

Risk and Portfolio Management

Spring 2010

Construction of Market Risk
Models: Treasurys and MBS

A general approach for modeling market risk in portfolios

Abstracting from the work done on equities, we study a general procedure for building risk models for fixed-income cash securities (Bonds, MBS, Credit-default swaps).

Step 1. Obtain the data, in the form of prices or yields of liquid market instruments

Step 2. Construct panel data

Step 3. Characterize the tail behavior of the factors using a distribution (Student T)

Step 4. Perform PCA on the data. Extract eigenvalues and eigenvectors.

Step 5. Factor Model based on simplified correlation matrix/factor structure

U.S. Treasurys (Data from H.15)

Data consists of daily recorded yields on constant maturity treasuries:

Yields for 6 months, 1 year, 2 years, 3-years, 5 years, 7 years and 10 years
TSY bills & bonds

Website: <http://www.federalreserve.gov>

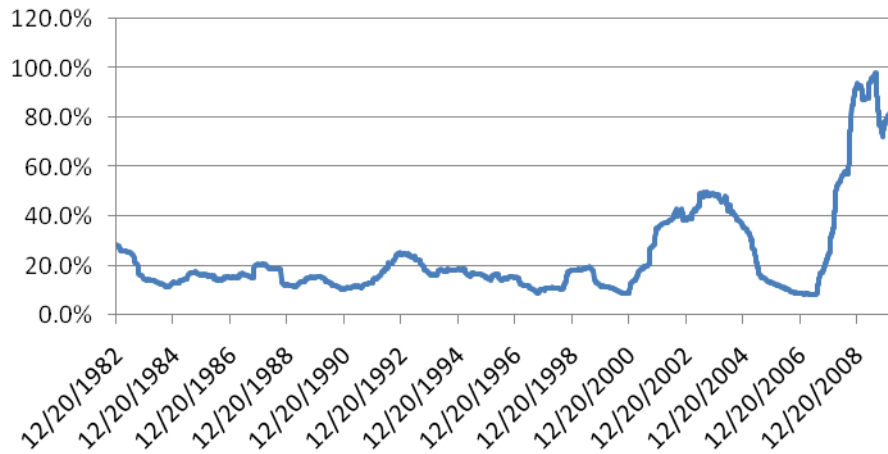
This site contains extensive historical data for most fixed-income instruments in the U.S. except credit derivatives

US Government Bonds

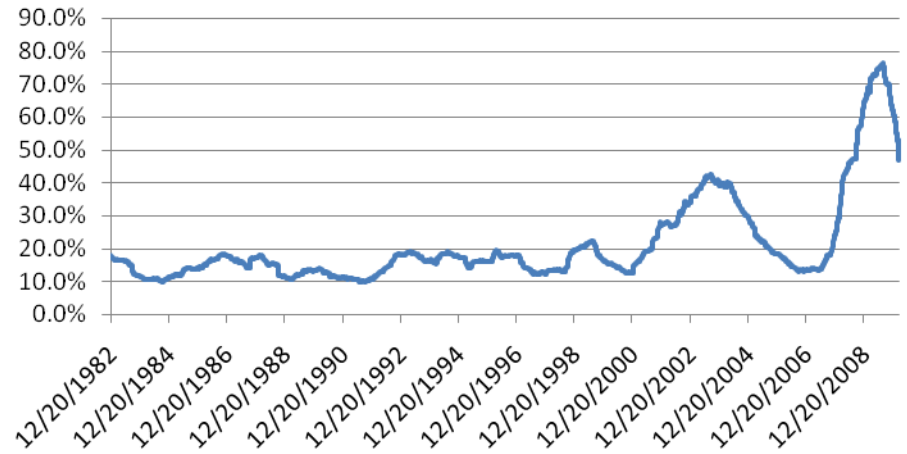
DATE	6M	1Y	2Y	3Y	5Y	10Y	30Y
1/4/1982	13.16	13.6	13.9	14.1	14.2	14.2	13.9
1/5/1982	13.41	13.8	14.1	14.3	14.4	14.4	14.1
1/6/1982	13.46	13.9	14.2	14.4	14.6	14.6	14.3
1/7/1982	13.43	13.9	14.3	14.5	14.7	14.6	14.3
1/8/1982	13.35	13.8	14.1	14.3	14.5	14.5	14.1
1/11/1982	13.84	14.3	14.6	14.7	14.8	14.8	14.4
1/12/1982	13.74	14.2	14.5	14.6	14.7	14.6	14.3
1/13/1982	13.97	14.5	14.8	14.8	14.9	14.8	14.5
1/14/1982	13.91	14.4	14.7	14.7	14.7	14.7	14.3
1/15/1982	14.01	14.5	14.8	14.9	14.9	14.8	14.4
1/18/1982	14.09	14.5	14.8	14.9	14.8	14.8	14.3
1/19/1982	14.2	14.6	14.8	14.8	14.8	14.8	14.4
1/20/1982	14.31	14.8	15	15	14.9	14.8	14.3
1/21/1982	14.42	14.8	15	14.9	14.8	14.6	14.2
1/22/1982	14.46	14.9	15.1	15	14.9	14.7	14.2
1/25/1982	14.61	14.9	14.9	14.9	14.8	14.6	14.2
1/26/1982	14.24	14.5	14.7	14.7	14.6	14.5	14.2
1/27/1982	14.02	14.4	14.6	14.7	14.6	14.5	14.2
1/28/1982	13.64	14	14.3	14.3	14.3	14.3	14
1/29/1982	13.76	14	14.2	14.3	14.2	14.1	13.9
2/1/1982	15.09	15.1	15	14.9	14.8	14.6	14.3
2/2/1982	14.8	14.7	14.9	14.7	14.6	14.5	14.3
2/3/1982	14.99	14.8	14.9	14.9	14.7	14.7	14.4
2/4/1982	14.97	14.8	15	14.9	14.8	14.8	14.5
2/5/1982	14.84	14.8	14.9	14.9	14.7	14.7	14.4

Annualized Volatility

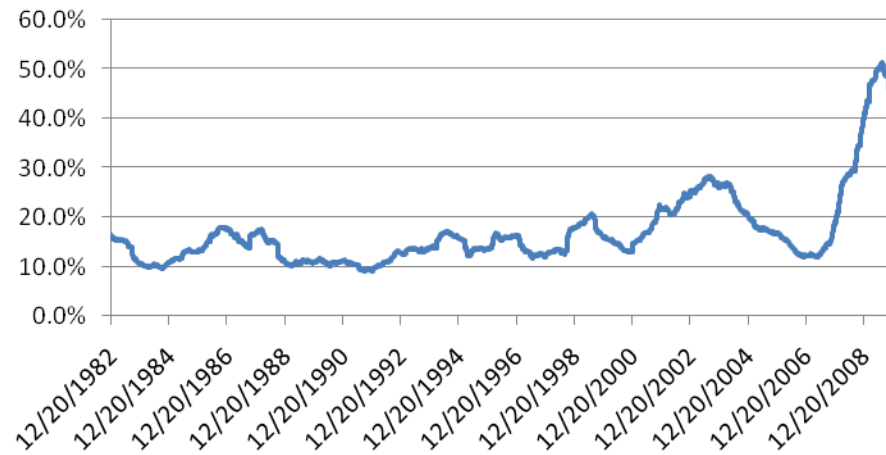
1Y



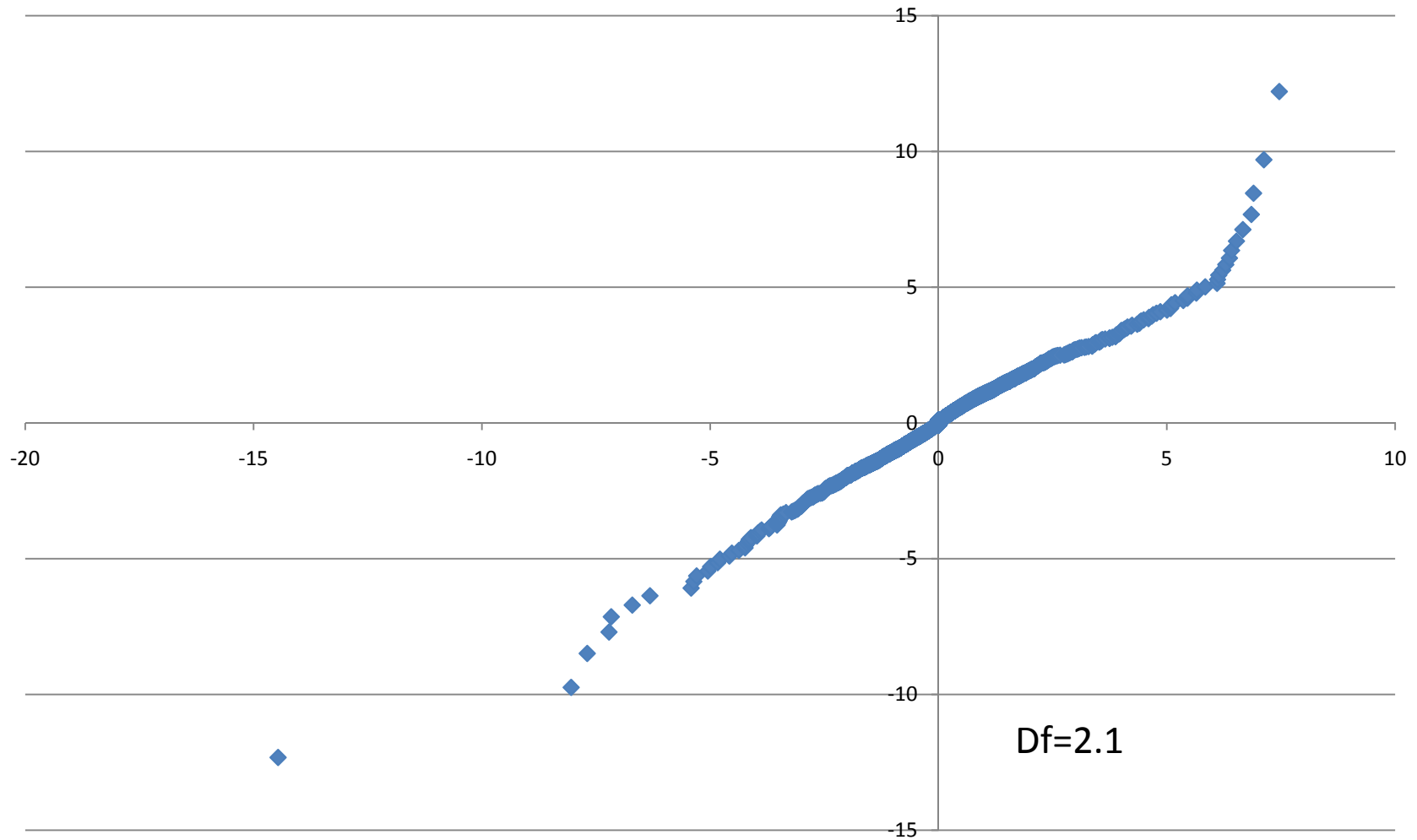
5Y



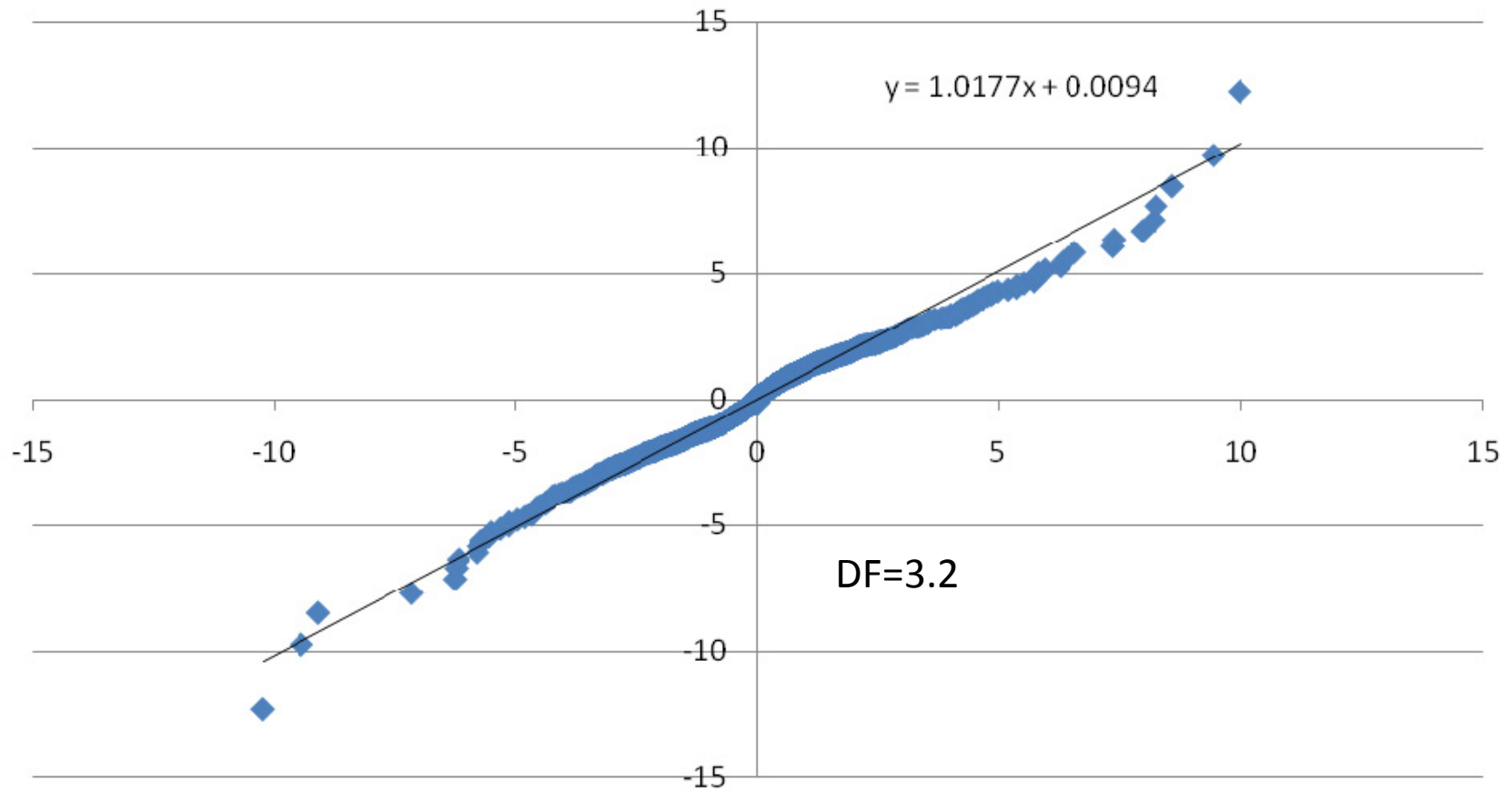
10Y



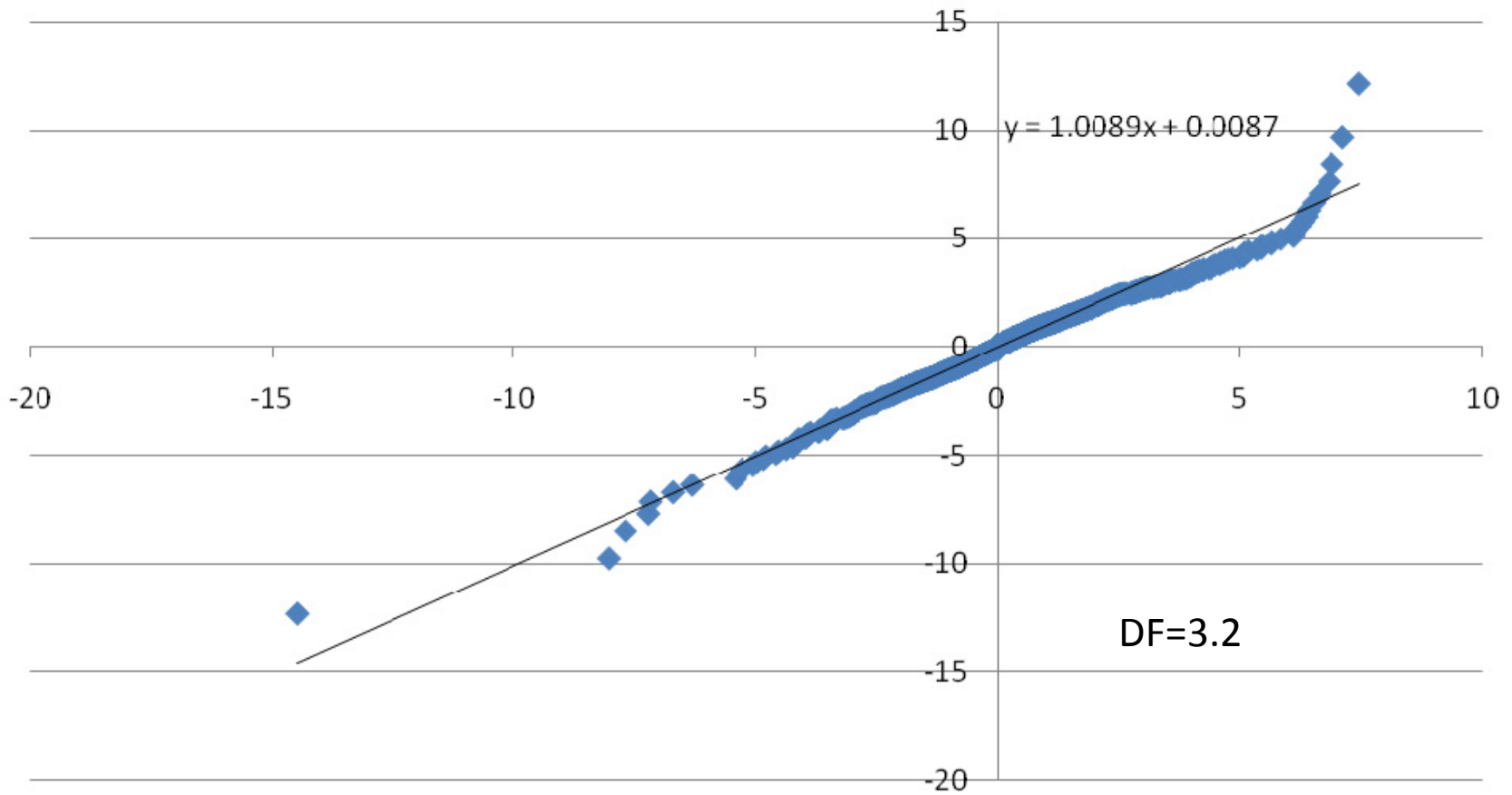
6-month rates: Q-Q plot of 1-day changes



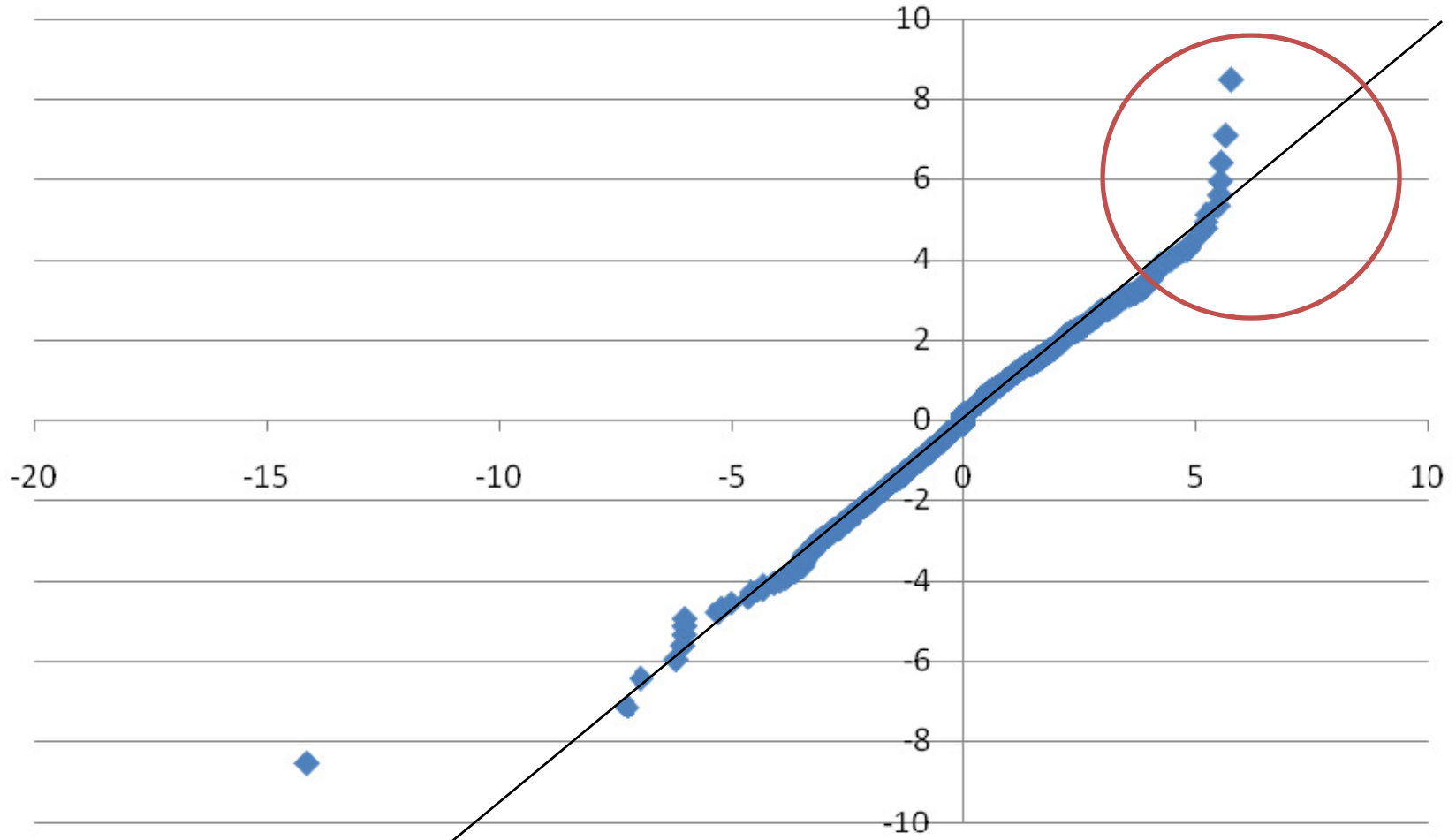
2-year TSY QQ-plot



5-Year TSY: QQ-Plot with Student t



10y TSY QQ Plot



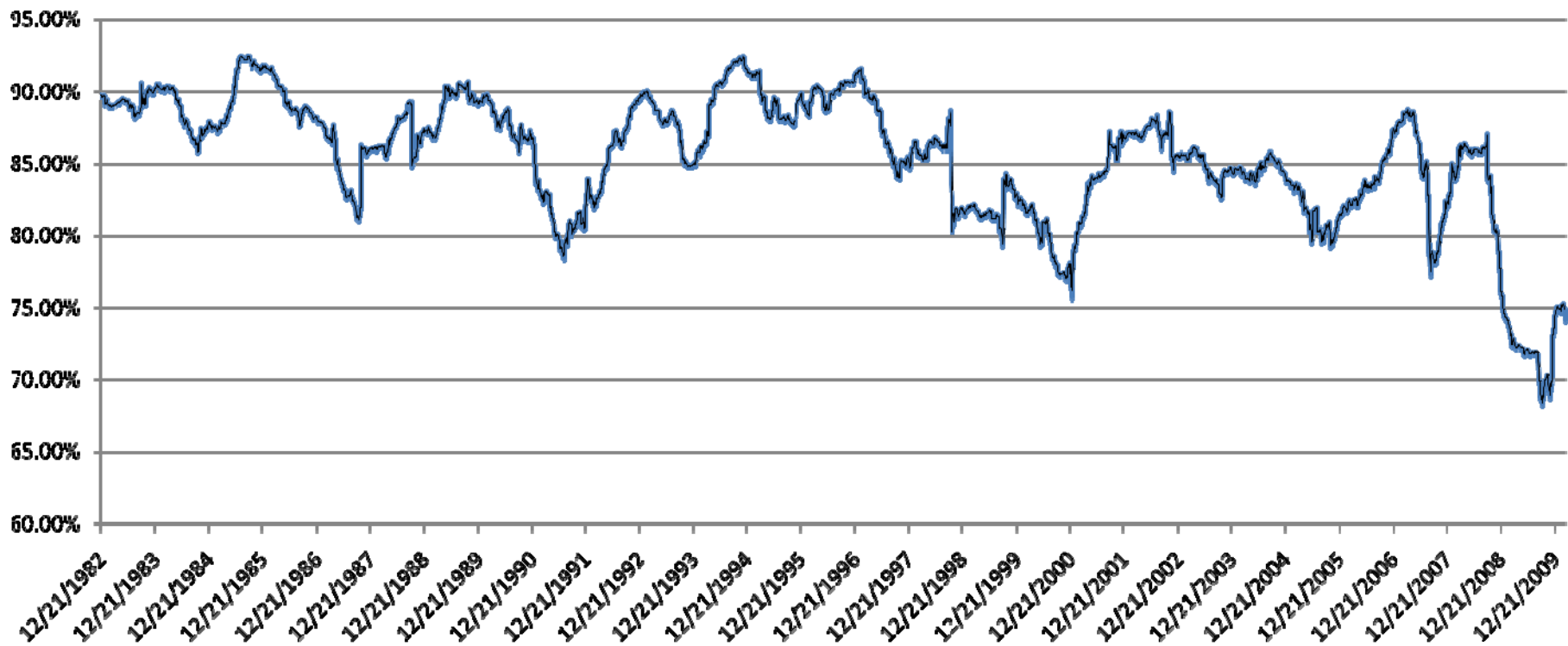
Student T with df=4

PCA

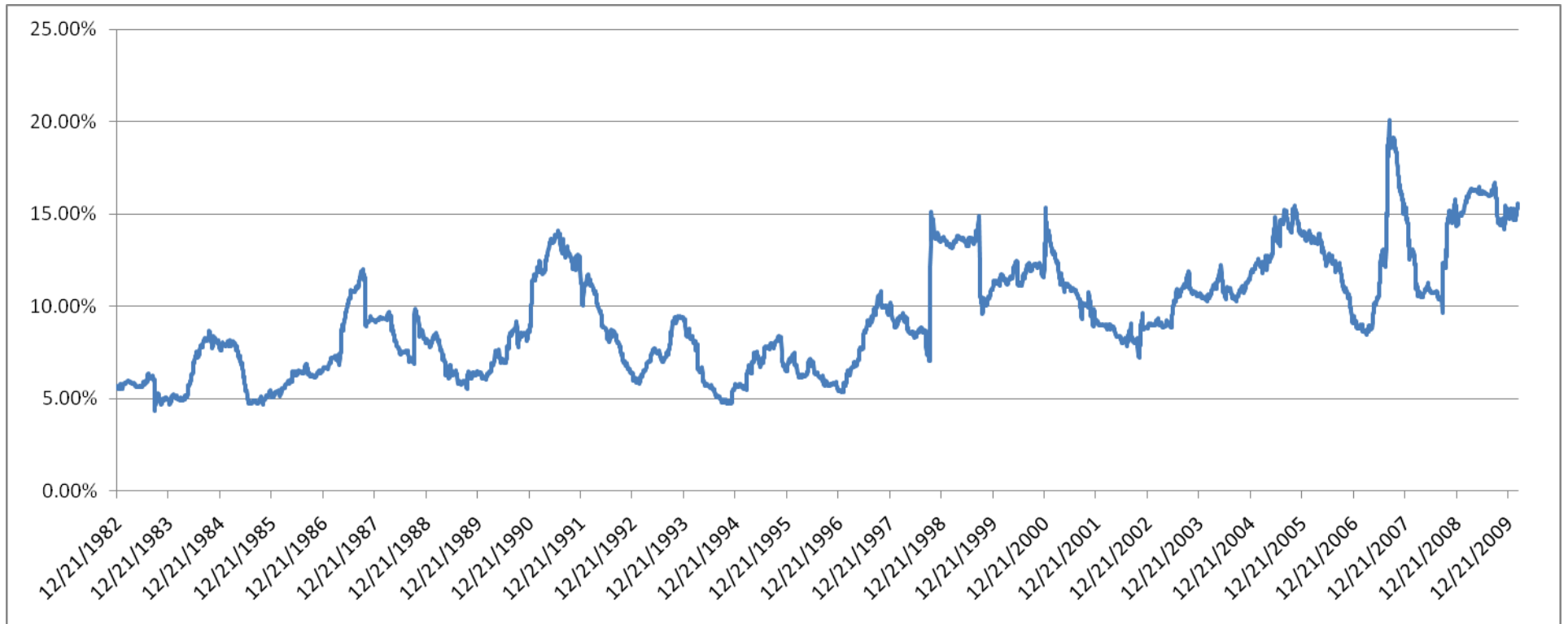
Perform PCA on daily yield data with a rolling window of 252 days

The 1-year cycle for volatilities and correlations is commonly used in the market

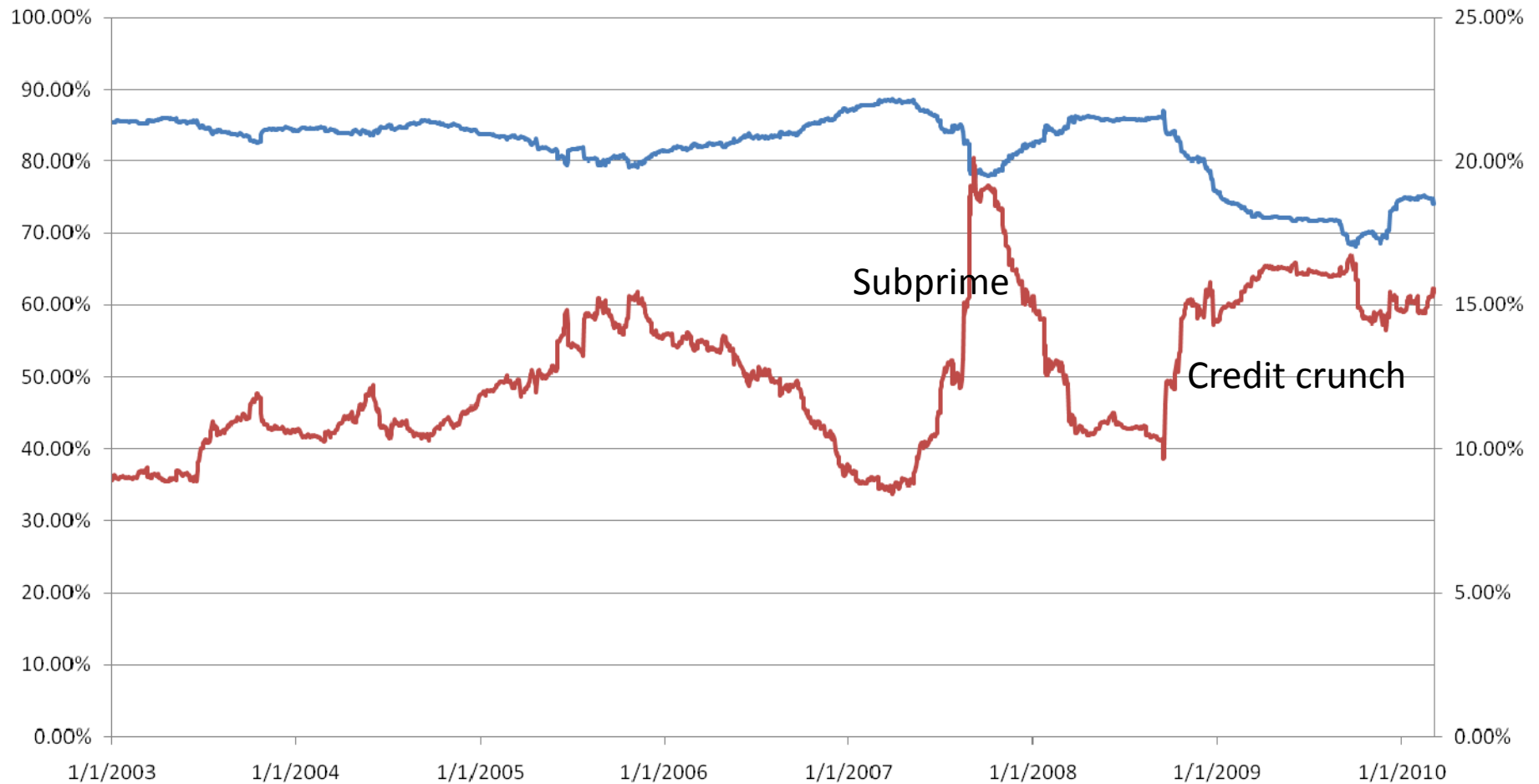
1st eigenvector, 1-year rolling window 1/1983-2/2010



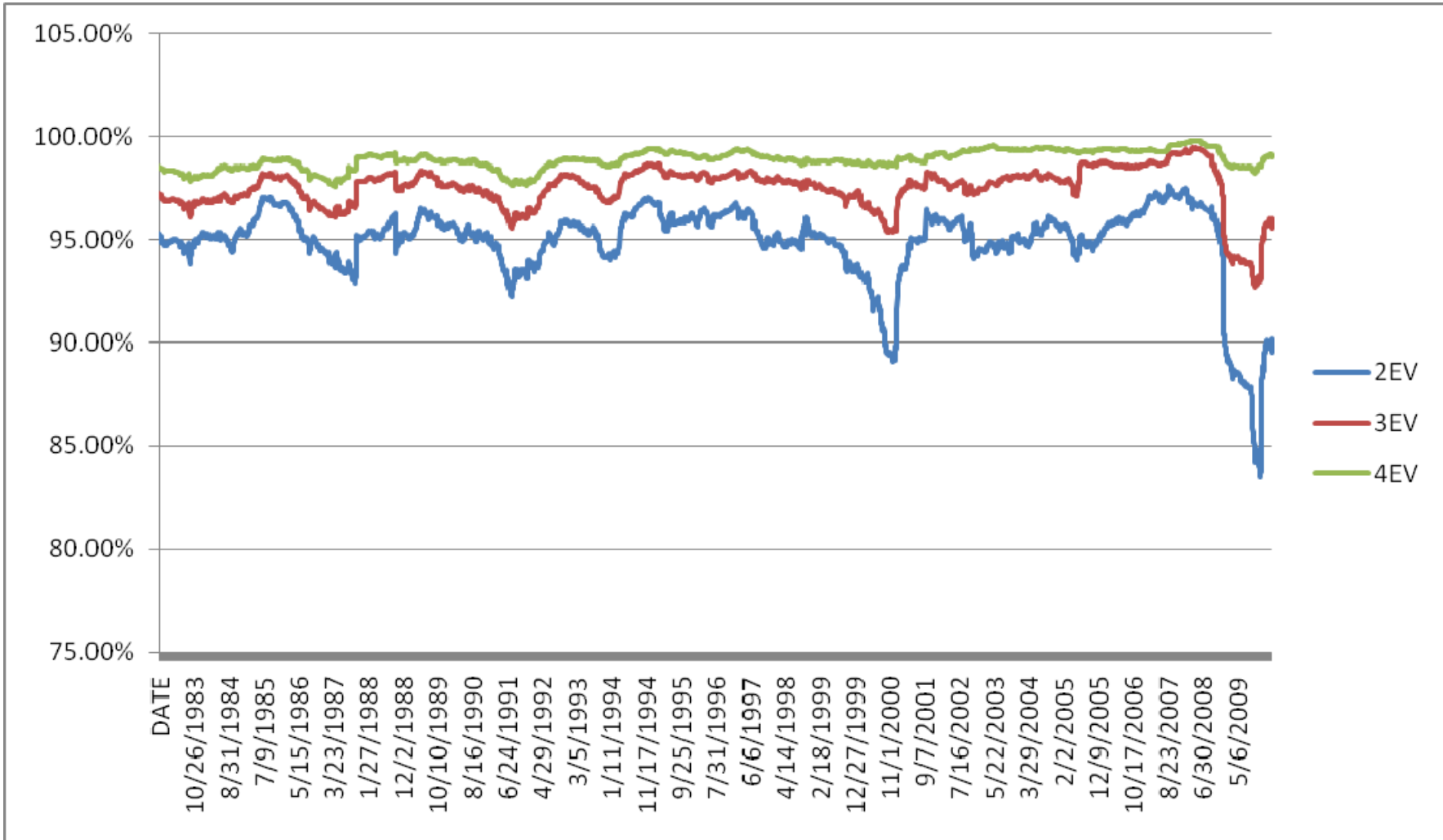
2nd eigenvalue (1/2003 to 2/2010)



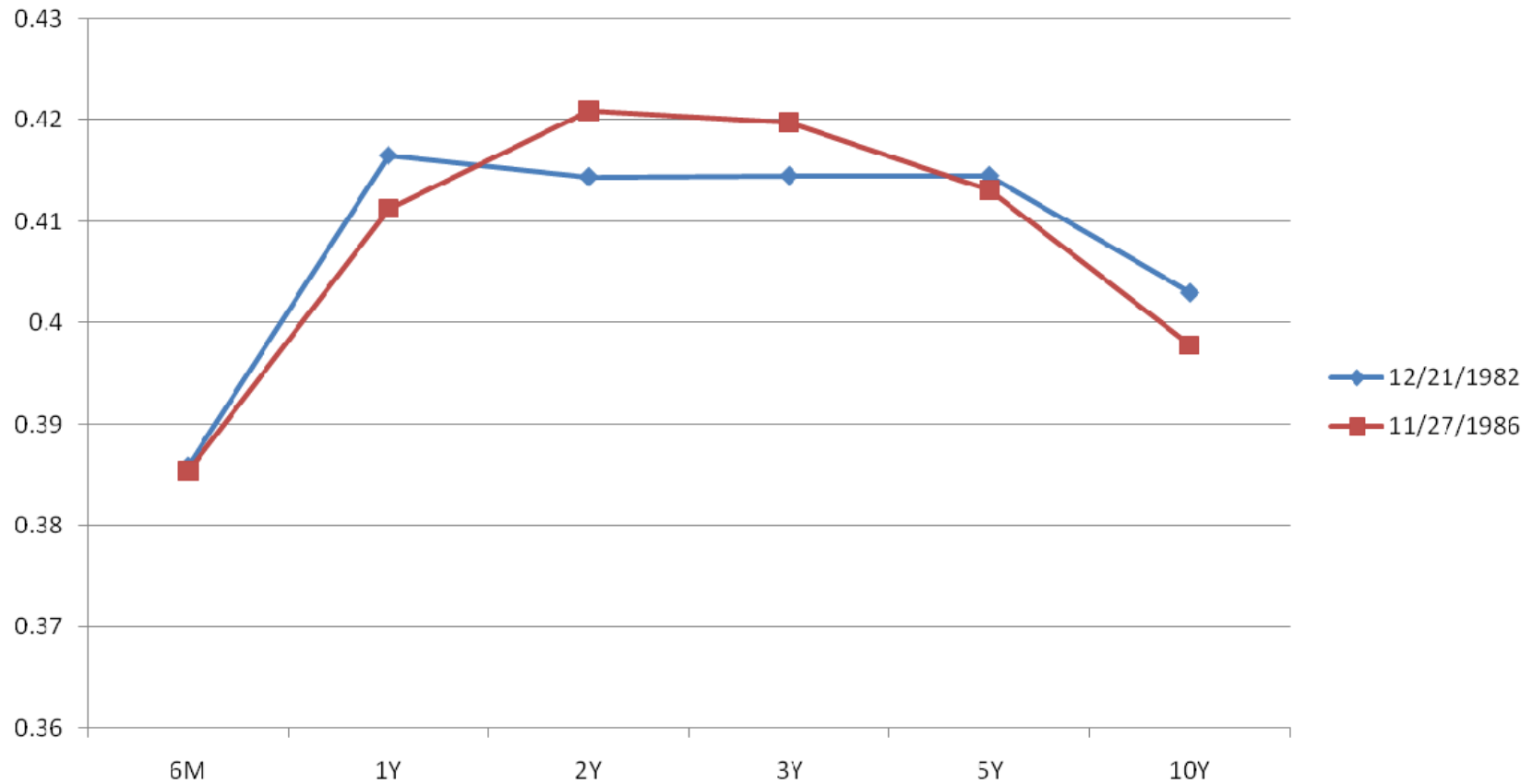
Zoom: 1st and 2nd Eigenvalues 1/2003-2/2010



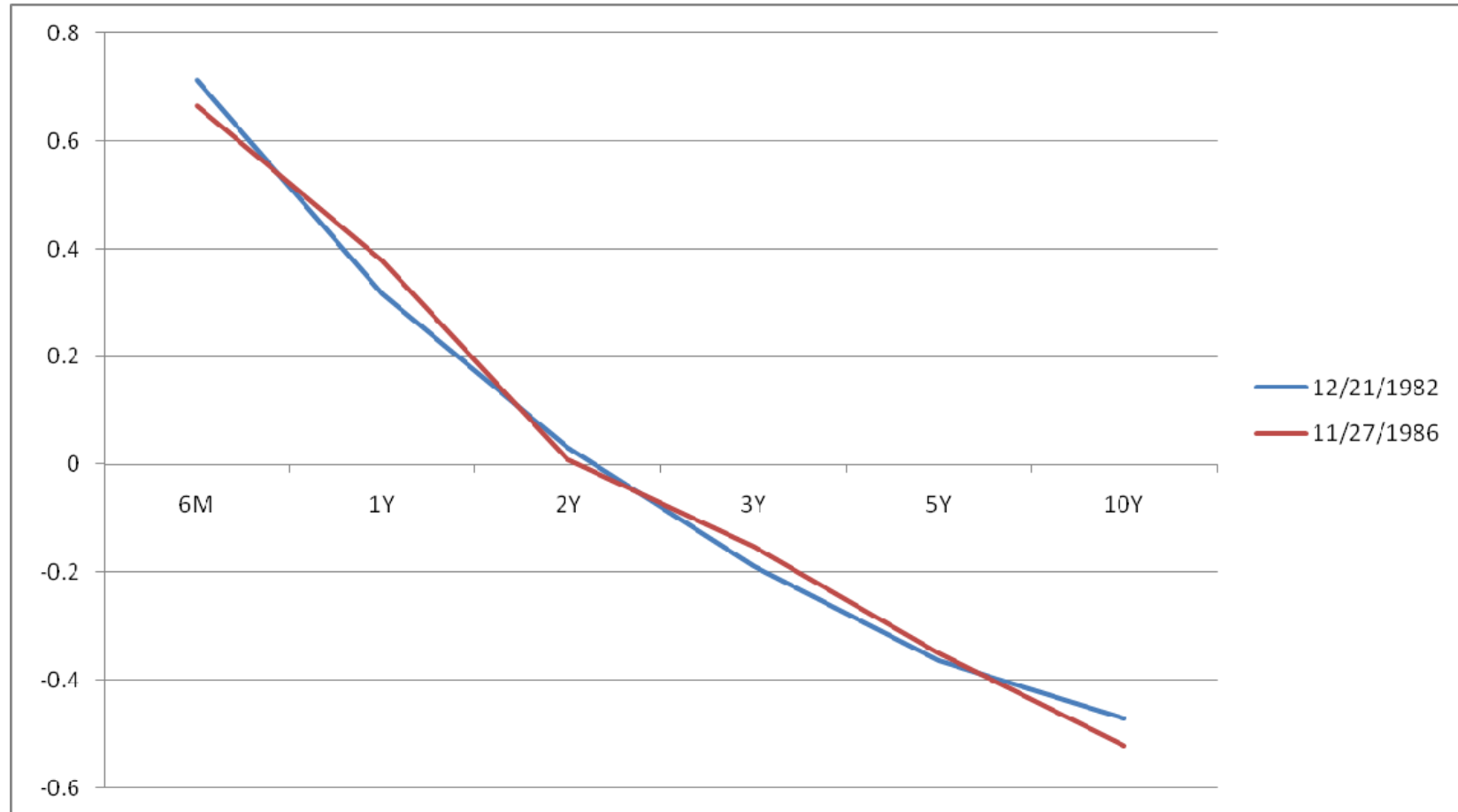
Percent of Variance Explained: 1 EV/2EV/3EV



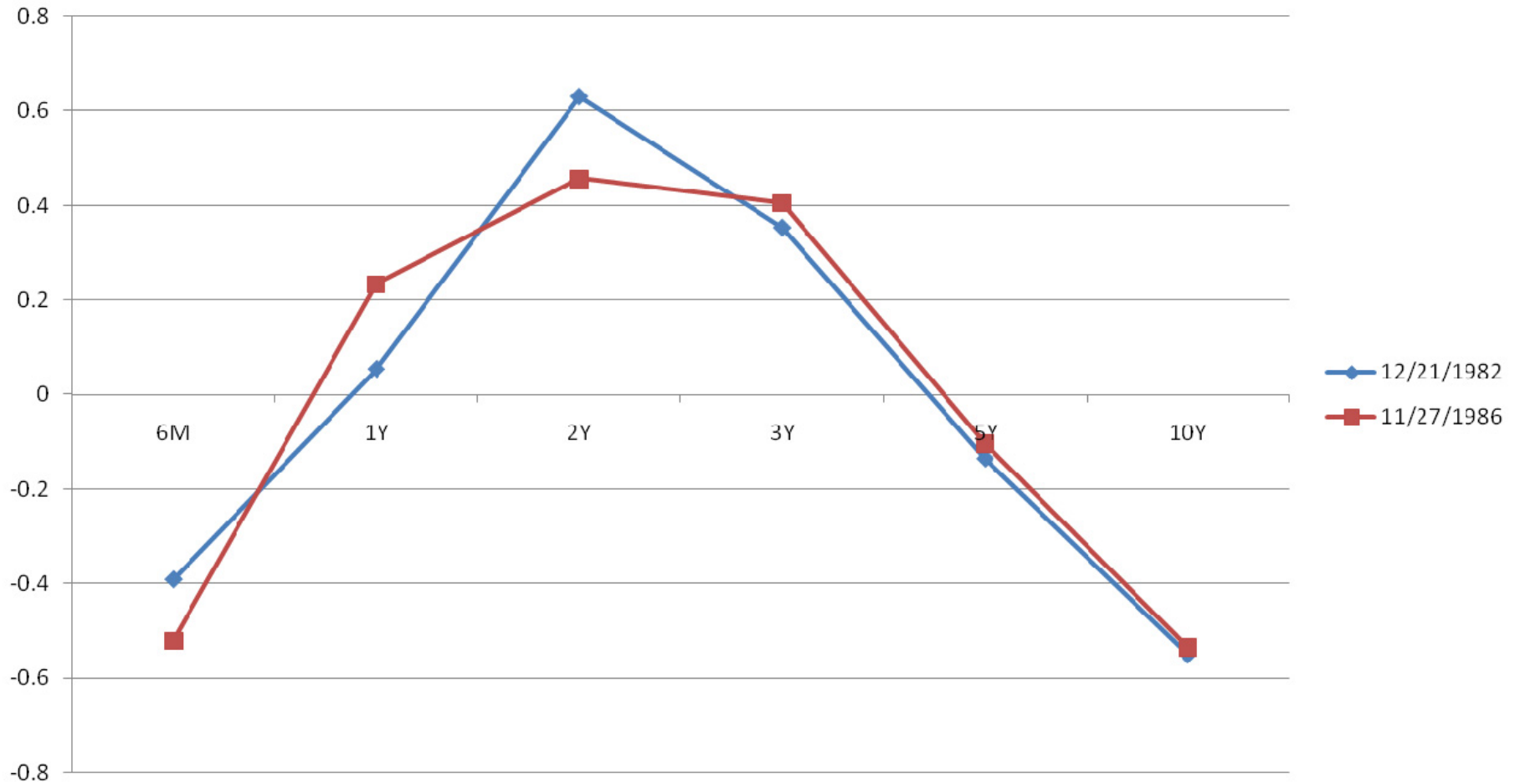
1st Eigenvector: ``Parallel Shift''



2nd Eigenvector: “Tilt”



3rd Eigenvalue: ``Twist''



Risk-management model for Treasurys (schematic)

Y = yield on a given bond

$$R_Y = \sigma_Y \left(\sum_{k=1}^m \beta_{Yk} F_k \right) + \sigma_Y \left(1 - \sum_{k=1}^m \beta_{Yk}^2 \right)^{1/2} G_Y$$

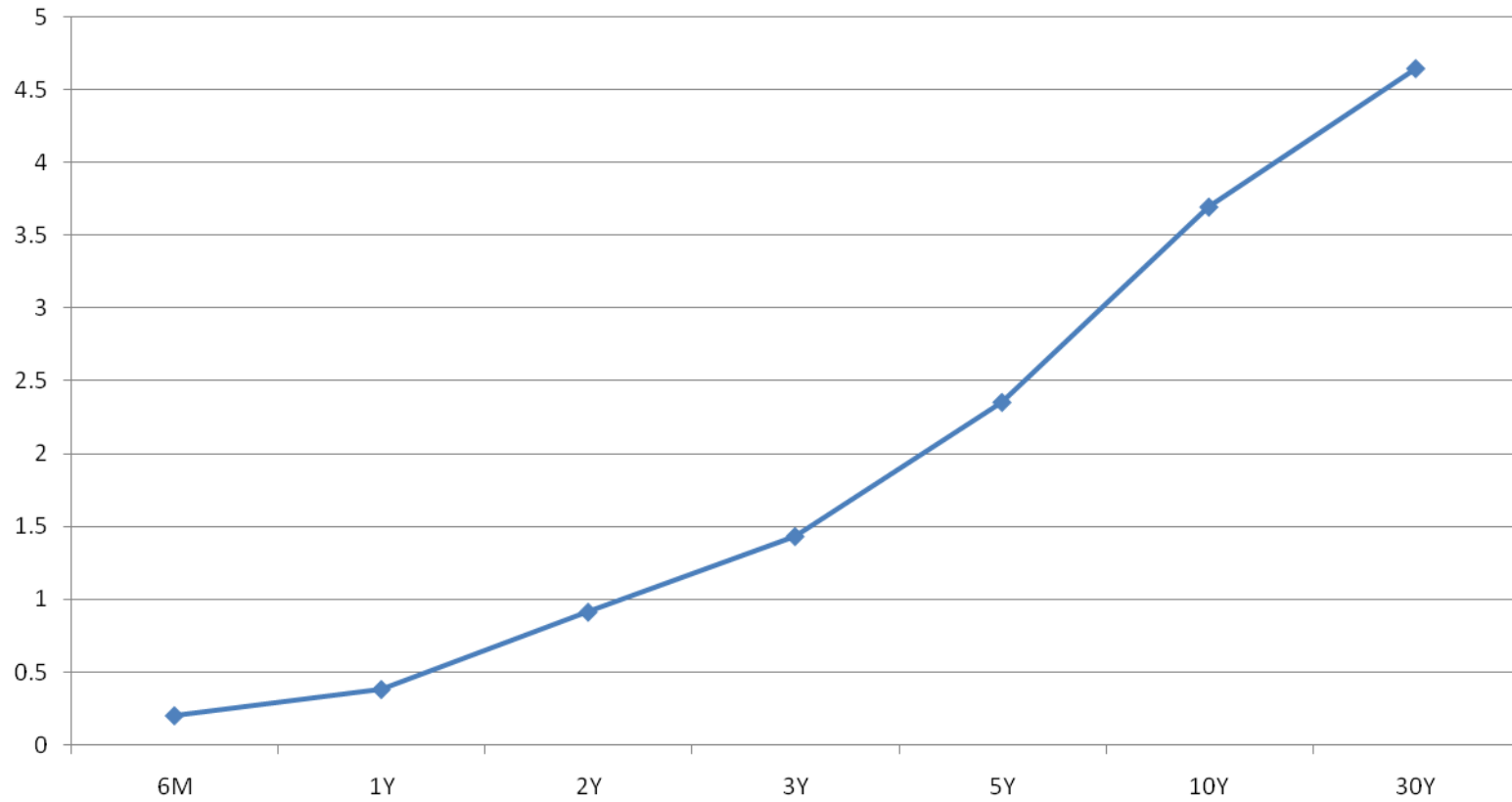
F_k = standardized return of k^{th} yield factor

G_Y = standardized idiosyncratic shock

m = number of factors (2 or 3 at most)

Any standard maturity bond yield is represented as a combination of factors & a residual.

TSY Yield Curve 3/5/2010



Mortgage-backed Securities

Mortgage-backed securities are pools of loans (residential, commercial) which are sold to investors as amortizing bonds.

Amortizing means bonds pay interest as well as principal.

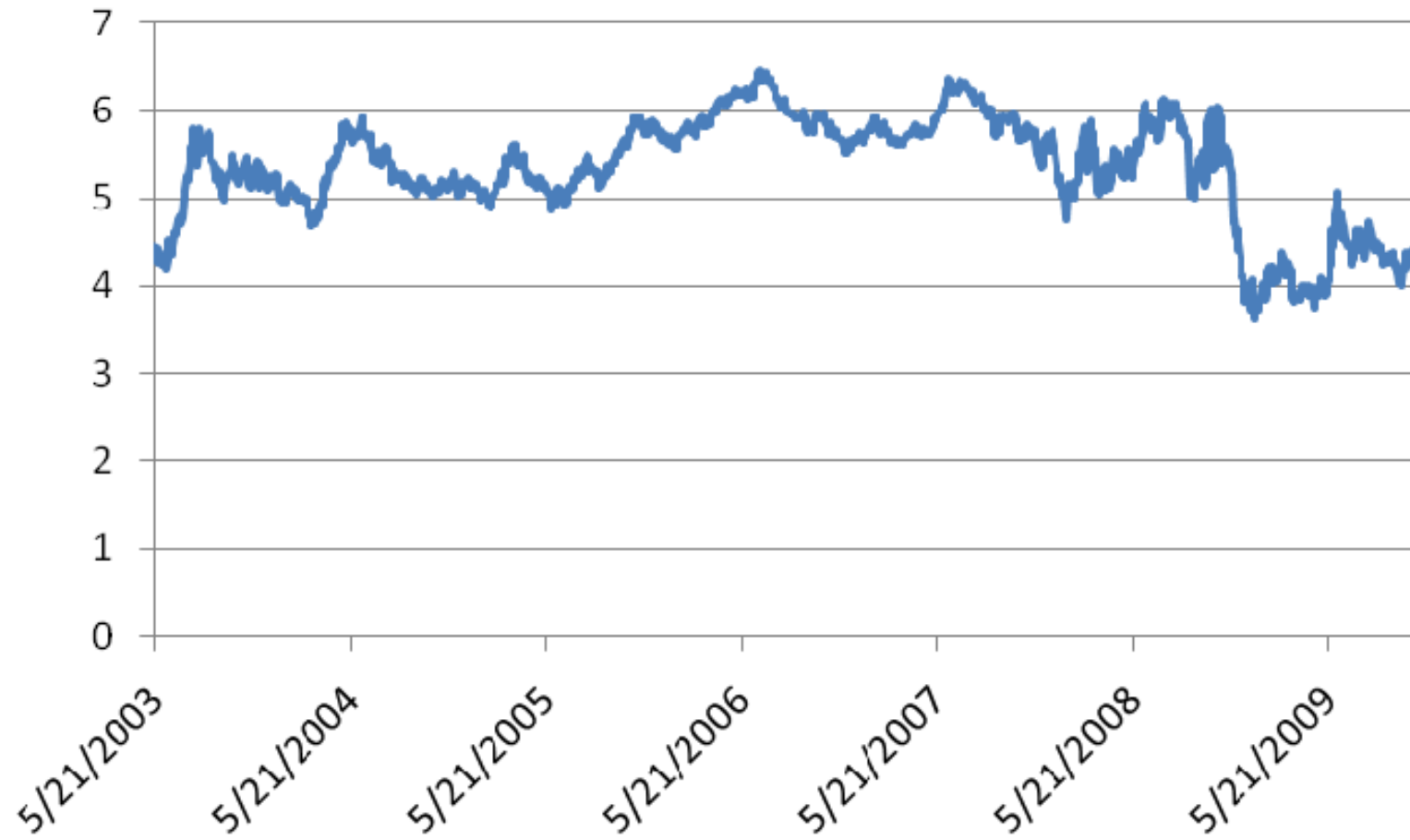
Agency MBS (FNMA, Freddie Mac) have implicit government guarantees, so there is no associated credit risk.

Prepayment risk: the risk that loans are paid before the expected payment schedule

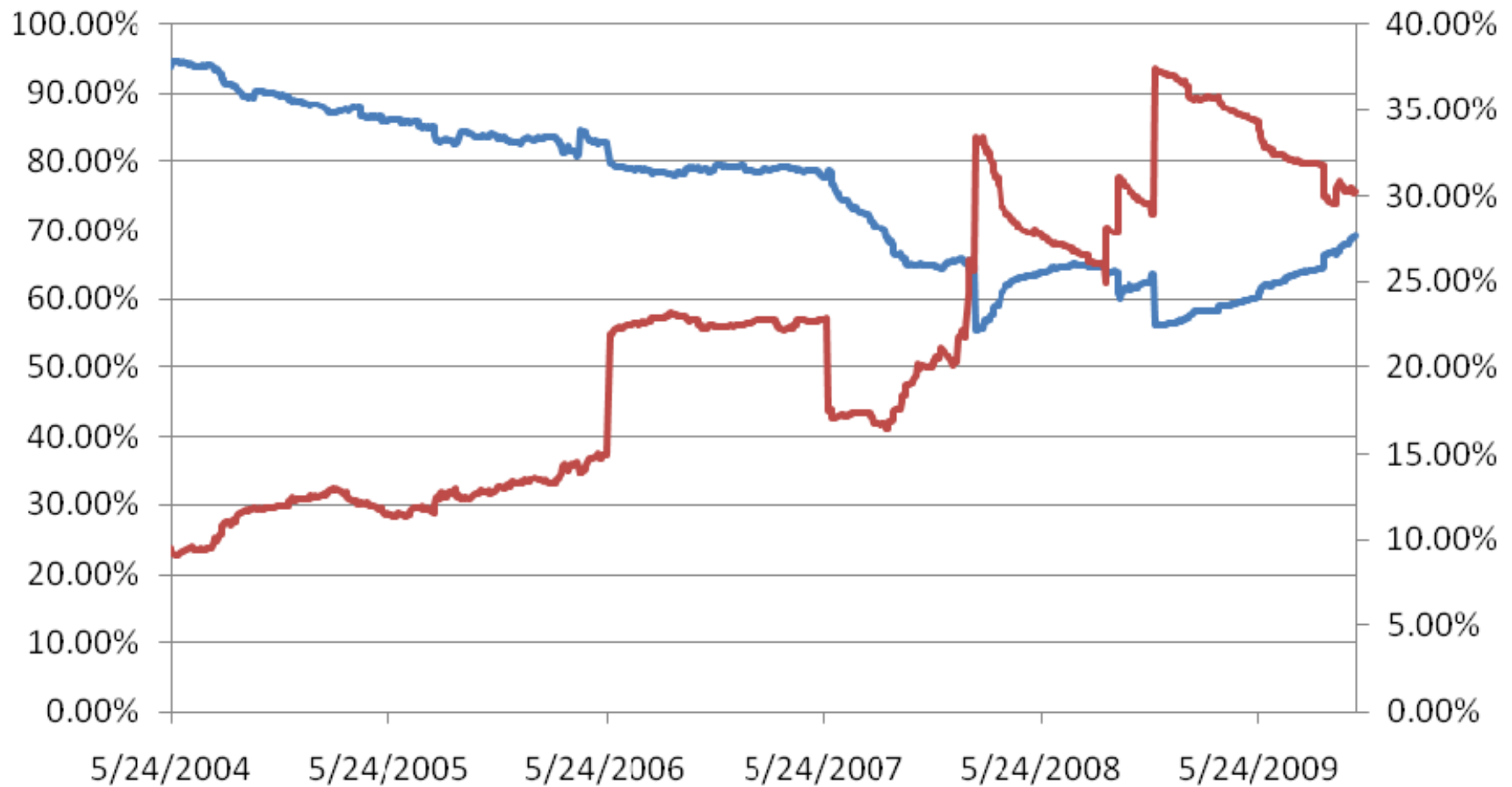
Private-label MBS are issued by banks and are not government guaranteed.

The ``To be announced'' (TBA) market is the market for forward delivery of Agency MBS. It aggregates information about the MBS market and is often used to model the volatility of MBS from a risk-management perspective.

Mortgage rate 2003-2010



TBA – Mortgage-Backed Securities 5/2004-2/2010



Eigenvectors of correlation matrix of TBA returns

