Forecasting Financial Markets conference

US yield curve identification and forecasting

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Motivations

- ECB definition: “a yield curve is a representation of the relationship between market remuneration rates and the remaining time to maturity of debt securities, also known as the term structure of interest rates”.

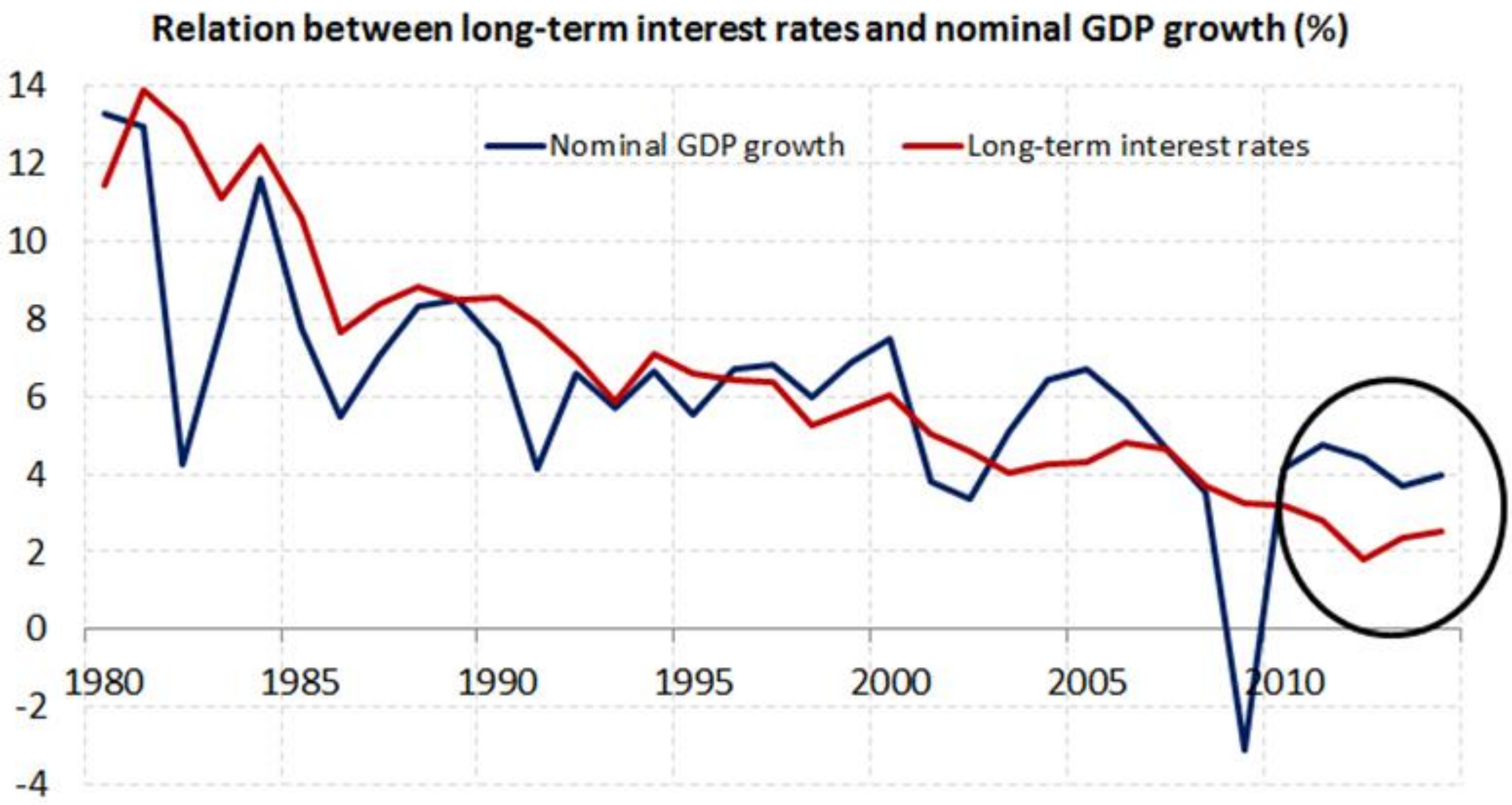
- A common benchmark yield curve grounded on a liquid government bond market is a key element for the banking sector to reach efficient capital allocation

- Useful for financial investors as it reflects the relationship between market supply and demand, for trading opportunities

- Also useful for policy makers to gauge market expectations, to analyze transmission effect of monetary policy

Motivations

- Actual debate about overvaluation of both stocks and bonds



Motivations

- Questions, worries about the market reaction after the first Fed funds rate hike in 2015.
- After 7 years of extraordinary easing monetary policy and very low interest rates, which evolution of long-term interest rates can we expect?
- What is the historical benchmark yield curve related to observed macro fundamentals?

Contributions

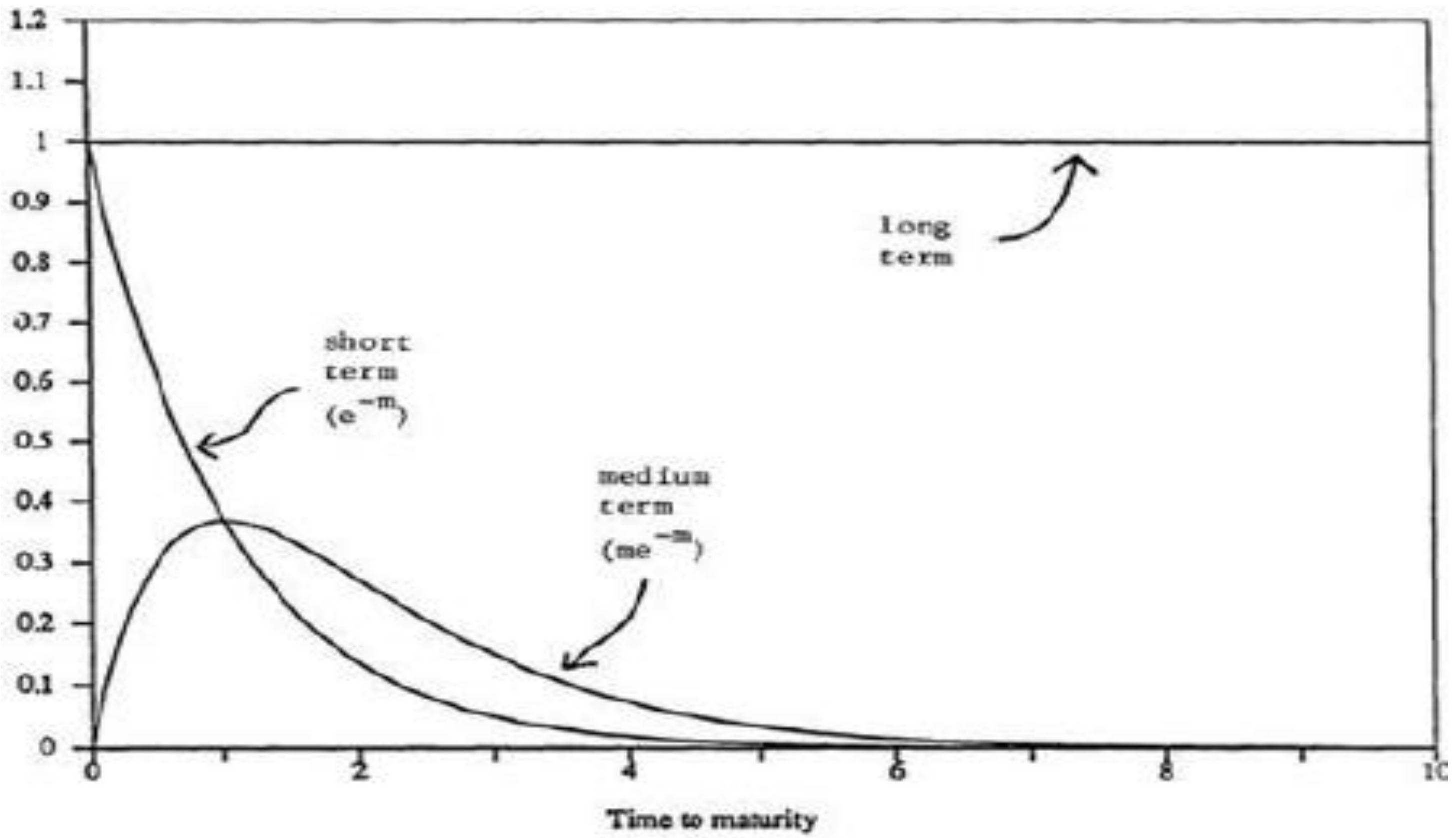
- **Recognition of archetypal yield curve shapes** beyond the simple three ‘normal’, ‘inverted’, ‘flat’ shapes generally identified
- **Identification of logical sequence** among the different forms through transition probabilities from one curve to another
- **Characterize non-linear dynamic interactions** between macroeconomic factors and the different shapes of the US yield curve
- **Forecasts** related to observed macroeconomic situation (without macro scenarios)

Literature review

- Charles R. Nelson and Andrew F. Siegel (1987): “Parsimonious modeling of yield curves”, The Journal of Business
- The approach aims at improving the understanding of the underlying relationship between yield and maturity without requiring complex models involving a large number of parameters.
- Translate discrete observed yields into a continuous function of the entire yield curve.

$$y(m) = \beta_0 + \beta_1 \frac{[1 - \exp(-m/\tau)]}{m/\tau} + \beta_2 \left(\frac{[1 - \exp(-m/\tau)]}{m/\tau} - \exp(-m/\tau) \right)$$

Literature review – Nelson Siegel model



Literature review

- The model aims at capturing the classical forms of curve: up, flat, inverted.

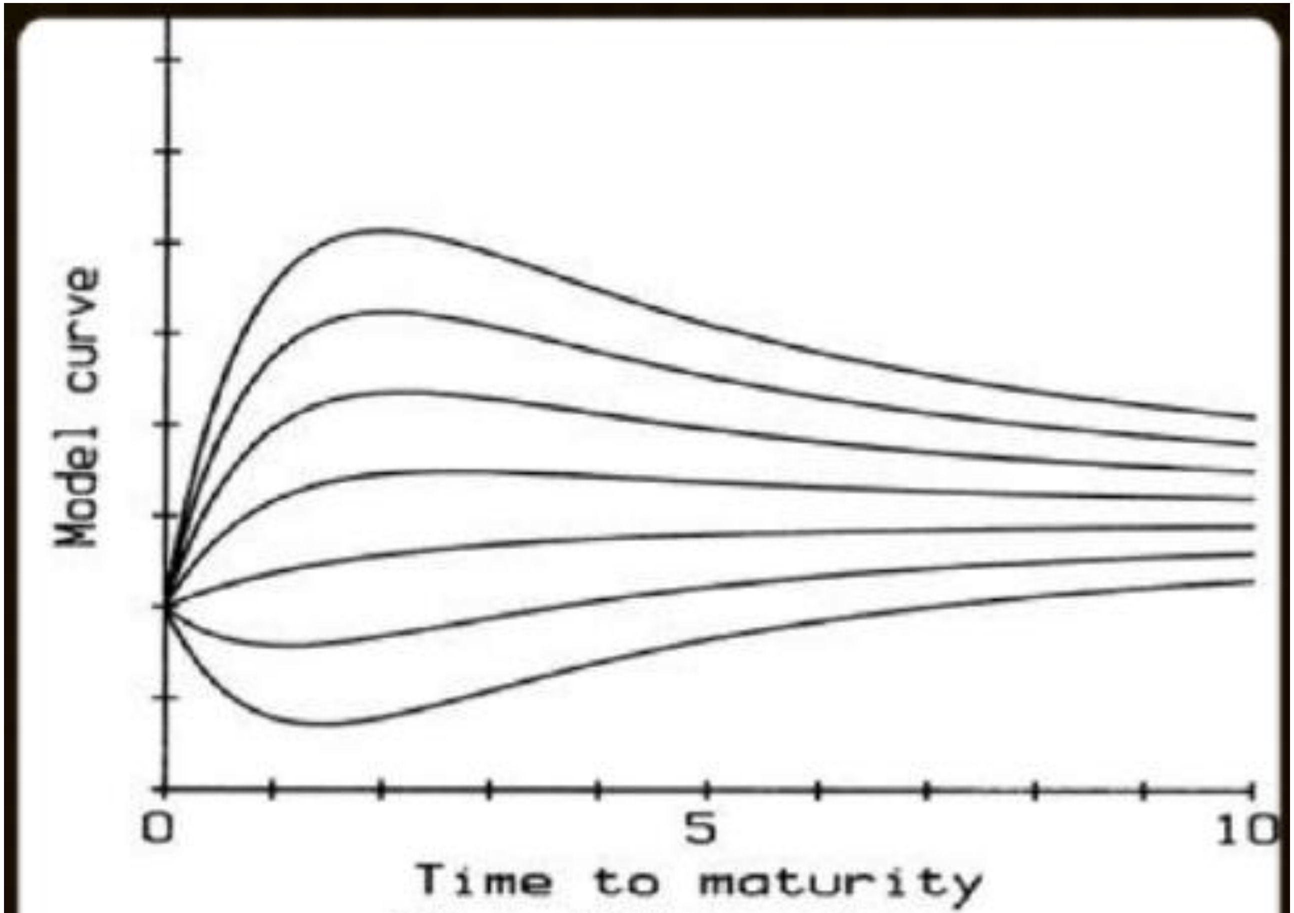


Fig. 1.—Yield curve shapes

Literature review

A good model of yield curve should be able to reproduce the historical stylized facts

- The average yield curve is increasing and concave
- The yield curve assumes a variety of shapes through time (upward sloping, humped, inverted humped etc.)
- Yield dynamics are persistent
- The short-end of the yield curve is more volatile than the long-end of the yield curve
- Long rates are more persistent than short rates.

Literature review

- Diebold et Li (2005): “Forecasting the term structure of government bond yields”, Journal of Econometrics

- Dynamic extension of the Nelson Siegel model

- Framework with exponential components which explore the yield curve using three dynamics parameters

Literature review

- Diebold et Li (2006): extension of the Nelson Siegel model

$$y_t(\tau) = \beta_{0t} + \beta_{1t}\left(\frac{1-e^{-\lambda_t\tau}}{\lambda_t\tau}\right) + \beta_{2t}\left(\frac{1-e^{-\lambda_t\tau}}{\lambda_t\tau} - e^{-\lambda_t\tau}\right)$$

- **Beta 0** denotes the long-run level of interest rates
- **Beta 1** represents the slope factor
- **Beta 2** is for the curvature of the yield curve
- **Lambda** is the exponential decay rate along maturities for each factor, with a larger lambda producing a faster decay. Diebold and Li (2006) fixed in the case of US lambda parameter at 0.0609 (which maximizes the impact of the medium-term factor at a maturity of 30 months in the US case)

Literature review

- Charles R. Nelson and Andrew F. Siegel (1987): “Parsimonious modeling of yield curves”, The Journal of Business
- Diebold et Li (2005): “Forecasting the term structure of government bond yields”, Journal of Econometrics
- Diebold, Rudebusch and Aruoba (2006): forecasting the yield curve with macroeconomic factors through a VAR
- However, forecasting the term structure of interest rates remains a challenging task.

Methodology

1. **Nelson Siegel model used to simplify** the term structure into three easily-interpretable latent factors

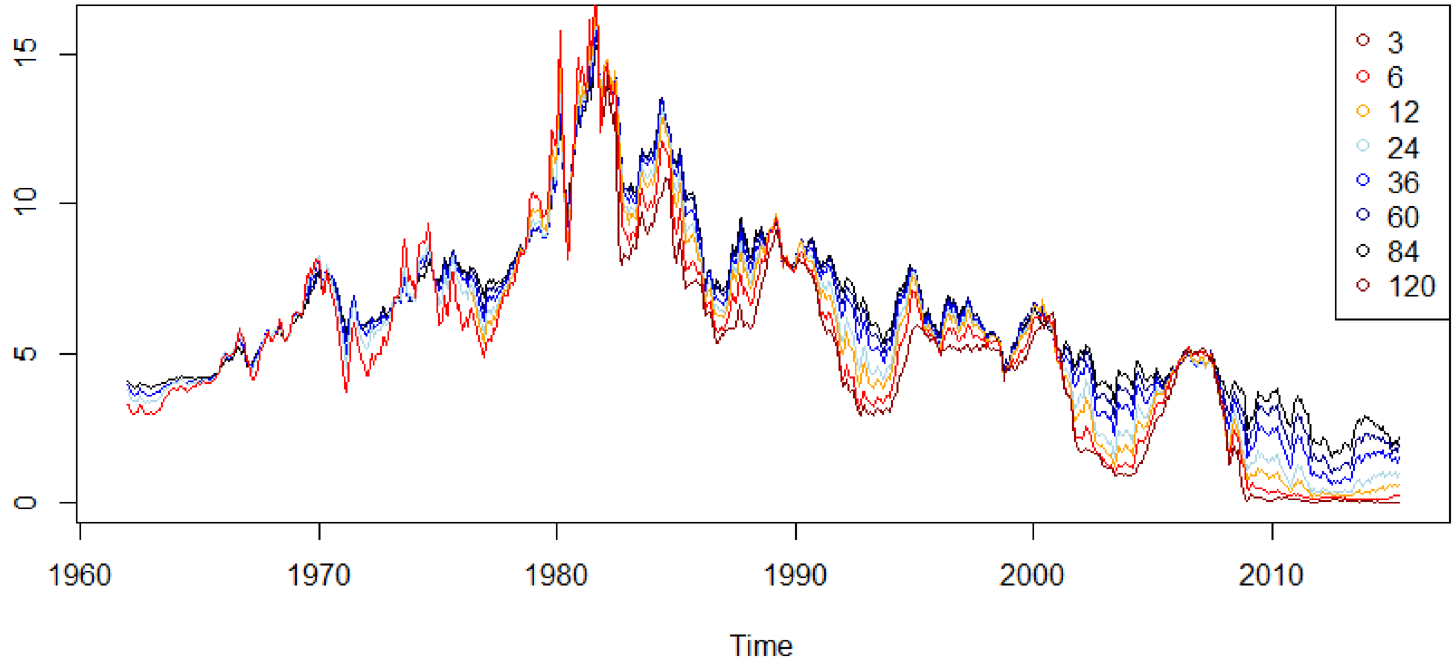
2. **K-means method used to identify** different shapes of the yield curve based on the three latent factors

3. **A recursive partitioning model (tree-based regression) to forecast** the different yield curve shapes based on exogenous macroeconomic determinants (GDP growth, inflation, Fed Funds rate, nairu gap)

Data

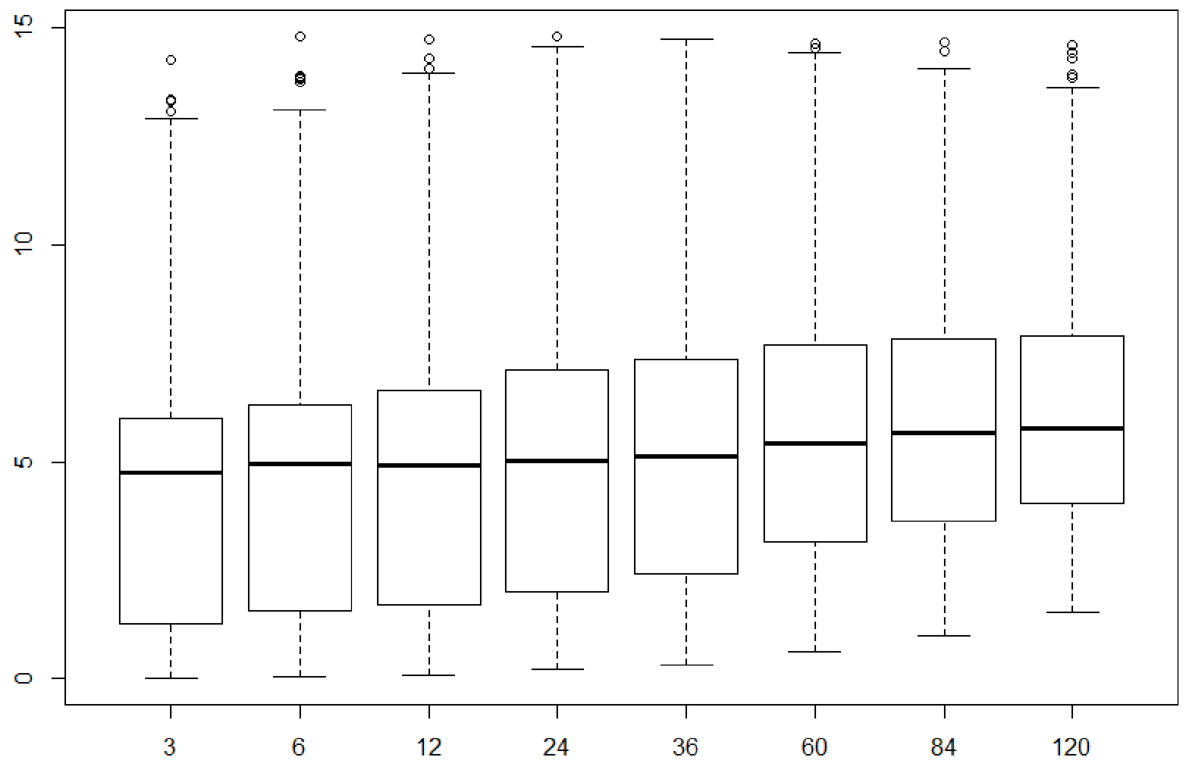
- Constant maturity treasury rates from the US Department of the Treasury
- On a monthly frequency over the period 1982-2014 (around 400 observations per maturity)
- Maturity: from 3 months to 10 years

Historical US treasury rates

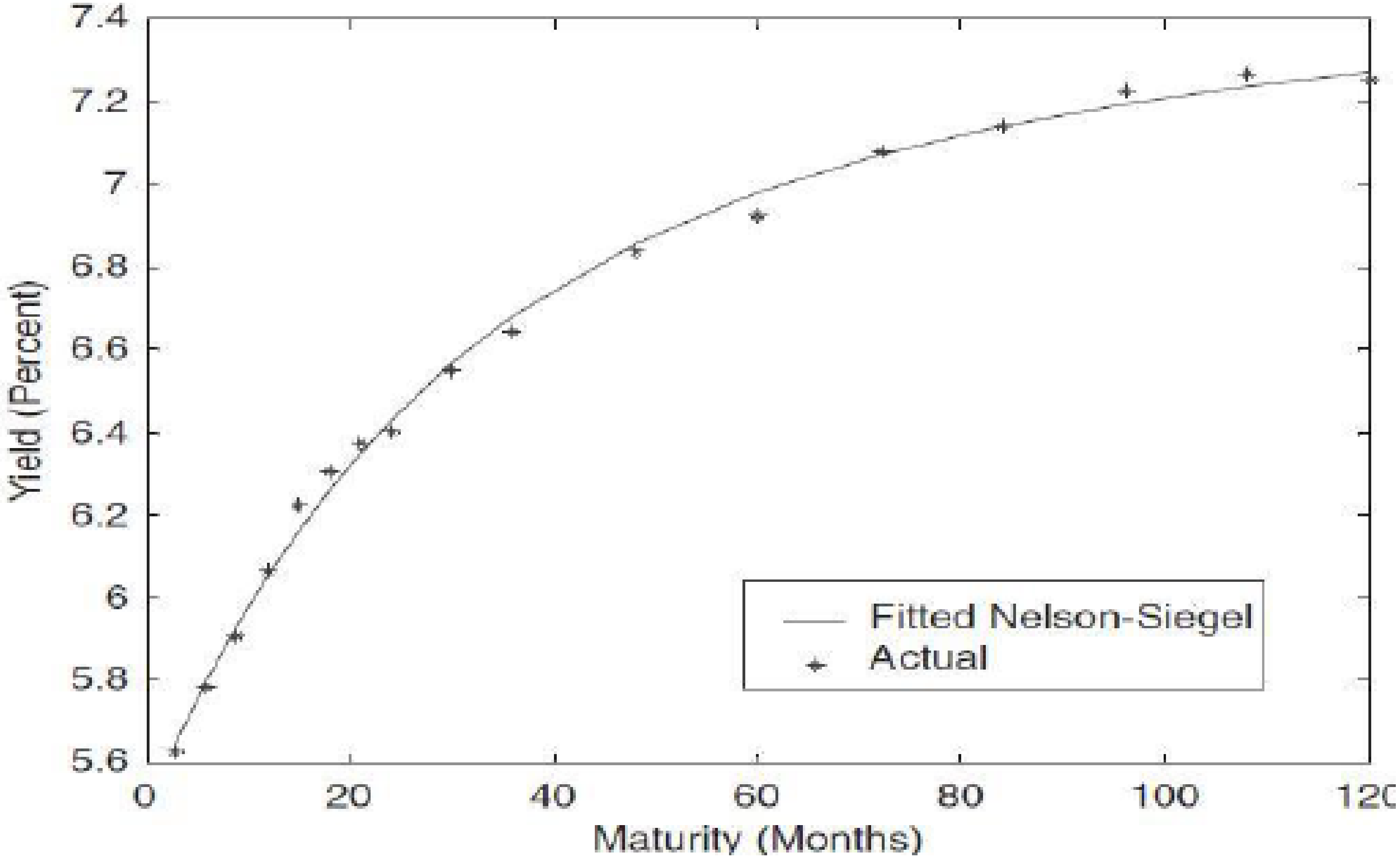


Data

Average yield curve over the sample period

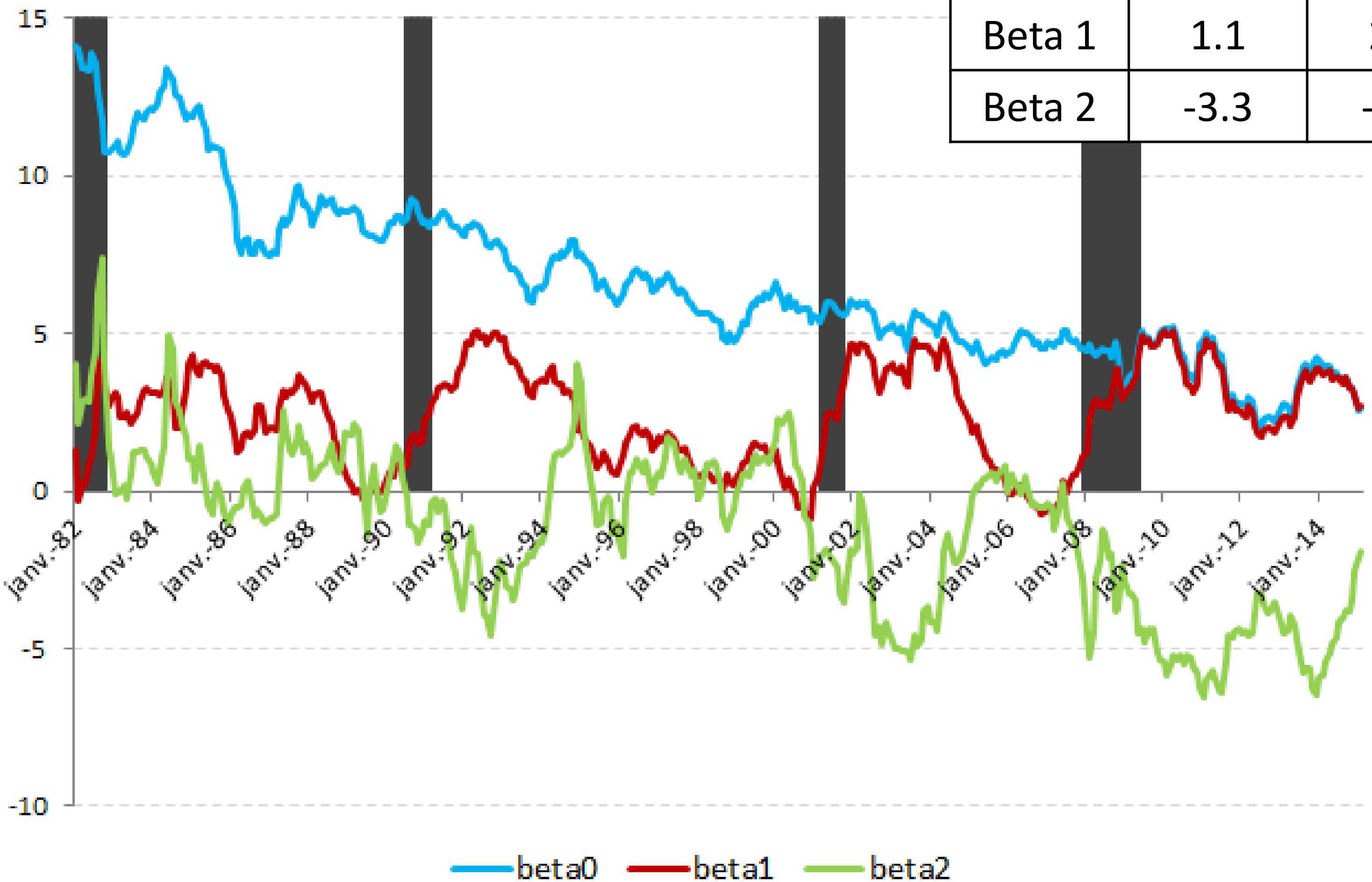


Estimated parameters from Nelson Siegel model



Estimated parameters from Nelson Siegel model

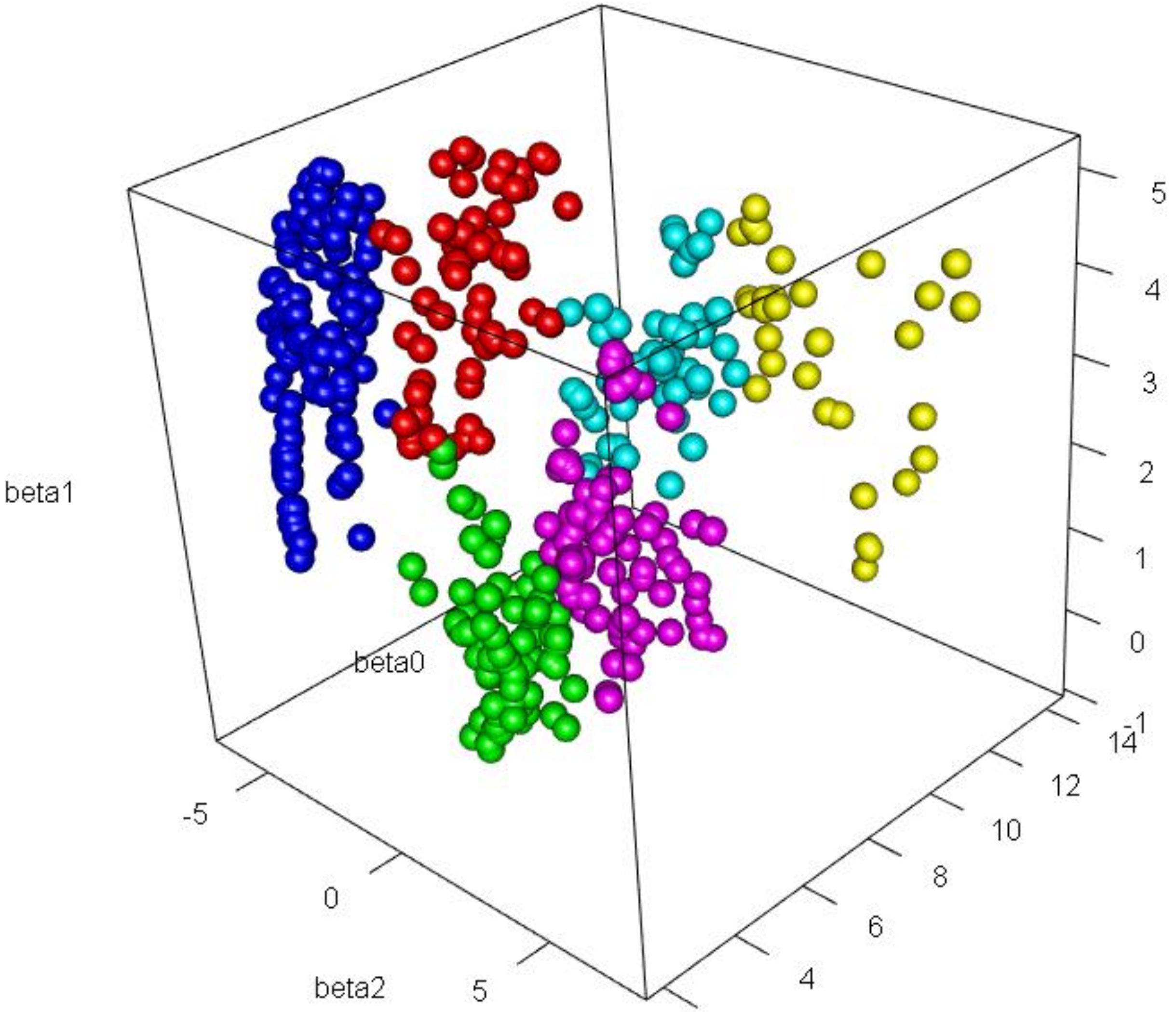
	25%	50%	75%
Beta 0	4.7	6.0	8.4
Beta 1	1.1	2.5	3.6
Beta 2	-3.3	-0.7	0.7



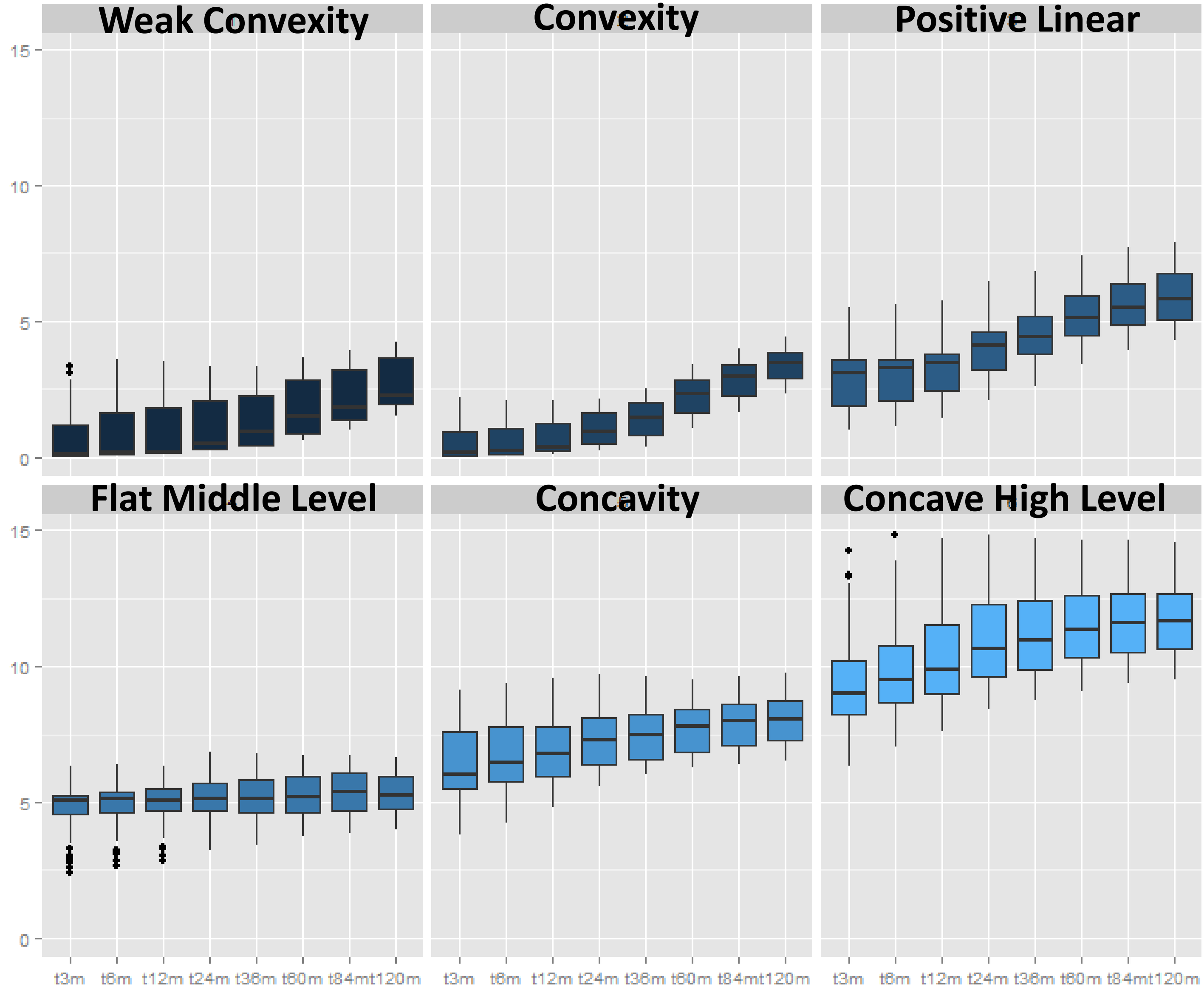
Quantiles on estimated parameters

		beta2				
		<-3.3	-3.3/-0.7	-0.7/0.7	>0.7	Total
	beta1	60	19	19	2	100
beta0<4.7	<1.1		4	14	2	20
	1.1-2.5	18	2	5		25
	2.5-3.6	22	13			35
	>3.6	20				20
		34	34	21	10	99
4.7<beta0<6.0	<1.1		15	18	9	42
	1.1-2.5		5	1	1	7
	2.5-3.6	3	5			8
	>3.6	31	9	2		42
		6	30	30	33	99
6.0<beta0<8.4	<1.1		4	9	7	20
	1.1-2.5		6	18	18	42
	2.5-3.6		8	2	7	17
	>3.6	6	12	1	1	20
			16	29	55	100
8.4<beta0	<1.1			3	15	18
	1.1-2.5		9	6	10	25
	2.5-3.6		3	13	23	39
	>3.6		4	7	7	18
	Total	100	99	99	100	398

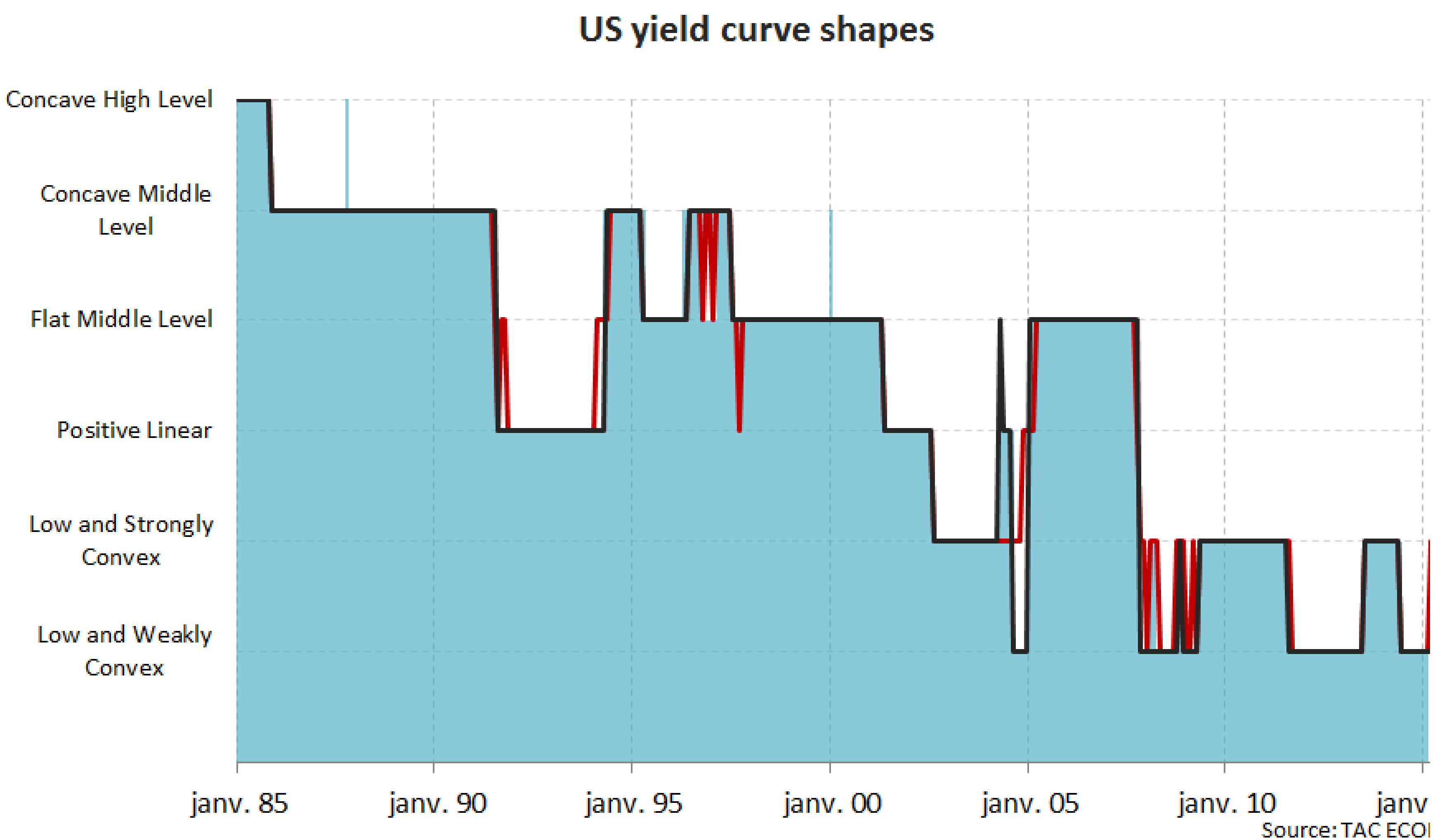
Results from K-means



Identification of archetypal shapes using K-means



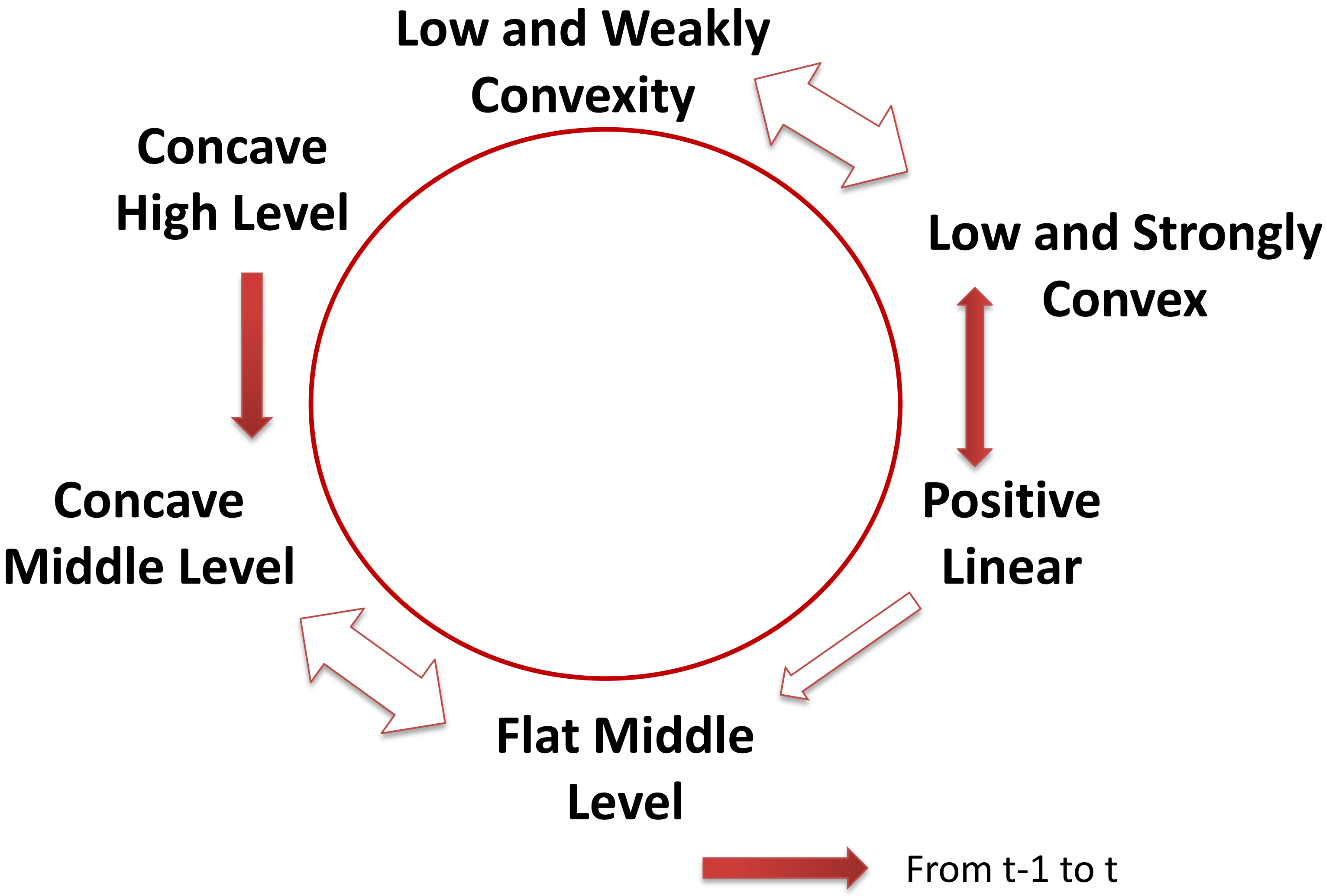
Historical US yield curve shapes



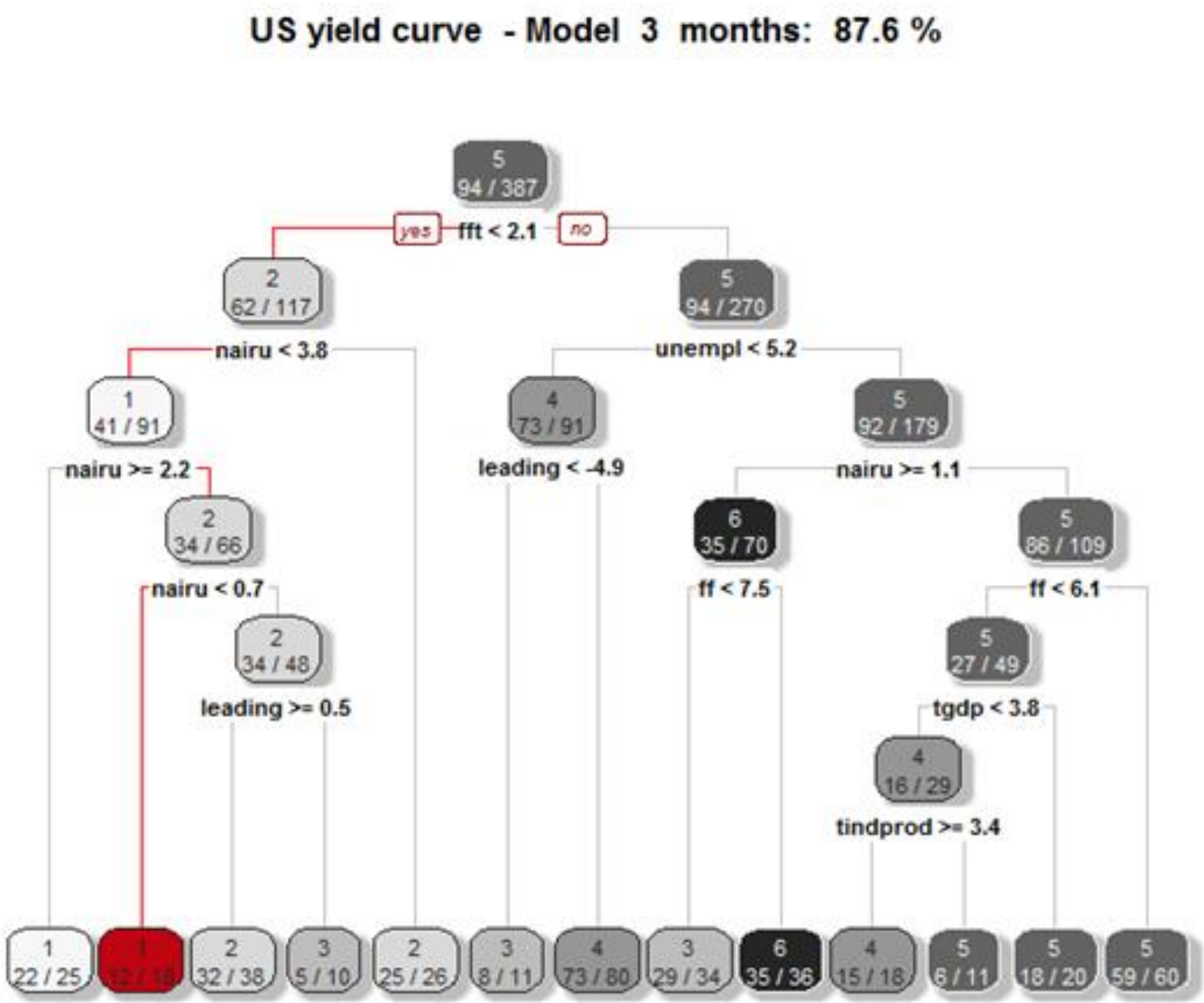
Transition matrix

T-1/T	Low and Weakly convex	Low and strongly convex	Positive Linear	Flat Middle Level	Concave Middle Level	Concave High Level
Low and Weakly Convex	**42**	4	0	1	0	0
Low and strongly convex	4	**59**	1	0	0	0
Positive Linear	1	1	**49**	0	1	0
Flat Middle Level	1	0	1	**87**	4	0
Concave Middle Level	0	0	1	5	**87**	1
Concave High Level	0	0	0	0	2	**45**

Logical sequence in archetypal US yield curve shape

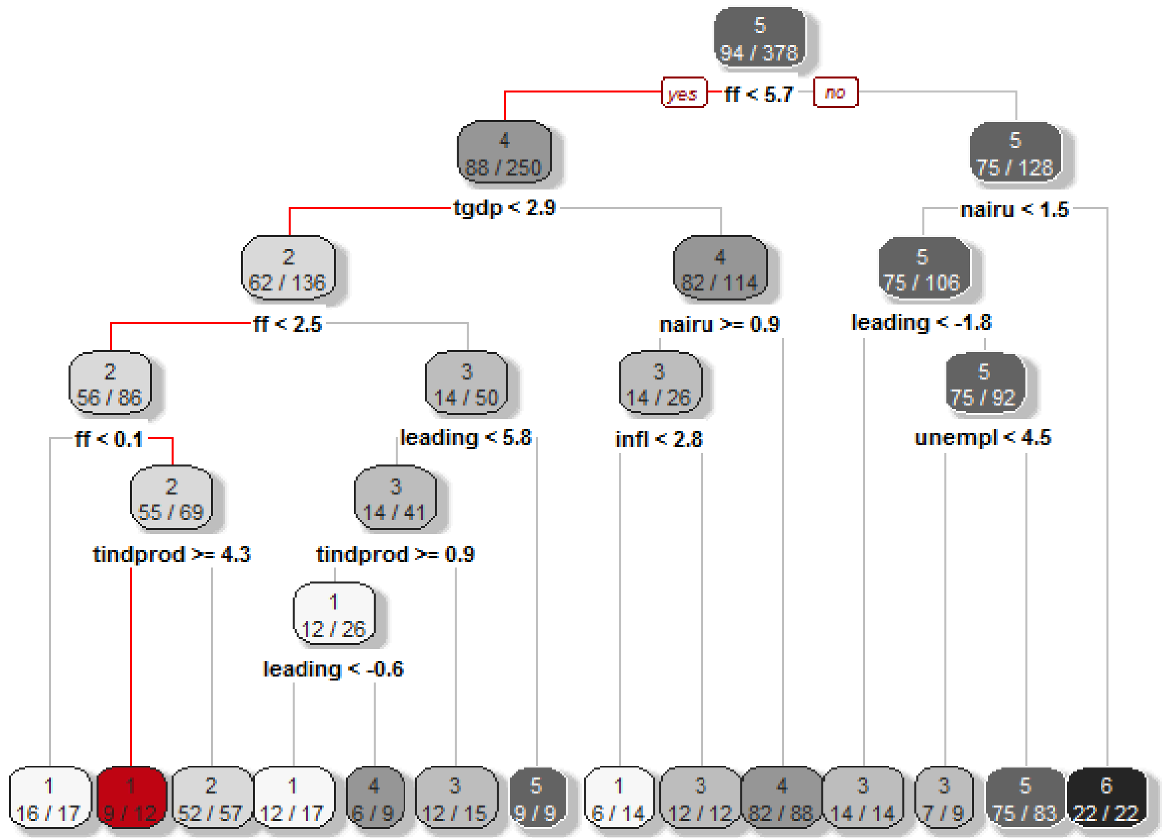


Recursive partitioning – Forecast 3 months

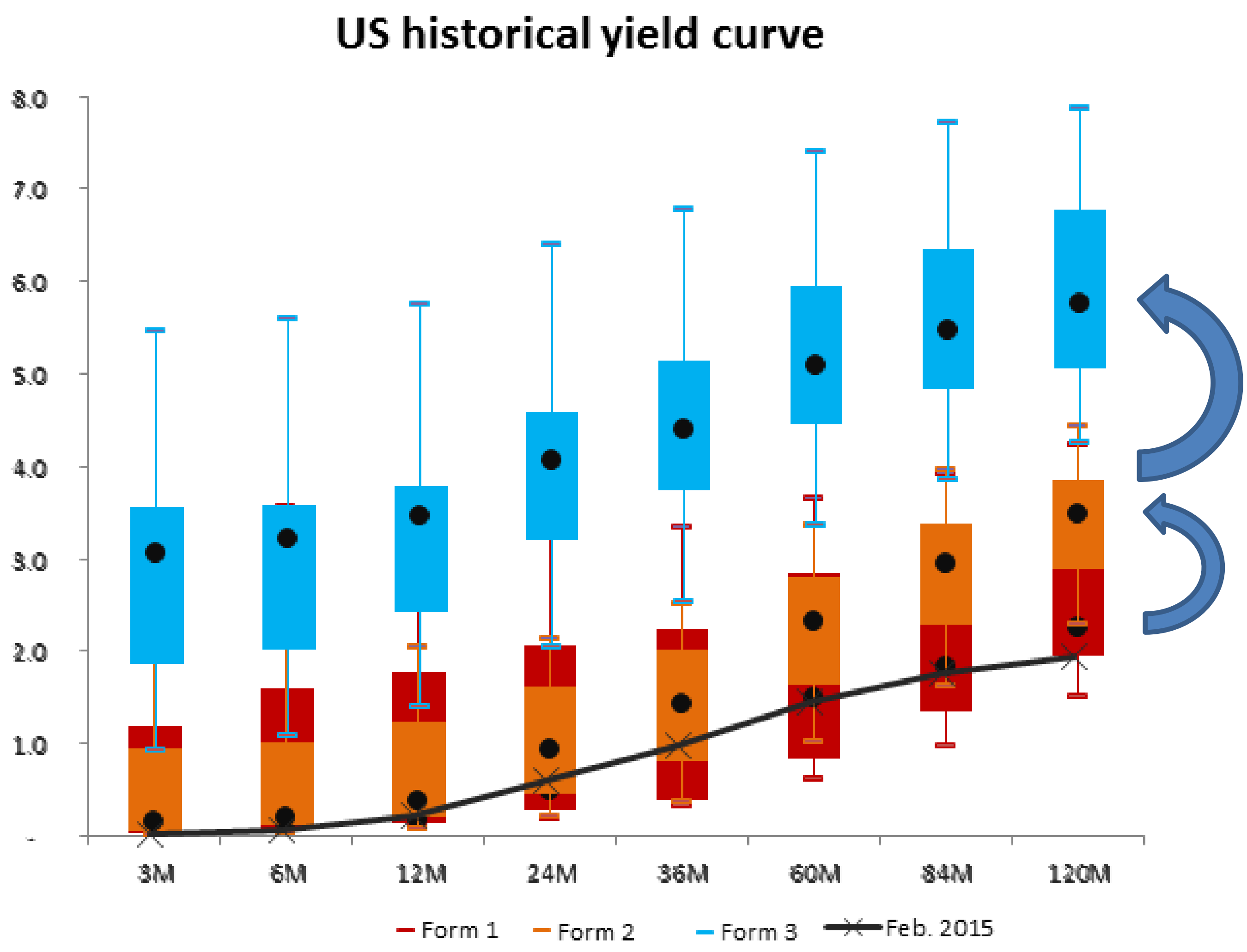


Recursive partitioning – Forecast 12 months

US yield curve - Model 12 months: 88.4 %



Forecasting



Conclusion

- Six archetypal shapes of the US yield curve over the period 1985-2014 characterized by the three parameters of the level the slope and the curvature.
- Identification of a logical sequence among the six forms.
- Strong evidence of the effects of the macroeconomic variables on future movements in the US yield curve
- Explanation of thresholds on macroeconomic data explaining transition from one curve to another.
- At the short-term horizon, expectation of a convexity of the yield curve through an increase of the long-term segment of the yield curve
- At the medium-term horizon, we expect a parallel translation of the yield curve at higher levels for all segment of the yield curve.

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Thank you for your attention!

Contacts

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