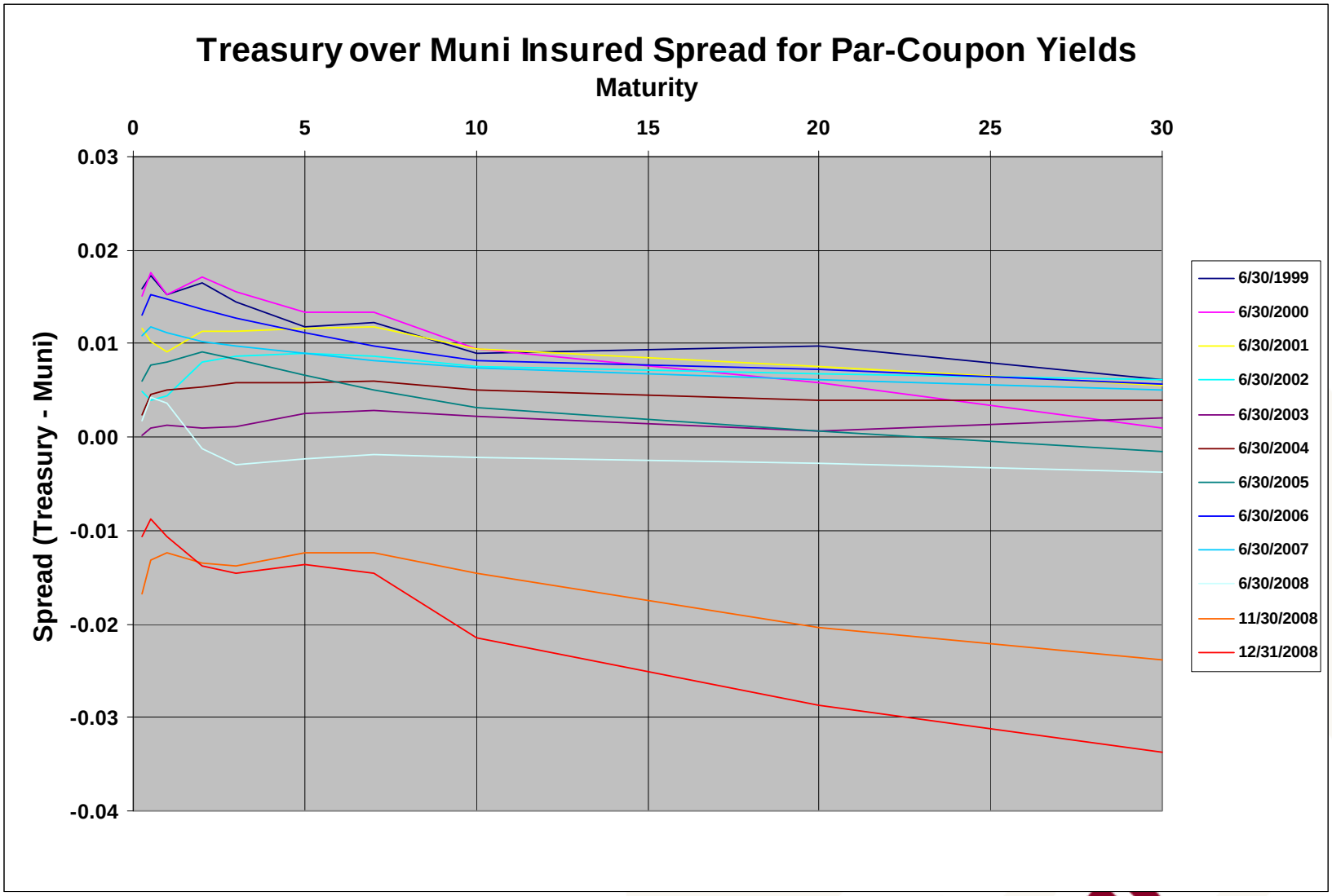
What to Do About 2008?



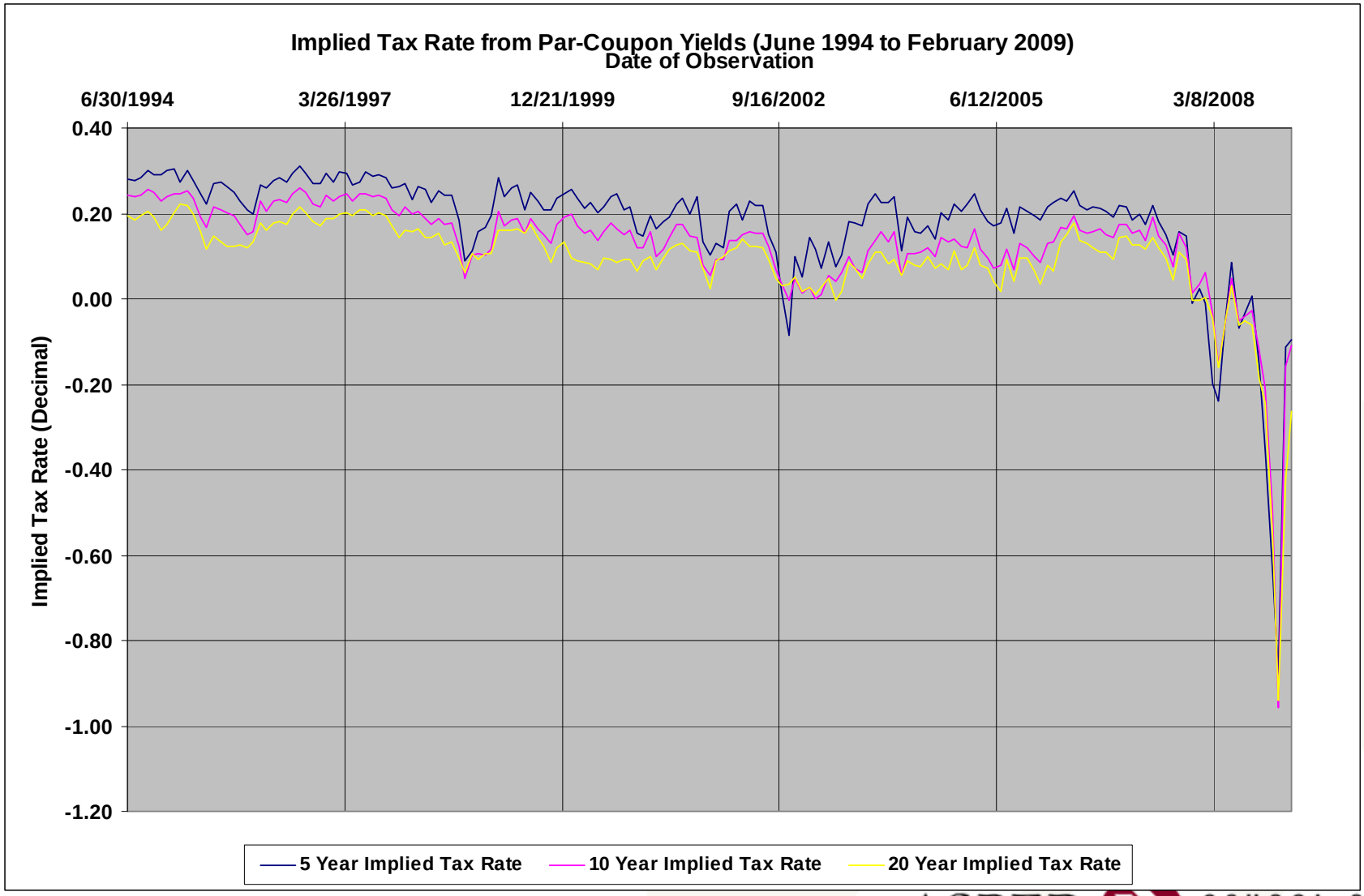
Muni Mess


Treasury to Insured Muni Par-Coupon Spread (June 1994 to February 2009)
Date of Observation
6/30/1994
3/26/1997
12/21/1999
9/16/2002
6/12/2005
3/8/2008
0.03
0.02
0.01
0.00
-0.01
-0.02
-0.03
-0.04
Spread (Treasury - Muni)
5 Year Spread
10 Year Spread
20 Year Spread

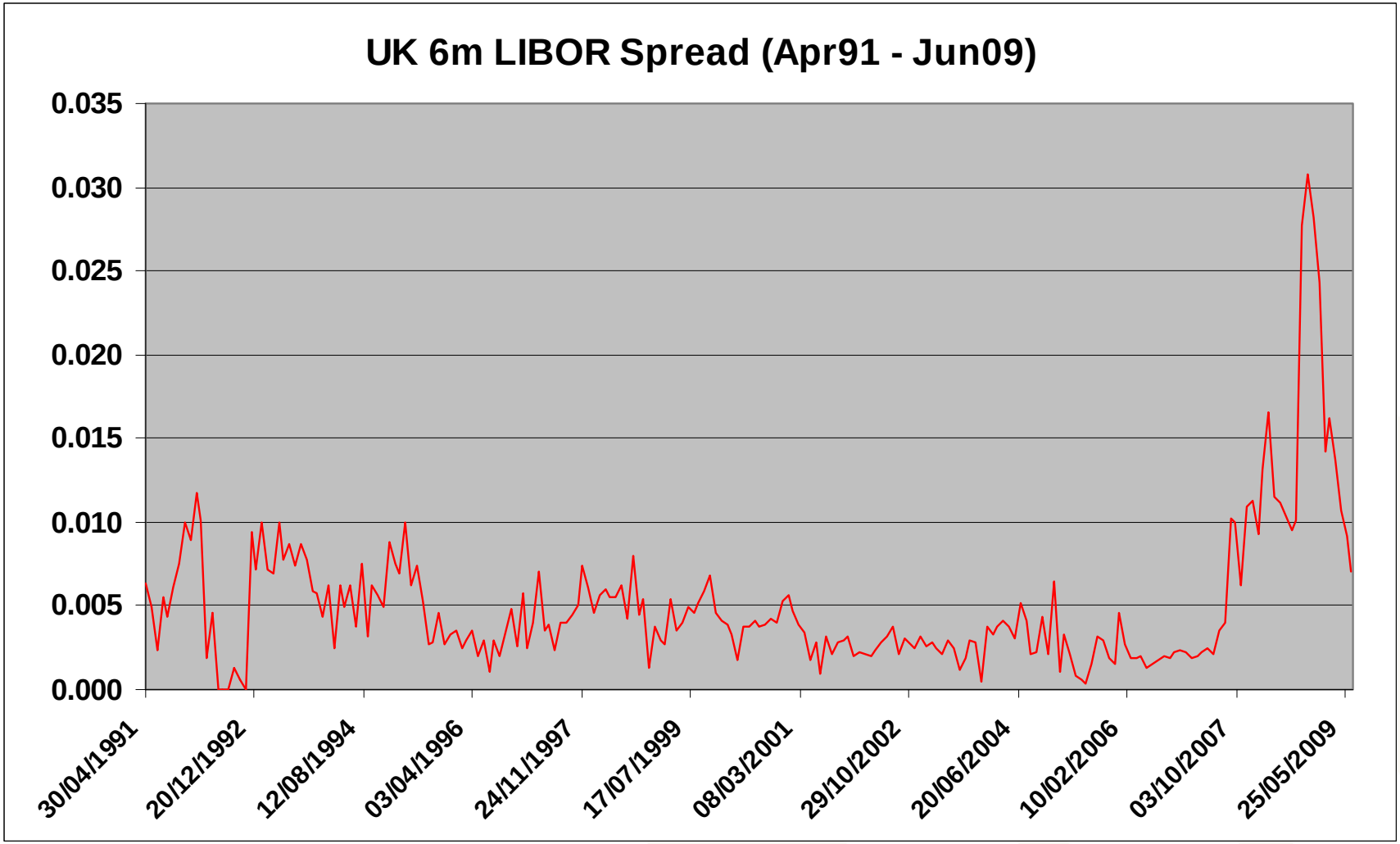
Muni Mess


Treasury over Muni Insured Spread for Par-Coupon Yields
Maturity
0
5
10
15
20
25
30
0.03
0.02
0.01
0.00
-0.01
-0.02
-0.03
-0.04
Spread (Treasury - Muni)
6/30/1999
6/30/2000
6/30/2001
6/30/2002
6/30/2003
6/30/2004
6/30/2005
6/30/2006
6/30/2007
6/30/2008
11/30/2008
12/31/2008

Muni Mess


Implied Tax Rate from Par-Coupon Yields (June 1994 to February 2009)
Date of Observation
6/30/1994
3/26/1997
12/21/1999
9/16/2002
6/12/2005
3/8/2008
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
Implied Tax Rate (Decimal)
5 Year Implied Tax Rate
10 Year Implied Tax Rate
20 Year Implied Tax Rate

What to Do About 2008?



What to Do About 2008?

- Unsettled. Just as uncertainty exists about the drivers of the Great Depression, so too will be the case with respect to the Great Recession.
- One is faced with the need to capture some features of systemic risk without destroying historical relationships within the ESG.
- Market collapses and terrible equity returns are associated with a variety of economic conditions within the historical record.

What to Do About 2008?

- If new systemic variables are introduced into the ESG, extreme care must be taken to avoid restricting the nature of the tail events the ESG can produce.
- A good ESG begins with a careful design of the interactions between asset classes. For example, a good ESG will capture the correlations between equity returns and corporate bond returns.

What to Do About 2008?

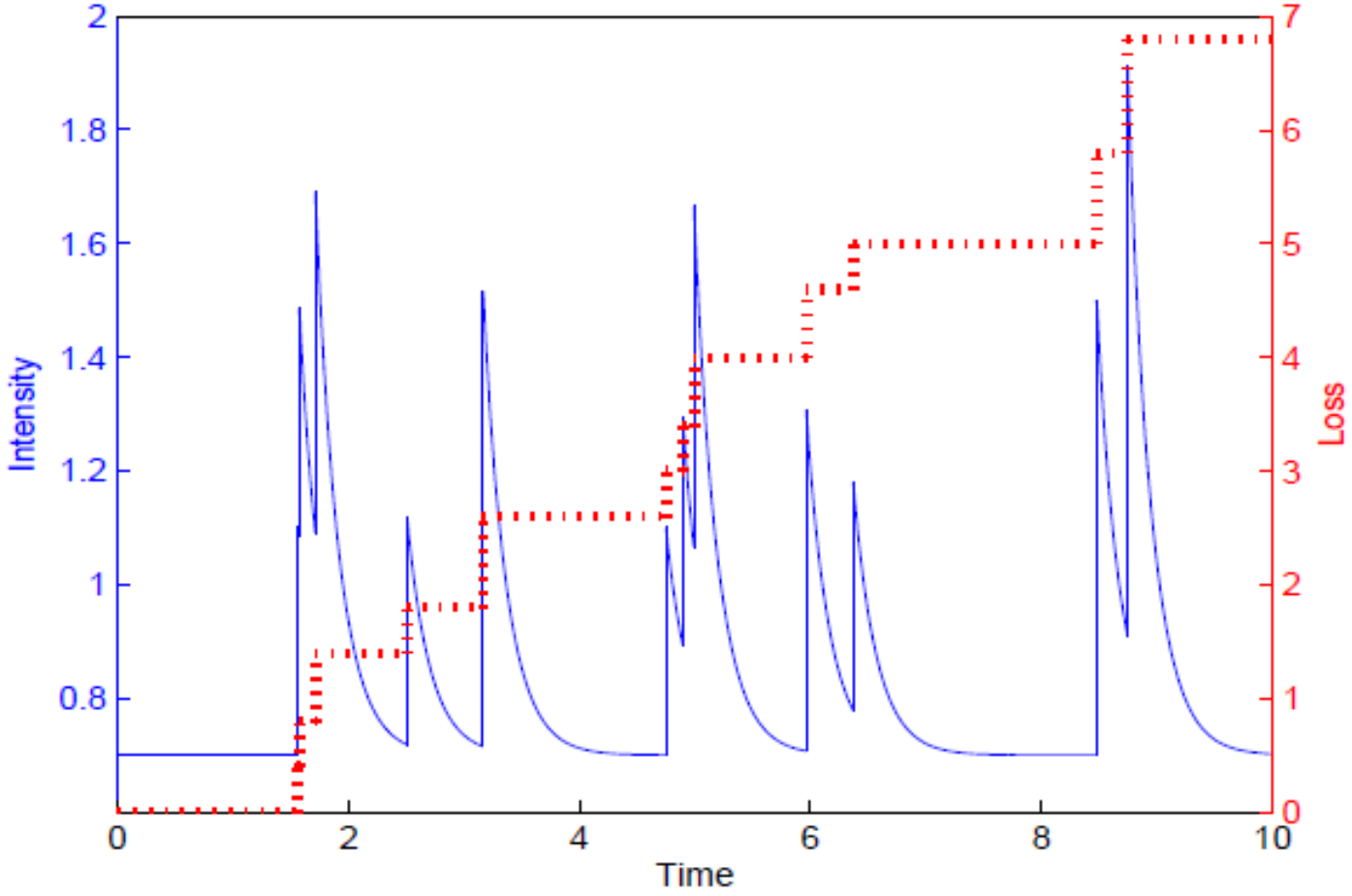
Correlation Matrix 1/1/89 -- 12/31/08 - Monthly						
	S&P 500	AAA	AA	A	BBB	High-Yield
S&P 500	1					
AAA	0.1597	1				
AA	0.2172	0.9768	1			
A	0.2735	0.9480	0.9668	1		
BBB	0.3794	0.8473	0.8887	0.9320	1	
High-Yield	0.5743	0.2890	0.3599	0.4893	0.6309	1

- If appropriate systemic risk factors are in place and the model was structured correctly to begin with then changes to the systemic risk structure can be made while maintaining model consistency.

What to Do About 2008?

- There is considerable research ongoing that holds promise in capturing the credit aspects of recent events.
- The work of Errais, Giesecke & Goldberg - Affine Point Processes and Portfolio Credit Risk is one example.
- The following picture gives the flavour of the model.

What to Do About 2008?



$$\lambda_t = u(t) + \int_0^t h(t-s)\, dL_s$$

$$h(v) = \delta e^{-\kappa v}, \qquad v \geq 0,$$

Conclusions

- A good ESG must have a wide range of specific attributes which are essential in obtaining reliable economic scenarios.
- Must provide scenarios that are consistent with the features of real market data. That is, the simulated artificial economy must look and feel just like the real economy both qualitatively and quantitatively.
- Must be computationally efficient and numerically stable.

Conclusions

- Must have a comprehensive estimation and validation support system.
- Must produce extreme but plausible scenarios that encapsulate historical behaviour.
- It is highly desirable, if not essential, to have the same suite of core models running for ALM and other real world applications that are running for embedded value and other pricing applications in the risk-neutral world.