Forecasting the Term Structure of Government Bond Yields

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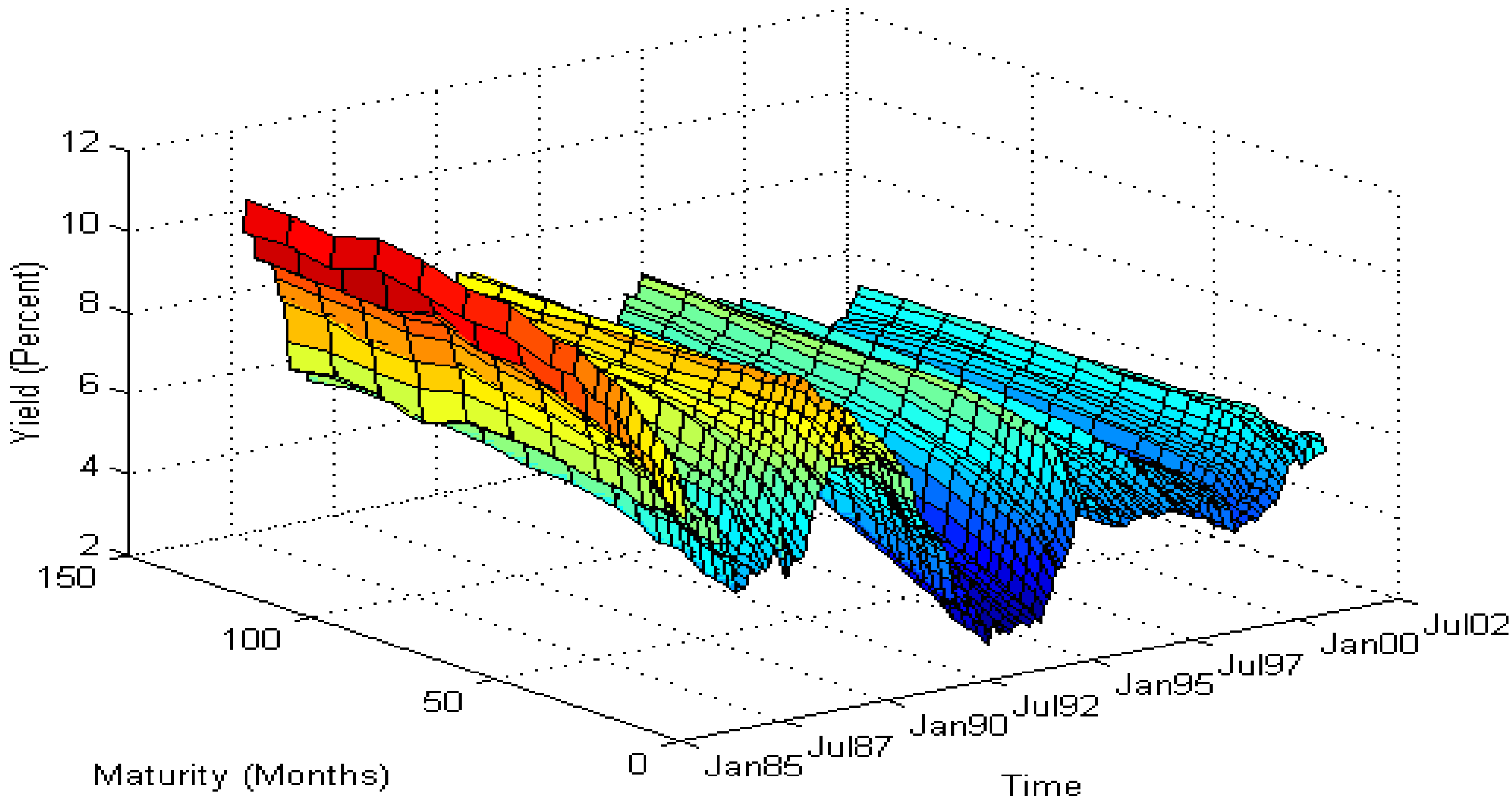
Yield Curves, 1985.01 - 2000.12



Yield Curve Data

Monthly CRSP

Fixed maturities (months):

3, 6, 9, 12, 15, 18, 21, 24,
30, 36, 48, 60, 72, 84, 96, 108, and 120

1985.01 - 2001.12

<u>Advances in Arbitrage-Free Modeling</u>

"Cross sectional flavor" (e.g., HJM, 1992 *Econometrica*)

"Time series flavor" (e.g., Dai and Singleton, 2000 *JF*)

What about forecasting?

We Take a Classic but Ad Hoc Yield Curve Model and:

- show that it has a modern interpretation
- show that it’s flexible
- show that it fits “well”
- show that it forecasts “well”

Definitions and Notation

$$P_t(\tau) \;=\; e^{-\tau\, y_t(\tau)}$$

$$f_t(\tau) \;=\; -P_t'(\tau)\,/\,P_t(\tau)$$

$$y_t(\tau) \;=\; \frac{1}{\tau}\int_0^{\tau} f_t(u)\,du$$

The Nelson-Siegel Yield Curve has a Modern Interpretation

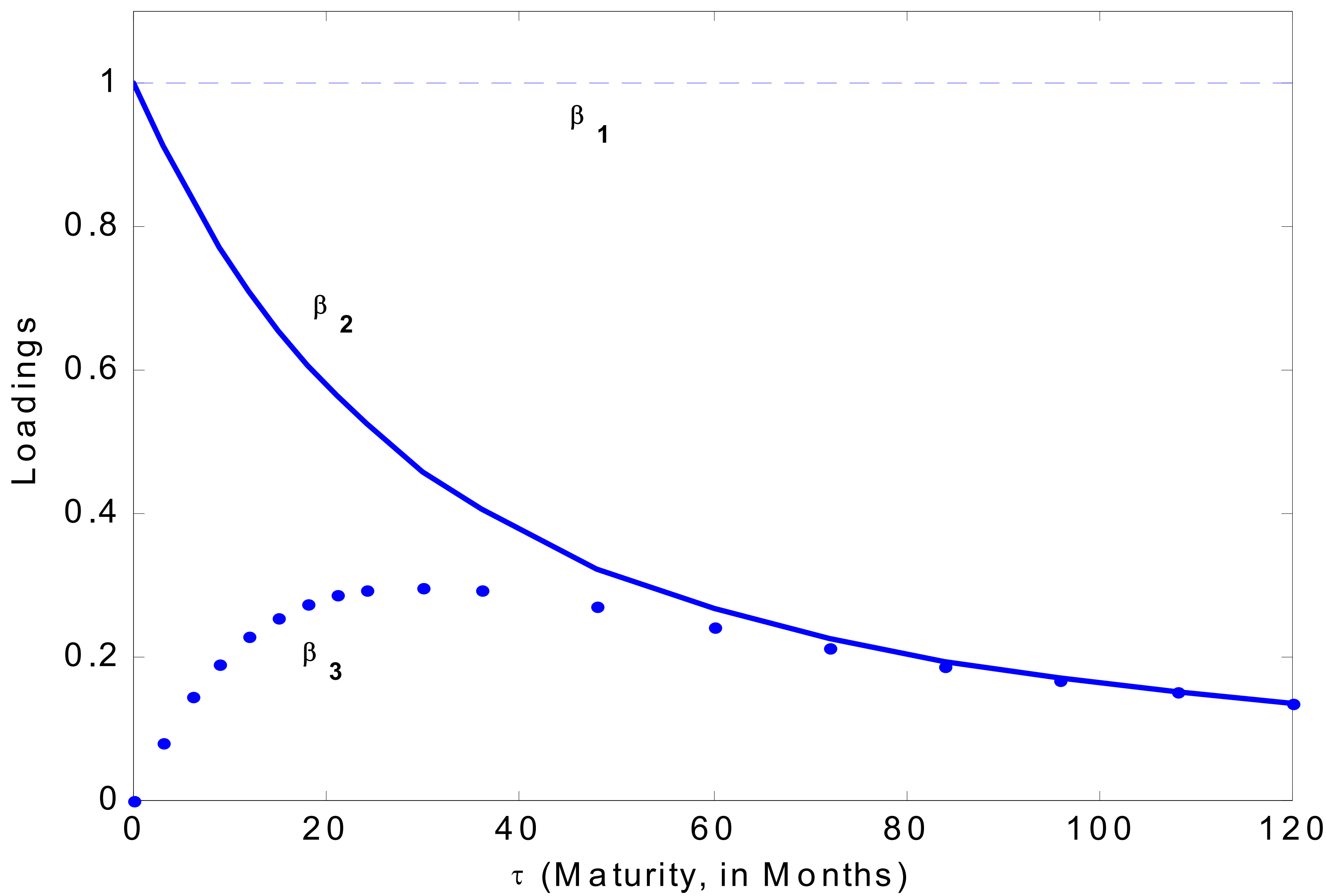
$$f_t(\tau) = \beta_{1t} + \beta_{2t} e^{-\lambda_t \tau} + \beta_{3t} \lambda_t \tau e^{-\lambda_t \tau}$$

Original: $$y_t(\tau) = b_{1t} + b_{2t}\left(\frac{1-e^{-\lambda_t \tau}}{\lambda_t \tau}\right) - b_{3t}\left(e^{-\lambda_t \tau}\right)$$

Ours: $$y_t(\tau) = \beta_{1t} + \beta_{2t}\left(\frac{1-e^{-\lambda_t \tau}}{\lambda_t \tau}\right) + \beta_{3t}\left(\frac{1-e^{-\lambda_t \tau}}{\lambda_t \tau} - e^{-\lambda_t \tau}\right)$$

“level, slope, curvature”

Factor Loadings in the Nelson-Siegel Model



Level

$$y_t(\infty) = \beta_{1t}$$

Empirical measure: $y_t(120)$

Slope

$$y_t(\infty) - y_t(0) = -\beta_{2t}$$

Empirical measure: $y_t(120) - y_t(3)$

Curvature

$$2y_t(mid) - y_t(0) - y_t(\infty)$$

$$2y_t(24) - y_t(0) - y_t(\infty) = 2y_t(24) - 2\beta_1 - \beta_2 \approx .3\beta_{3t}$$

$$2y_t(24) - y_t(3) - y_t(120) = .00053\,\beta_{2t} + .37\,\beta_{3t}$$

The Model is Flexible

Yield curve facts:

(1) Average curve is increasing and concave

(2) Many shapes

(3) Yield dynamics are persistent

(4) Spread dynamics are much less persistent

(5) Short rates are more volatile than long rates

(6) Long rates are more persistent than short rates

The Model Fits Well

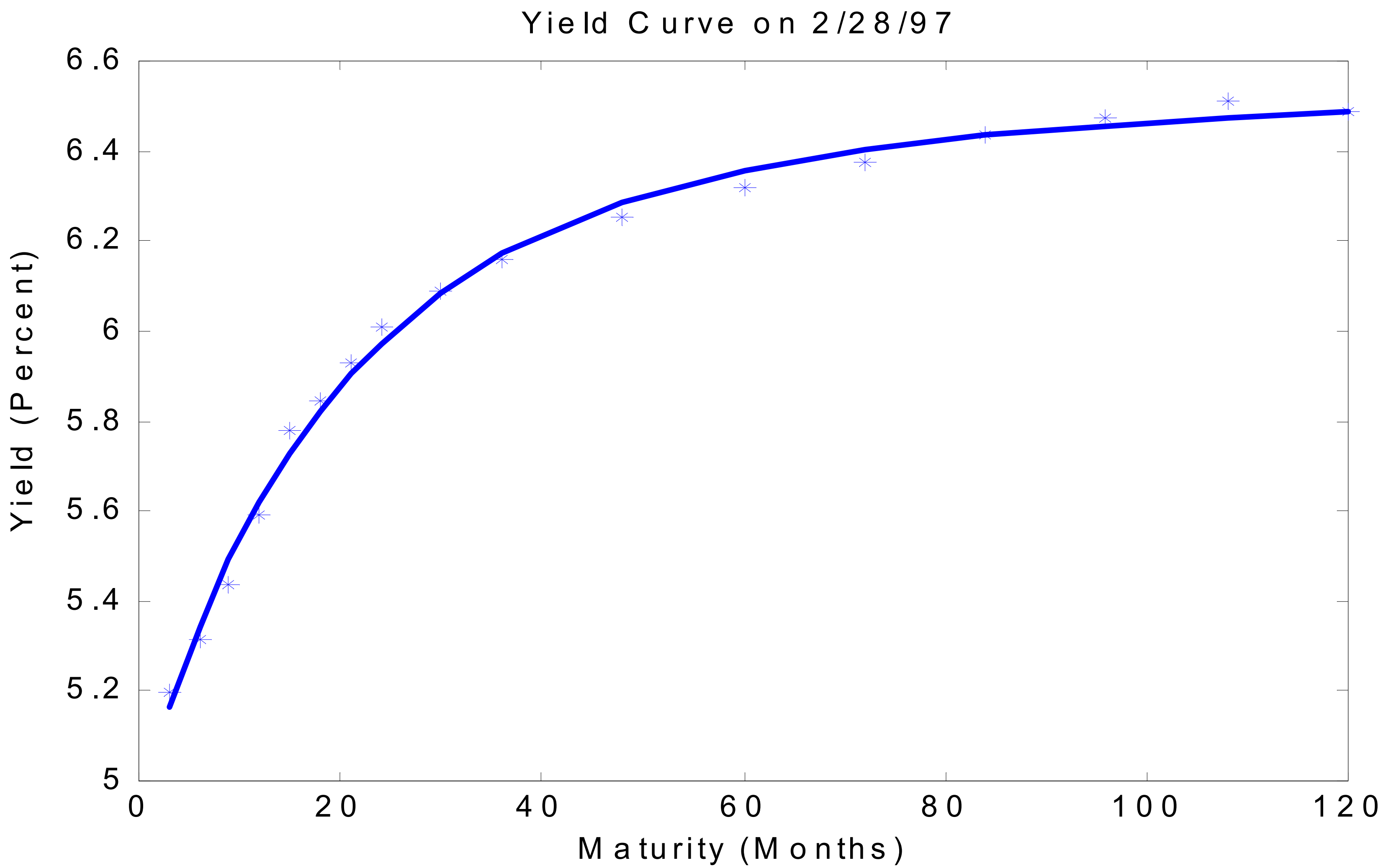
$$y_t(\tau) = \beta_{1t} + \beta_{2t}\left(\frac{1-e^{-\lambda_t\tau}}{\lambda_t\tau}\right) + \beta_{3t}\left(\frac{1-e^{-\lambda_t\tau}}{\lambda_t\tau} - e^{-\lambda_t\tau}\right)$$

$$\eta_t(\tau) \equiv y_t(\tau) - \beta_{1t} + \beta_{2t}\left(\frac{1-e^{-\lambda_t\tau}}{\lambda_t\tau}\right) + \beta_{3t}\left(\frac{1-e^{-\lambda_t\tau}}{\lambda_t\tau} - e^{-\lambda_t\tau}\right)$$

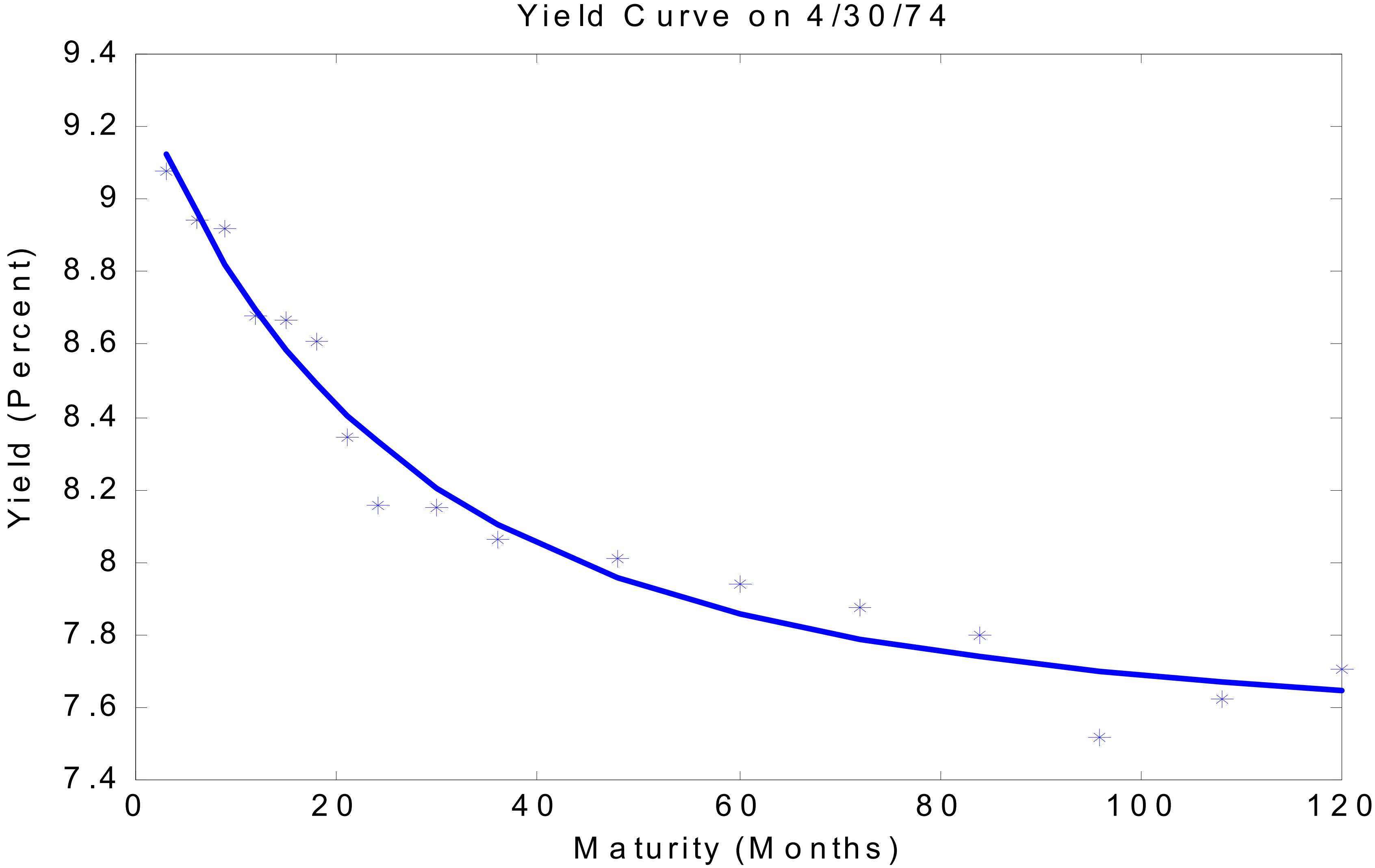
$$\hat{\theta}_t = argmin_{\theta_t} \sum_{\tau=1}^{N} \eta_t(\tau)^2$$

OLS with $\lambda = 0.002$

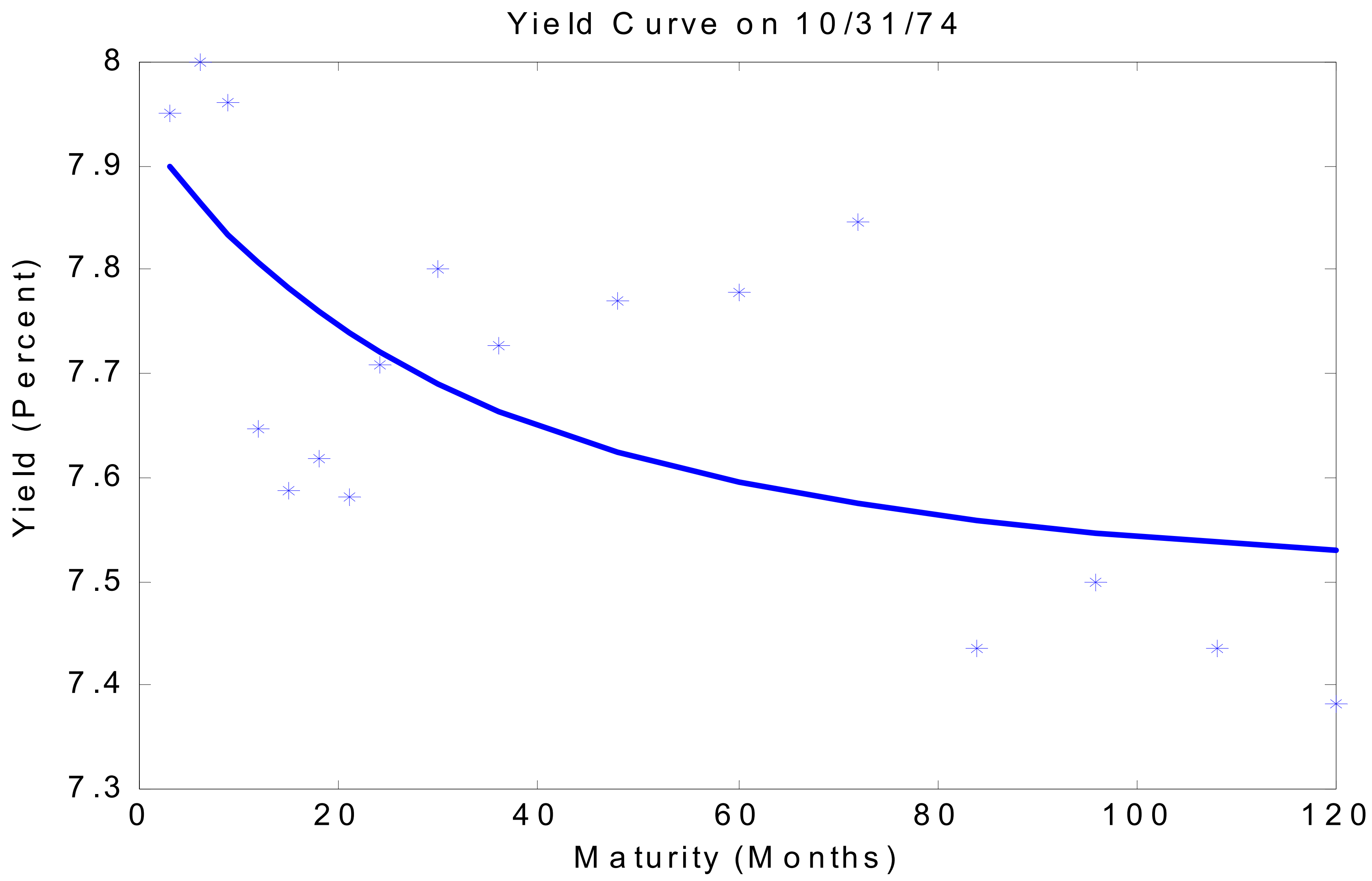
Fitted Yield Curve I

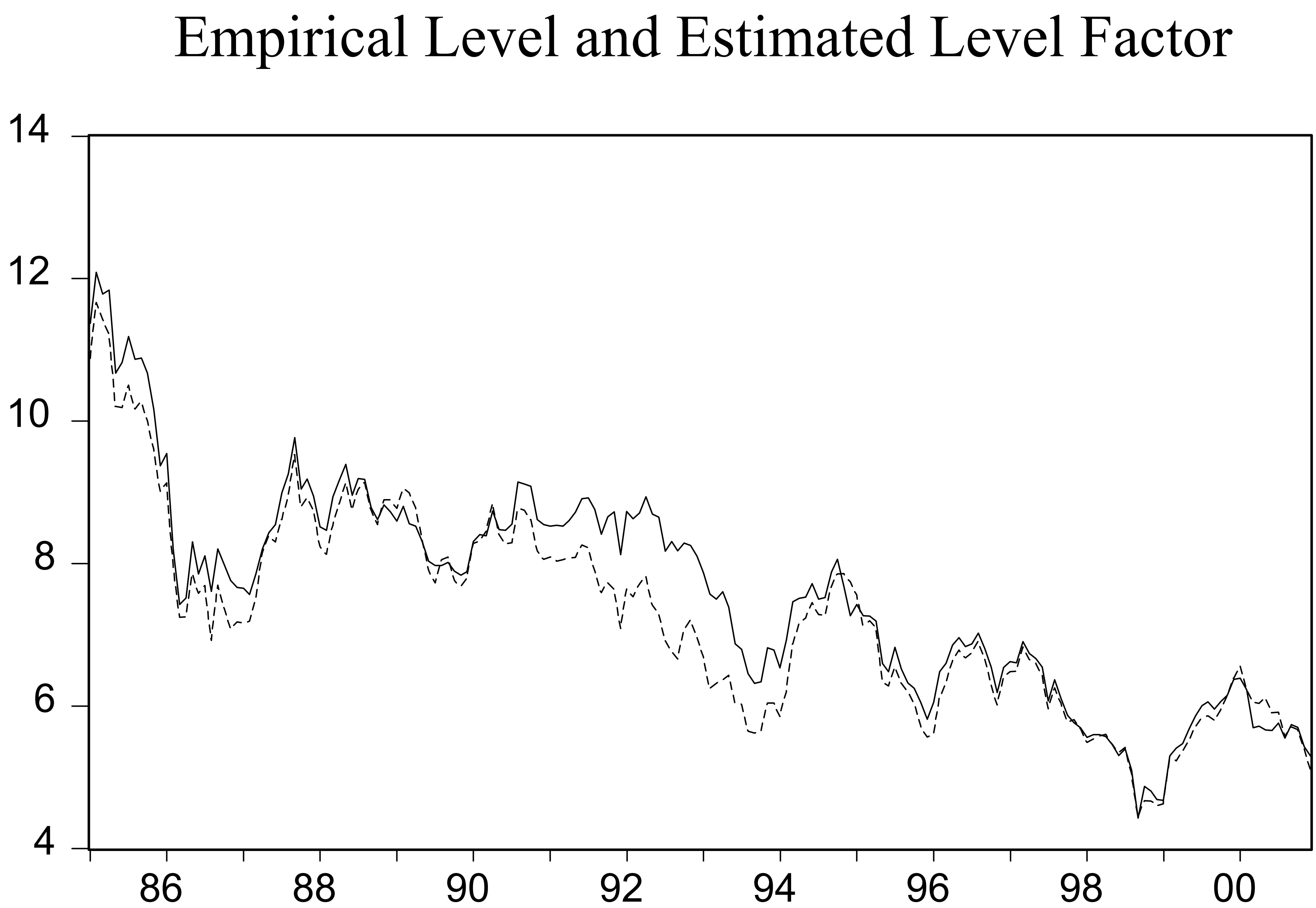


Fitted Yield Curve II

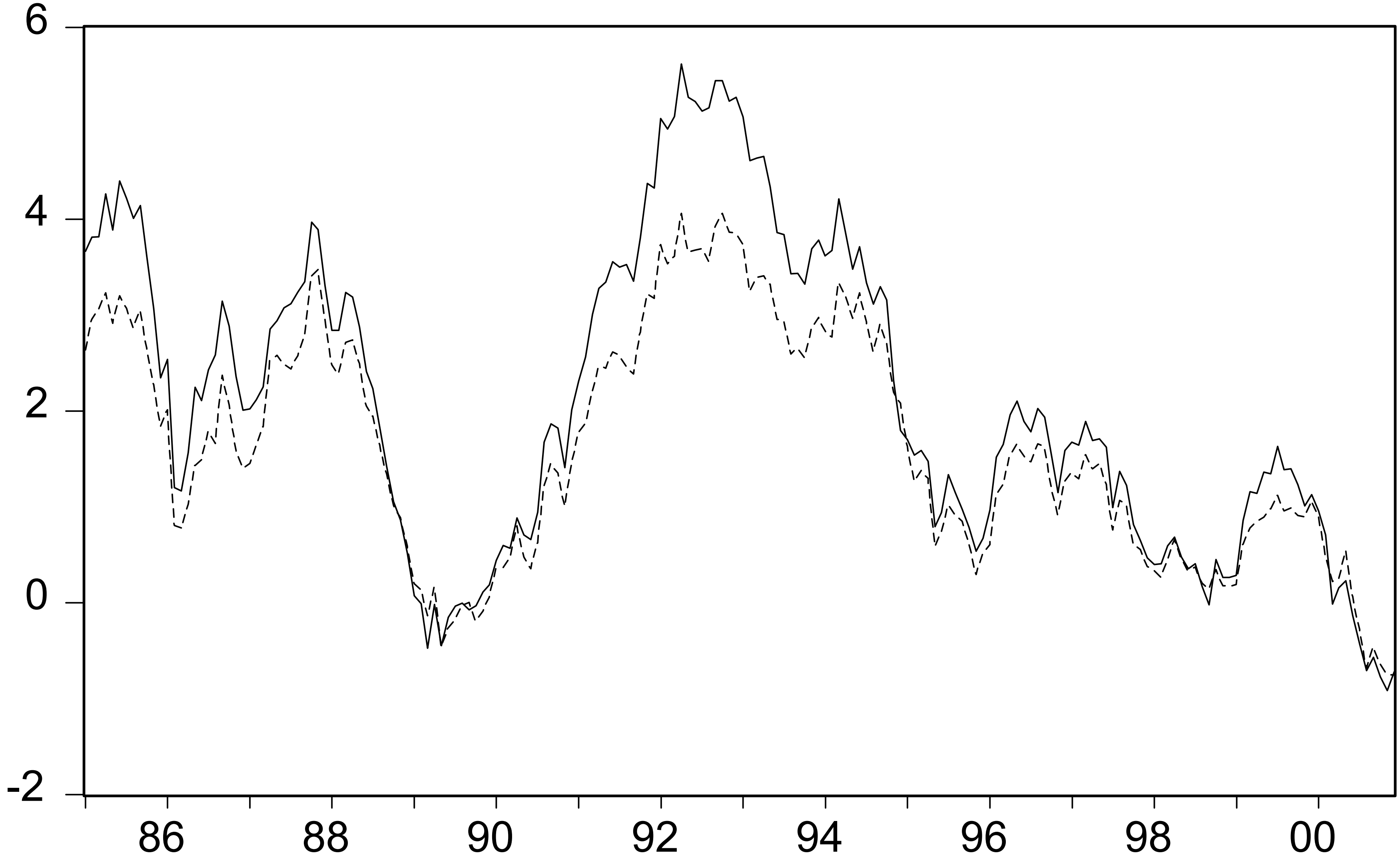


Fitted Yield Curve III

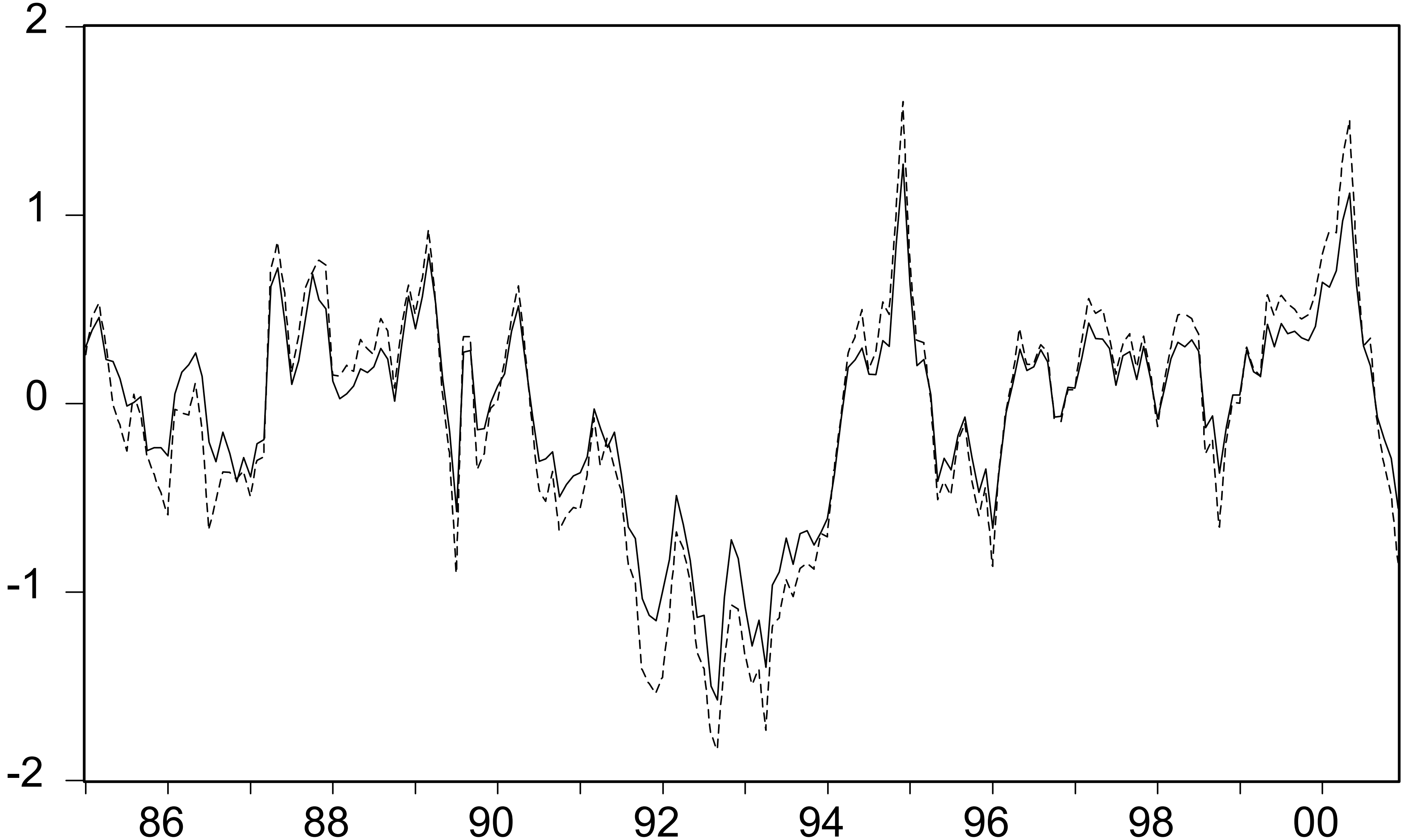



Empirical Level and Estimated Level Factor
14
12
10
8
6
4
86
88
90
92
94
96
98
00

Empirical Slope and Estimated Slope Factor



Empirical Curvature and Estimated Curvature Factor



The Model Forecasts Well: Modeling and Forecasting Level, Slope and Curvature

Estimated level, slope, and curvature factors: $\hat{\beta}_{1t}, \hat{\beta}_{2t}, \hat{\beta}_{3t}$

Nelson-Siegel with AR(1) Factors

$$\hat{y}_{t+h/t}(\tau) = \hat{\beta}_{1,t+h/t} + \hat{\beta}_{2,t+h/t}\left(\frac{1-e^{-\lambda\tau}}{\lambda\tau}\right) + \hat{\beta}_{3,t+h/t}\left(\frac{1-e^{-\lambda\tau}}{\lambda\tau} - e^{-\lambda\tau}\right)$$

$$\hat{\beta}_{i,t+h/t} = \hat{c}_i + \hat{\gamma}_i \hat{\beta}_{it}, \qquad i = 1,\ 2,\ 3$$

Nelson-Siegel with VAR(1) Factors

$$\hat{y}_{t+h/t}(\tau) = \hat{\beta}_{1,t+h/t} + \hat{\beta}_{2,t+h/t}\left(\frac{1-e^{-\lambda\tau}}{\lambda\tau}\right) + \hat{\beta}_{3,t+h/t}\left(\frac{1-e^{-\lambda\tau}}{\lambda\tau}-e^{-\lambda\tau}\right)$$

$$\hat{\beta}_{t+h/t} = \hat{c} + \hat{\Gamma}\,\hat{\beta}_t$$

Random Walk

$$\hat{y}_{t+h/t}(\tau) = y_t(\tau)$$

Slope Regression

$$\hat{y}_{t+h/t}(\tau) - y_t(\tau) = \hat{c}(\tau) + \hat{\gamma}(\tau)\,(y_t(\tau) - y_t(3))$$

Fama-Bliss Forward Regression

$$\hat{y}_{t+h/t}(\tau) - y_t(\tau) = \hat{c}(\tau) + \hat{\gamma}(\tau)\left(f_t^h(\tau) - y_t(\tau)\right)$$

Cochrane-Piazzesi Forward Regression

$$\hat{y}_{t+h/t}(\tau) - y_t(\tau) = \hat{c}(\tau) + \hat{\gamma}_0(\tau)\, y_t(\tau) + \hat{\gamma}_k(\tau) \sum_{k=1}^{9} f_t^{12k}(12)$$

AR(1) on Yield Levels

$$\hat{y}_{t+h/t}(\tau) = \hat{c} + \hat{\gamma} y_t(\tau)$$

VAR(1) on Yield Levels

$$\hat{y}_{t+h/t}(\tau) = \hat{c} + \hat{\Gamma} y_t(\tau)$$

VAR(1) on Yield Changes

$$\hat{z}_{t+h/t} = \hat{c} + \hat{\Gamma} z_t$$

$$z_t \equiv [y_t(3) - y_{t-1}(3),\; y_t(12) - y_{t-1}(12),\; y_t(36) - y_{t-1}(36),\; y_t(60) - y_{t-1}(60),\; y_t(120) - y_{t-1}(120)]'$$

ECM(1) with One Common Trend

$$\hat{z}_{t+h} = \hat{c} + \hat{\Gamma} z_t$$

$$z_t \equiv [y_t(3) - y_{t-1}(3) \;\; y_t(12) - y_t(3) \;\; y_t(36) - y_t(3) \;\; y_t(60) - y_t(3) \;\; y_t(120) - y_t(3)]'$$

ECM(1) with Two Common Trends

$$\hat{z}_{t+h/t} = \hat{c} + \hat{\Gamma} z_t$$

$$z_t \equiv [y_t(3) - y_{t-1}(3) \;\; y_t(12) - y_{t-1}(12) \;\; y_t(36) - y_t(3) \;\; y_t(60) - y_t(3) \;\; y_t(120) - y_t(3)]'$$

ECM(1) with Three Common Trends

$$\hat{z}_{t+h} = \hat{c} + \hat{\Gamma} z_t$$

$$z_t \equiv [y_t(3) - y_{t-1}(3) \;\; y_t(12) - y_{t-1}(12) \;\; y_t(36) - y_{t-1}(36) \;\; y_t(60) - y_t(3) \;\; y_t(120) - y_t(3)]'$$

1-Month-Ahead Forecast Error Analysis, 1990.01 - 2000.12

Nelson-Siegel with AR(1) Factor Dynamics

Maturity (τ)	Mean	Std. Dev.	RMSE	$\hat{\rho}(1)$	$\hat{\rho}(12)$
3 months	-0.045	0.170	0.176	0.247	0.017
1 year	0.023	0.235	0.236	0.425	-0.213
3 years	-0.056	0.273	0.279	0.332	-0.117
5 years	-0.091	0.277	0.292	0.333	-0.116
10 years	-0.062	0.252	0.260	0.259	-0.115

Random Walk

Maturity (τ)	Mean	Std. Dev.	RMSE	$\hat{\rho}(1)$	$\hat{\rho}(12)$
3 months	0.033	0.176	0.179	0.220	0.053
1 year	0.021	0.240	0.241	0.340	-0.153
3 years	0.007	0.279	0.279	0.341	-0.133
5 years	-0.003	0.276	0.276	0.275	-0.131
10 years	-0.011	0.254	0.254	0.215	-0.145

6-Month-Ahead Forecast Error Analysis, 1990.01 - 2000.12

Nelson-Siegel with AR(1) Factor Dynamics

Maturity (τ)	Mean	Std. Dev.	RMSE	$\hat{\rho}(6)$	$\hat{\rho}(18)$
3 months	0.083	0.510	0.517	0.301	-0.190
1 year	0.131	0.656	0.669	0.168	-0.174
3 years	-0.052	0.748	0.750	0.049	-0.189
5 years	-0.173	0.758	0.777	0.069	-0.273
10 years	-0.251	0.676	0.721	0.058	-0.288

Random Walk

Maturity (τ)	Mean	Std. Dev.	RMSE	$\hat{\rho}(6)$	$\hat{\rho}(18)$
3 months	0.220	0.564	0.605	0.381	-0.214
1 year	0.181	0.758	0.779	0.139	-0.150
3 years	0.099	0.873	0.879	0.018	-0.211
5 years	0.048	0.860	0.861	0.008	-0.249
10 years	-0.020	0.758	0.758	0.019	-0.271

1-Year-Ahead Forecast Error Analysis, 1990.01 - 2000.12

Nelson-Siegel with AR(1) Factor Dynamics

Maturity (τ)	Mean	Std. Dev.	RMSE	$\hat{\rho}(12)$	$\hat{\rho}(24)$
3 months	0.150	0.724	0.739	-0.288	0.001
1 year	0.173	0.823	0.841	-0.332	-0.004
3 years	-0.123	0.910	0.918	-0.408	0.015
5 years	-0.337	0.918	0.978	-0.412	0.003
10 years	-0.531	0.825	0.981	-0.433	-0.003

Random Walk

Maturity (τ)	Mean	Std. Dev.	RMSE	$\hat{\rho}(12)$	$\hat{\rho}(24)$
3 months	0.416	0.930	1.019	-0.118	-0.109
1 year	0.388	1.132	1.197	-0.268	-0.019
3 years	0.236	1.214	1.237	-0.419	0.060
5 years	0.130	1.184	1.191	-0.481	0.072
10 years	-0.033	1.051	1.052	-0.508	0.069

1-Year-Ahead Forecast Error Analysis, 1990.01 - 2000.12

Nelson-Siegel with AR(1) Factor Dynamics

Maturity (τ)	Mean	Std. Dev.	RMSE	$\hat{\rho}(12)$	$\hat{\rho}(24)$
3 months	0.150	0.724	0.739	-0.288	0.001
1 year	0.173	0.823	0.841	-0.332	-0.004
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10 years	-0.531	0.825	0.981	-0.433	-0.003

Nelson-Siegel with VAR(1) Factor Dynamics

Maturity (τ)	Mean	Std. Dev.	RMSE	$\hat{\rho}(12)$	$\hat{\rho}(24)$
3 months	-0.463	1.000	1.102	-0.163	-0.111
1 year	-0.416	1.224	1.293	-0.265	-0.065
3 years	-0.576	1.268	1.393	-0.317	-0.036
5 years	-0.673	1.210	1.385	-0.315	-0.039
10 years	-0.721	1.056	1.279	-0.299	-0.037

1-Year-Ahead Forecast Error Analysis, 1990.01 - 2000.12

Nelson-Siegel with AR(1) Factor Dynamics

Maturity (τ)	Mean	Std. Dev.	RMSE	$\hat{\rho}(12)$	$\hat{\rho}(24)$
3 months	0.150	0.724	0.739	-0.288	0.001
1 year	0.173	0.823	0.841	-0.332	-0.004
3 years	-0.123	0.910	0.918	-0.408	0.015
5 years	-0.337	0.918	0.978	-0.412	0.003
10 years	-0.531	0.825	0.981	-0.433	-0.003

Slope Regression

Maturity (τ)	Mean	Std. Dev.	RMSE	$\hat{\rho}(12)$	$\hat{\rho}(24)$
3 months	NA	NA	NA	NA	NA
1 year	0.896	1.235	1.526	-0.187	-0.024
3 years	0.641	1.316	1.464	-0.212	0.024
5 years	0.515	1.305	1.403	-0.255	0.035
10 years	0.362	1.208	1.261	-0.268	0.042

1-Year-Ahead Forecast Error Analysis, 1990.01 - 2000.12

Nelson-Siegel with AR(1) Factor Dynamics

Maturity (τ)	Mean	Std. Dev.	RMSE	$\hat{\rho}(12)$	$\hat{\rho}(24)$
3 months	0.150	0.724	0.739	-0.288	0.001
1 year	0.173	0.823	0.841	-0.332	-0.004
3 years	-0.123	0.910	0.918	-0.408	0.015
5 years	-0.337	0.918	0.978	-0.412	0.003
10 years	-0.531	0.825	0.981	-0.433	-0.003

Fama-Bliss Forward Regression

Maturity (τ)	Mean	Std. Dev.	RMSE	$\hat{\rho}(12)$	$\hat{\rho}(24)$
3 months	0.942	1.010	1.381	-0.046	-0.096
1 year	0.875	1.276	1.547	-0.142	-0.039
3 years	0.746	1.378	1.567	-0.291	0.035
5 years	0.587	1.363	1.484	-0.352	0.040
10 years	0.547	1.198	1.317	-0.403	0.062

1-Year-Ahead Forecast Error Analysis, 1990.01 - 2000.12

Nelson-Siegel with AR(1) Factor Dynamics

Maturity (τ)	Mean	Std. Dev.	RMSE	$\hat{\rho}(12)$	$\hat{\rho}(24)$
3 months	0.150	0.724	0.739	-0.288	0.001
1 year	0.173	0.823	0.841	-0.332	-0.004
3 years	-0.123	0.910	0.918	-0.408	0.015
5 years	-0.337	0.918	0.978	-0.412	0.003
10 years	-0.531	0.825	0.981	-0.433	-0.003

Cochrane-Piazzesi Forward Regression

Maturity (τ)	Mean	Std. Dev.	RMSE	$\hat{\rho}(12)$	$\hat{\rho}(24)$
3 months	NA	NA	NA	NA	NA
1 year	-0.162	1.275	1.285	-0.179	-0.079
3 years	-0.377	1.275	1.330	-0.274	-0.028
5 years	-0.529	1.225	1.334	-0.301	-0.021
10 years	-0.760	1.088	1.327	-0.307	-0.020

1-Year-Ahead Forecast Error Analysis, 1990.01 - 2000.12

Nelson-Siegel with AR(1) Factor Dynamics

Maturity (τ)	Mean	Std. Dev.	RMSE	$\hat{\rho}(12)$	$\hat{\rho}(24)$
3 months	0.150	0.724	0.739	-0.288	0.001
1 year	0.173	0.823	0.841	-0.332	-0.004
3 years	-0.123	0.910	0.918	-0.408	0.015
5 years	-0.337	0.918	0.978	-0.412	0.003
10 years	-0.531	0.825	0.981	-0.433	-0.003

Univariate AR(1)s on Yield Levels

Maturity (τ)	Mean	Std. Dev.	RMSE	$\hat{\rho}(12)$	$\hat{\rho}(24)$
3 months	0.246	0.808	0.845	-0.213	-0.073
1 year	0.182	0.953	0.970	-0.271	-0.004
3 years	-0.113	0.996	1.002	-0.380	0.061
5 years	-0.301	0.961	1.007	-0.433	0.058
10 years	-0.603	0.835	1.030	-0.431	0.020

1-Year-Ahead Forecast Error Analysis, 1990.01 - 2000.12

Nelson-Siegel with AR(1) Factor Dynamics

Maturity (τ)	Mean	Std. Dev.	RMSE	$\hat{\rho}(12)$	$\hat{\rho}(24)$
3 months	0.150	0.724	0.739	-0.288	0.001
1 year	0.173	0.823	0.841	-0.332	-0.004
3 years	-0.123	0.910	0.918	-0.408	0.015
5 years	-0.337	0.918	0.978	-0.412	0.003
10 years	-0.531	0.825	0.981	-0.433	-0.003

VAR(1) on Yield Levels

Maturity (τ)	Mean	Std. Dev.	RMSE	$\hat{\rho}(12)$	$\hat{\rho}(24)$
3 months	-0.276	1.006	1.043	-0.219	-0.099
1 year	-0.390	1.204	1.266	-0.322	-0.058
3 years	-0.467	1.240	1.325	-0.345	-0.015
5 years	-0.540	1.201	1.317	-0.348	-0.012
10 years	-0.744	1.060	1.295	-0.328	-0.010

1-Year-Ahead Forecast Error Analysis, 1990.01 - 2000.12

Nelson-Siegel with AR(1) Factor Dynamics

Maturity (τ)	Mean	Std. Dev.	RMSE	$\hat{\rho}(12)$	$\hat{\rho}(24)$
3 months	0.150	0.724	0.739	-0.288	0.001
1 year	0.173	0.823	0.841	-0.332	-0.004
3 years	-0.123	0.910	0.918	-0.408	0.015
5 years	-0.337	0.918	0.978	-0.412	0.003
10 years	-0.531	0.825	0.981	-0.433	-0.003

VAR(1) on Yield Changes

Maturity (τ)	Mean	Std. Dev.	RMSE	$\hat{\rho}(12)$	$\hat{\rho}(24)$
3 months	0.717	1.072	1.290	-0.068	-0.127
1 year	0.704	1.240	1.426	-0.223	-0.041
3 years	0.627	1.341	1.480	-0.399	0.051
5 years	0.559	1.281	1.398	-0.459	0.070
10 years	0.408	1.136	1.207	-0.491	0.072

1-Year-Ahead Forecast Error Analysis, 1990.01 - 2000.12

Nelson-Siegel with AR(1) Factor Dynamics

Maturity (τ)	Mean	Std. Dev.	RMSE	$\hat{\rho}(12)$	$\hat{\rho}(24)$
3 months	0.150	0.724	0.739	-0.288	0.001
1 year	0.173	0.823	0.841	-0.332	-0.004
3 years	-0.123	0.910	0.918	-0.408	0.015
5 years	-0.337	0.918	0.978	-0.412	0.003
10 years	-0.531	0.825	0.981	-0.433	-0.003

ECM(1) with one Common Trend

Maturity (τ)	Mean	Std. Dev.	RMSE	$\hat{\rho}(12)$	$\hat{\rho}(24)$
3 months	0.738	0.982	1.228	-0.163	-0.123
1 year	0.767	1.143	1.376	-0.239	-0.072
3 years	0.546	1.203	1.321	-0.278	-0.013
5 years	0.379	1.191	1.250	-0.278	-0.003
10 years	0.169	1.095	1.108	-0.224	0.009

1-Year-Ahead Forecast Error Analysis, 1990.01 - 2000.12

Nelson-Siegel with AR(1) Factor Dynamics

Maturity (τ)	Mean	Std. Dev.	RMSE	$\hat{\rho}(12)$	$\hat{\rho}(24)$
3 months	0.150	0.724	0.739	-0.288	0.001
1 year	0.173	0.823	0.841	-0.332	-0.004
3 years	-0.123	0.910	0.918	-0.408	0.015
5 years	-0.337	0.918	0.978	-0.412	0.003
10 years	-0.531	0.825	0.981	-0.433	-0.003

ECM(1) with Two Common Trends

Maturity (τ)	Mean	Std. Dev.	RMSE	$\hat{\rho}(12)$	$\hat{\rho}(24)$
3 months	0.778	1.037	1.296	-0.175	-0.129
1 year	0.868	1.247	1.519	-0.286	-0.033
3 years	0.586	1.186	1.323	-0.288	-0.034
5 years	0.425	1.155	1.231	-0.304	-0.014
10 years	0.220	1.035	1.058	-0.274	0.015

1-Year-Ahead Forecast Error Analysis, 1990.01 - 2000.12

Nelson-Siegel with AR(1) Factor Dynamics

Maturity (τ)	Mean	Std. Dev.	RMSE	$\hat{\rho}(12)$	$\hat{\rho}(24)$
3 months	0.150	0.724	0.739	-0.288	0.001
1 year	0.173	0.823	0.841	-0.332	-0.004
3 years	-0.123	0.910	0.918	-0.408	0.015
5 years	-0.337	0.918	0.978	-0.412	0.003
10 years	-0.531	0.825	0.981	-0.433	-0.003

ECM(3) with Three Common Trends

Maturity (τ)	Mean	Std. Dev.	RMSE	$\hat{\rho}(12)$	$\hat{\rho}(24)$
3 months	0.810	0.951	1.249	-0.245	-0.082
1 year	0.786	1.261	1.486	-0.248	-0.064
3 years	0.613	1.453	1.577	-0.289	0.028
5 years	0.306	1.236	1.273	-0.246	-0.069
10 years	0.063	1.141	1.143	-0.191	-0.086

Forecast Accuracy Comparisons

Maturity (τ)	1-Month Horizon		6-Month Horizon		12-Month Horizon	
	against RW	against FB	against RW	against FB	against RW	against FB
3 months	-0.27	0.18	-1.30	-2.53*	-1.65*	-2.43*
1 year	-0.64	-0.56	-1.70*	-2.08*	-2.04*	-2.31*
3 years	-0.02	-0.58	-1.91*	-2.02*	-2.11*	-2.18*
5 years	0.97	0.57	-1.22	-1.56	-1.61	-1.90*
10 years	0.49	0.34	-0.62	-0.95	-0.63	-1.35

Summary

- New interpretation of Nelson-Siegel
- Long-horizon forecasting success

Extensions

- Consistency with standard interest rate processes
- Generalized duration
- State-space representation
- The great forecastability increase post-1985

Consistency with Standard Interest Rate Processes

Nelson-Siegel:

$$f_t(\tau) = \beta_{1t} + \beta_{2t} e^{-\lambda\tau} + \beta_{3t} \lambda\tau e^{-\lambda\tau}$$

Björk-Christensen (1999):

$$f_t(\tau) = \beta_{1t} + \beta_{2t}\tau + \beta_{3t} e^{-\lambda\tau} + \beta_{4t}\tau e^{-\lambda\tau} + \beta_{5t} e^{-2\lambda\tau}$$

- Consistent with Ho-Lee (1986 *JF*) and Hull-White (1990, *RFS*) short rate dynamics

Generalized Duration

Discount bond:

$$-\frac{dP_t(\tau)}{P_t(\tau)} = \tau\, d\beta_{1t} + \left(\frac{1-e^{-\lambda\tau}}{\lambda}\right) d\beta_{2t} + \left(\frac{1-e^{-\lambda\tau}}{\lambda} - \tau e^{-\lambda\tau}\right) d\beta_{3t}$$

Coupon bond:

$$-\frac{dP_{ct}}{P_{ct}} = \sum_{i=1}^{n}\left(w_i x_i \tau_i\right) d\beta_{1t} + \sum_{i=1}^{n}\left(w_i x_i \frac{1-e^{-\lambda\tau_i}}{\lambda}\right) d\beta_{2t} + \sum_{i=1}^{n}\left(w_i x_i \frac{1-e^{-\lambda\tau_i}}{\lambda} - w_i x_i \tau_i e^{-\lambda\tau_i}\right) d\beta_{3t}$$

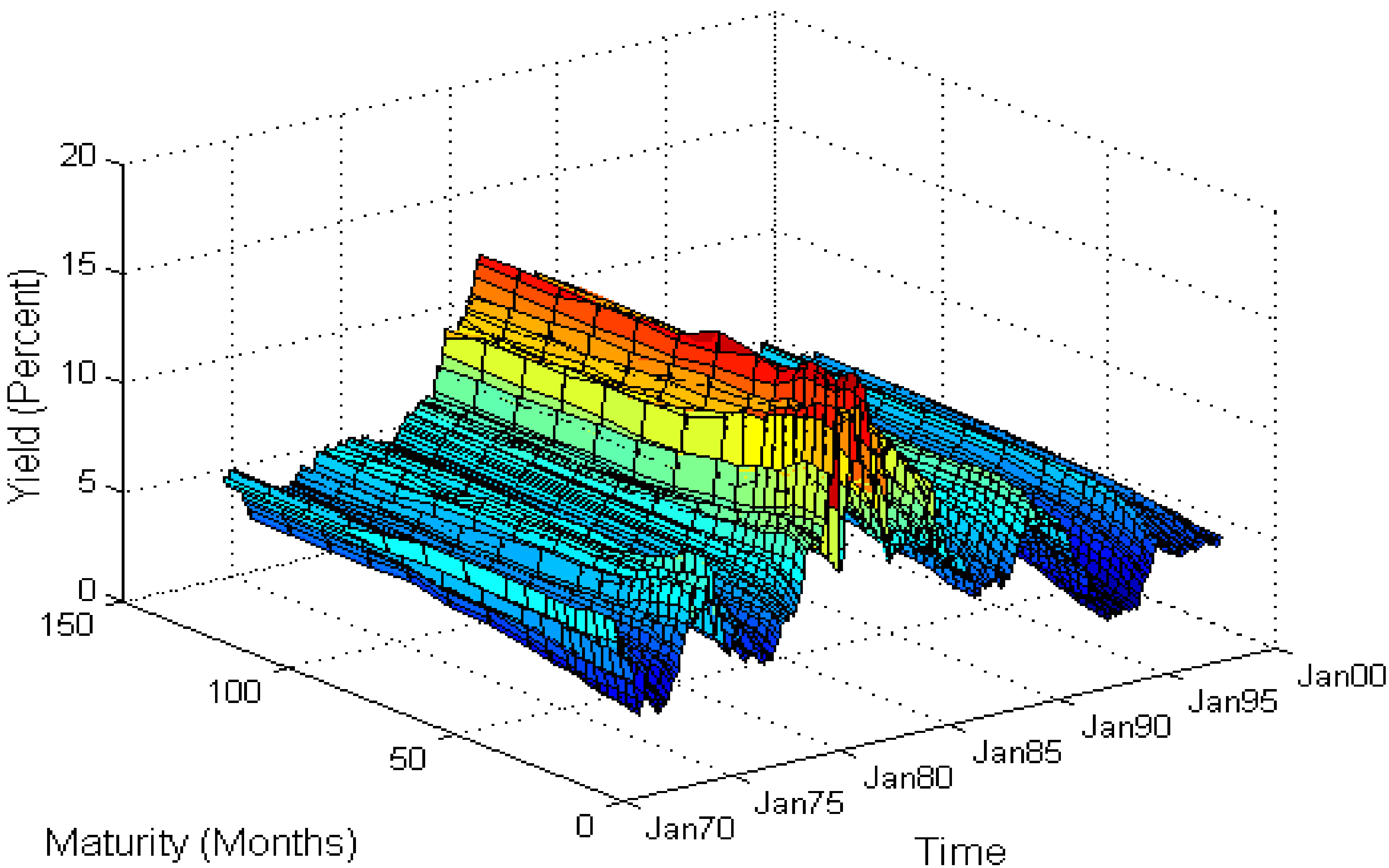
State-Space Representation

$$y_t(\tau) = Z_t \beta_t + \varepsilon_t$$

$$\beta_t = c + A_t \beta_{t-1} + R_t \eta_t$$

- One-step exact maximum-likelihood estimation
- Optimal extraction of latent factors
- Macro and liquidity variables
- Optimal point and interval forecasts
- Incorporation of conditional heteroskedasticity

Yield Curves, 1970.01 - 1997.12



The "Great Forecastability Increase" of 1985: Yield Curve Model Residuals, 1970.01 - 1997.12