Recent Advances in Fixed Income Securities Modeling Techniques

Day 3: No Arbitrage Term Structure Models and the Macro Economy

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Bank of Italy: June 2007

Introduction

- The previous lectures discussed some empirical regularities about bond returns, and the models that are able to explain them.
- What does determine these empirical regularities to start with? Can we link the dynamics of interest rates and expected returns to the macro-economy and monetary policy?
- Recent research has focused exactly on these issues. Today, we cover the following topics
  1. Monetary policy and bond prices (Piazzesi (2005))
  2. Macro-economic factors and bond yields (Ang and Piazzesi (2003), Monch (2007))

Piazzesi (2005)

- Piazzesi (2005) introduces explicitly the meetings of the Federal Reserve in the model
- Realizes Fed Fund since 1994 essentially follows a specific "Jump" process, with few characteristics which we want to take into account in our models of the term structure

  1. Jumps are occurring a predefined times (the calendar of Federal Open Market Committee)
  2. The size of the jumps is restricted to 25bs
  3. The direction of the changes in Fed Fund depend on macro-economic conditions
     – The Fed changes the Fed Fund target to affect expected inflation and expected real economic growth

Fed Fund and Interest Rates

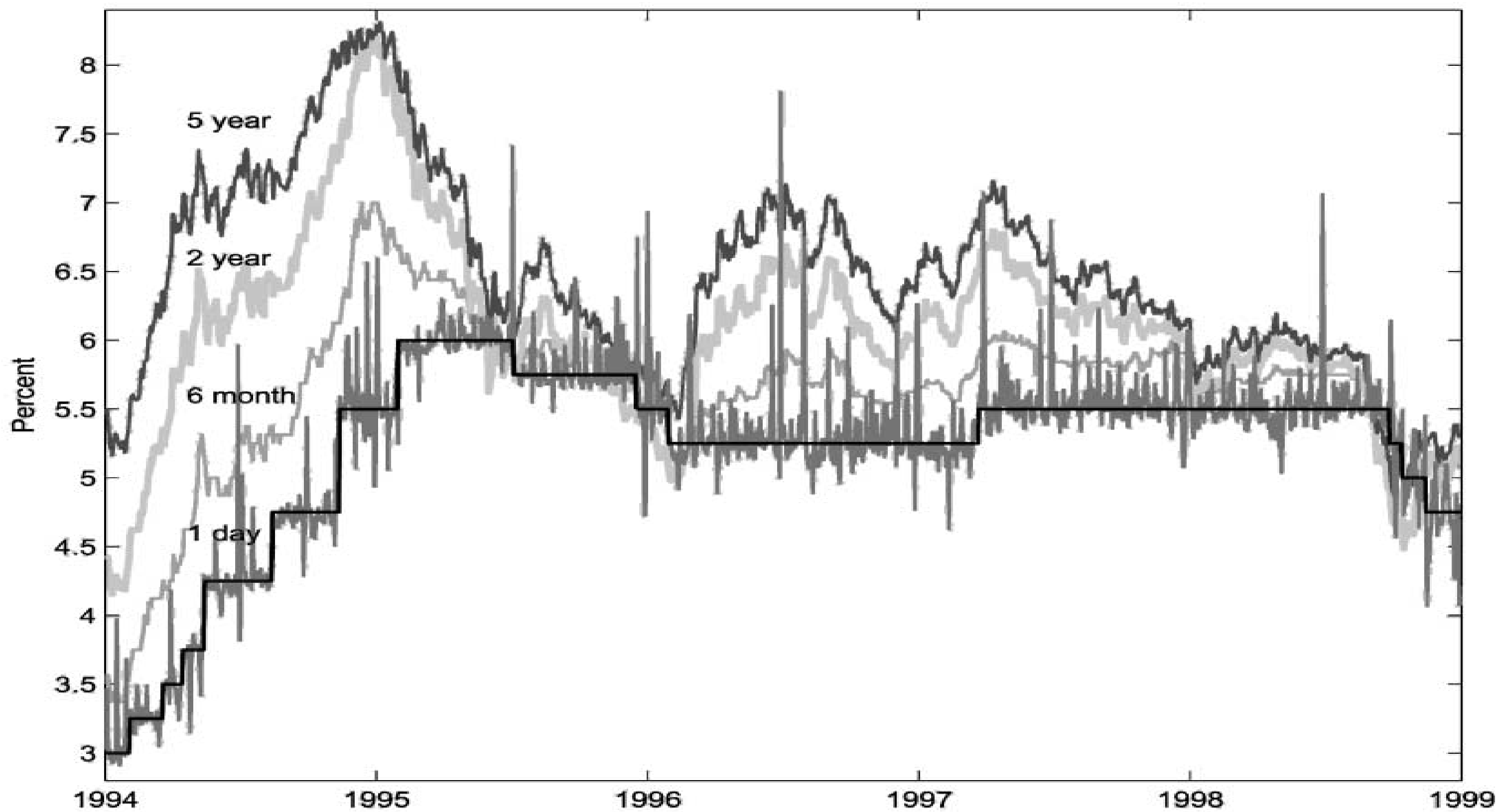


FIG. 1.—Daily data on target (step function), federal funds rate (one-day), LIBOR (six-month), and swap yields (two- and five-year), 1994–98.

The Term Structure Model

- State variables

$$\mathbf{X}_t = (\theta_t, s_t, v_t, z_t)'$$

- The Fed Funds Target θ_t follows a pure jump process

$$d\theta_t = 0.0025\left(dN_t^U - dN_t^D\right)$$

  - where N_t^U, N_t^D are jumps with intensities λ_t^U and λ_t^D

- The spread between short rate and the target Fed fund is $s_t = r_t - \theta_t$

$$ds_t = -k_s s_t dt + \sqrt{v_t} dw_t^s$$

- The volatility v_t follows

$$dv_t = k_v\left(\overline{v} - v_t\right)dt + \sqrt{v_t}\sigma_v dw_t^v$$

- Finally, other relevant macro-information is captured by the variable z_t, following the process

$$dz_t = -k_z z_t dt + dw_t^z$$

- The econometrician (us) only observe θ_t, but not s_t, v_t or z_t.
  - As is standard, the latter are backed out from yields.

Federal Reserve Meetings and the Monetary Policy

- Each meeting occurs at given time intervals $[t_{i-1}, t_i]$. During such times, the intensity of a jump in Fed Fund Target is

$$\lambda_t^U = \overline{\lambda}^U + \boldsymbol{\lambda}_X' \left(\mathbf{X}_t - \overline{\mathbf{X}}\right); \qquad \lambda_t^D = \overline{\lambda}^D - \boldsymbol{\lambda}_X' \left(\mathbf{X}_t - \overline{\mathbf{X}}\right) \quad \text{for} \quad t \in [t_{i-1}, t_i]$$

  - That is, the Federal Reserve reacts to state variables $\mathbf{X}_t$.

- Monetary Policy:
  - Define compensated jump process $M_t^j = N^j - \int_0^t \lambda_u^j du$, for $j = U, D$
  - Monetary shock $M_t = M_t^U - M_t^D$

- Rewrite then the process for the Fed Fund Target as

$$d\theta = k_\theta[(a + \mathbf{b}' X_t) - \theta_t]dt + 0.0025 dM_t$$

- where k_θ, a and $\mathbf{b}$ are obtained from the identity

$$-2\boldsymbol{\lambda}_x \left(\mathbf{X}_t - \overline{\mathbf{X}}\right) = k_\theta[(a + \mathbf{b}' X_t) - \theta_t]$$

- $\Longrightarrow (a + \mathbf{b}' X_t) =$ desired Fed Fund rate, k_θ speed of adjustment.

The Pricing Kernel

- Assume the pricing kernel is given by

$$\frac{d\pi_t}{\pi_t} = -r_t dt - \boldsymbol{\sigma}_\pi(\mathbf{X}_t)\, d\mathbf{w}_t$$

  – where $\mathbf{w}_t = [0, w_t^s, w_t^v, w_t^z]'$

- The market price of risk $\sigma_\pi(\mathbf{X}_t)$ takes the form

$$\boldsymbol{\sigma}_\pi(\mathbf{X}_t) = [0, q_s\sqrt{v_t}, q_v\sigma_v\sqrt{v}_t, q_z]$$

- Recall the market price of risk determines the expected return on bonds

$$E\left[\frac{dZ}{Z} - r_t dt\right] = \boldsymbol{\sigma}_\pi(\mathbf{X}_t)'\, \boldsymbol{\sigma}_Z(\mathbf{X}_t)$$

  – where $\boldsymbol{\sigma}_Z(\mathbf{X}_t)$ is the bond diffusion term

- The form of the market price of risk implies

  1. Jumps are not priced
  2. The premium is higher when the spread rate volatility v_t is higher.
  3. Macro information variable z_t affects the premium, but not its time variation.

The Pricing Methodology

- How do we obtain the price of a zero coupon bond with maturity T?
- Need to compute

$$Z(t,T) = E_t\left[\frac{\pi_T}{\pi_t}\right]$$

- Turn to risk neutral pricing
  - Define new probability measure Q using $\xi_t = \pi_t e^{\int_0^t r_u du}$ as new density.
  - Under new probability measure

$$Z(\mathbf{X}_t, t; T) = E_t^Q\left[e^{-\int_t^T r_u du}\right]$$

  - The risk neutral process for state variables $\mathbf{X}$ is the same, but substitute

$$dw_t = dw_t^Q - \boldsymbol{\sigma}_\pi(\mathbf{X}_t)\,dt$$

  - Invoke Feynman Kac Theorem, according to which expectations satisfy PDE

$$\begin{aligned} r_t Z &= \frac{\partial Z}{\partial t} + \frac{\partial Z}{\partial \mathbf{X}} E^Q[d\mathbf{X}] + \frac{1}{2} tr\left(\frac{\partial^2 Z}{\partial X^2} E^Q[d\mathbf{X} d\mathbf{X}']\right) \\ &\quad + \lambda^U [Z(\mathbf{X}+\mathbf{J}, t; T)) - Z(\mathbf{X}_t, t; T)] + \lambda^D [Z(\mathbf{X}-\mathbf{J}, t; T)) - Z(\mathbf{X}_t, t; T)] \end{aligned}$$

    * The shifting probabilities λ_t^U and λ_t^D depend on whether there is $FOMC$ meeting or not.

The Pricing Formula

- The solution to the PDE has the form

$$Z(t;T) = e^{\overline{c}(t;T)+c_\theta(t;T)\theta_t+c_s(t;T)s_t+c_v(t;T)v_t+c_z(t;T)z_t}$$

  - where the coefficients satisfy a set of ODEs.

- Define

$$\mathbf{c}_x(t;T) = [c_\theta(t;T), c_s(t;T), c_v(t;T), c_z(t;T)]$$

- and we obtain the affine yield

$$y(t;T) = -\frac{log(Z(\mathbf{X}_t, t;T))}{T-t} = \overline{c}^y(t;T) + \mathbf{c}_x^y(t;T)'\mathbf{X}_t$$

  - The coefficients $c^y(t;T)$ take into account whether t is within a FOMC or not.
  - Recall that we (the econometrician) only observe the Fed Fund Target θ_t in $\mathbf{X}_t$
  - $\Longrightarrow$ can use affine equation to back out unobservable vector and use it for estimation.

Estimation Issues

- Numerous issues to estimate model

1. Fed Fund $>$ TB rates $\Longrightarrow$ use Swap data.
   - Swap rate $Y(t,t+\tau)$ determined by equality

$$1 = Z(t,t+\tau) + \frac{Y(t,t+\tau)}{2}\sum_{j=1}^{2\tau} Z(t,t+0.5j)$$

   - $\Longrightarrow$ interpret r_t as the rate on short term LIBOR bond.
   - $\Longrightarrow$ similar credit quality as Fed Fund loan.
2. The Likelihood Function

$$f(\mathbf{Y}_t,t|\mathbf{Y}_\tau,\tau;\boldsymbol{\gamma}) = f_X(g(\mathbf{Y}_t,\boldsymbol{\gamma}),t|\mathbf{Y}_\tau,\tau;\boldsymbol{\gamma})|\Delta_Y g(\mathbf{Y}_t,\boldsymbol{\gamma})|$$

   is not known in closed form. $\Longrightarrow$ use Simulated Maximum Likelihood with Jumps.
3. The map $\mathbf{X}_t = g(\mathbf{Y}_t,\boldsymbol{\gamma})$ must be inverted numerically.
4. Syncronicity: easier to use weekly frequency.
   - Most FOMC meetings are on Tuesdays. Some extend to Wednesdays.
   - To make sure that announcement of new target affect LIBOR and swap rates, record rates on Thursdays.
5. Need to impose $\lambda_t^U > 0$ and $\lambda_t^D > 0$.

TABLE 1
SIMULATED MAXIMUM LIKELIHOOD ESTIMATES

	Model with Stochastic Volatility		Model with Constant Volatility	
	Estimate	t-Ratio	Estimate	t-Ratio
Mean reversion:				
κ_s	9.75	4.69	1.56	4.10
κ_v	.04	.42	…	…
κ_z	.72	4.34	.29	3.03
Means:				
$\bar{\theta}$	.0522	…	.0522	…
$\bar{v}$	.000415	1.07	…	…
Intensities:				
$\bar{\lambda}$	10	.55	84	.40
λ_θ	−9,408.9	−4.18	−4,876.7	−4.30
λ_s	7,267	1.86	7,582	2.25
λ_v	548,315	1.63	…	…
λ_z	237.6	17.87	119.5	18.63
Risk premia:				
q_s	−47.62	−2.90	70.29	8.67
q_v	−2,537.5	−.81	…	…
q_z	.1126	.18	−.2132	33.36
Volatility:				
σ_v	.0058	.78	…	…
$\sqrt{\bar{v}}$	…	…	.0089	12.50

NOTE.—The model with stochastic volatility refers to eqq. (1)–(5) and (10). The model with constant volatility sets $v_t = \bar{v}$. The estimation of the constant volatility model assumes that the two-year swap yield is measured with error. The autocorrelation of this error is estimated to be 0.955 (with a t-ratio of 15), and its volatility is estimated to be 0.002 (with t-ratio of 56). The parameter $\bar{\theta}$ is fixed to the average target over the sample. Apps. B and C contain practical details about the estimation. The sample is weekly from January 1994 to December 1998.

Estimates

- Intensity $\overline{\lambda}$ of target move is imprecisely estimated (short sample)
  - To understand size: 8 meetings / year $\Longrightarrow 8 \times \overline{\lambda}/365 = 0.22 \Longrightarrow$ approximately one change every 5 years.
  - $\Longrightarrow$ too low: there were 5 down and seven up within 5 year sample. But large standard error...
- Main driver of λ_t are θ_t and z_t (high t-stats).
- "Macro" factor z_t
  - z_t is relatively persistent (1/2 life $\approx$ 1 year). Positive macro shocks (z_t) increase probability of rate change today (λ_t goes up) and at future meetings (because of persistence).
  - $\Longrightarrow$ *policy inertia*: macro shocks induce slow adjustments.
  - From estimates, z_t mainly related to 2 year swap rate.
- θ_t also impacts the probability of target change: $\lambda_\theta < 0$ implies
  - $\theta_t > \overline{\theta} \Longrightarrow \lambda_t^D \uparrow \Longrightarrow$ high probability of rate cut
  - $\theta_t < \overline{\theta} \Longrightarrow \lambda_t^U \uparrow \Longrightarrow$ high probability of rate increase.
  - Slow mean reversion $\Longrightarrow$ interest rate smoothing.
- Deviations of market rates from target are short lived.
  - Speed of mean reversion $k_s = 9.75 \Longrightarrow$ half life $< 1 month$.
  - Money Market Noise

Bond-Pricing Performance

- By construction, it performs perfectly on the six-month LIBOR, 2 year and 5 year swap rate.
- The others?

TABLE 3
PRICING ERRORS (in Basis Points)

	1 Month	3 Months	1 Year	3 Years	4 Years
$\hat{\gamma}$	25.7	11.0	3.2	1.8	1.8
$v_t = \bar{v}$	12.5	7.5	6.8	9.5	5.8
Dai-Singleton	237.3	66.2	9.9	6.4	5.7

NOTE.—This table computes mean absolute pricing errors in basis points over the weekly sample from January 1994 to December 1998 for three different models. The first row uses the model evaluated at the parameter values $\hat{\gamma}$ from table 1. The second row uses a version of the model with constant volatility $v_t = \bar{v}$. The third row shows the mean absolute pricing errors of the $A_1(3)_{DS}$ model by Dai and Singleton (2000) at their parameter estimates.

  – The model was designed to better explain short term bonds.
  – Compared to Dai and Singleton 3 factor model, the performance at the short end is very good.
    * The short rate in Dai and Singleton miss the true short rate in the data, both in means and in correlation.

Policy Rules

- What does the model imply as the expected change in the target rate during a FOMC *conditional on information up to the meeting time*?
- Compute

$$E[\theta_{t+1/52}] = 0.0036 + 0.87\theta_t + 0.1s_t + 7.51v_t + 0.0033z_t$$

- Compare the model to Taylor rule (1993)

$$\theta_{t+1/52} = 3 + 1.5 \times \text{inflation} + 0.5 \times \text{gap}$$

- Extended Taylor Rule

$$\theta_{t+1/52} = -.3602 + .4968 \times \text{inflation} + .3411\text{gap} + 0.9195 \times \theta_t$$

Policy Rules

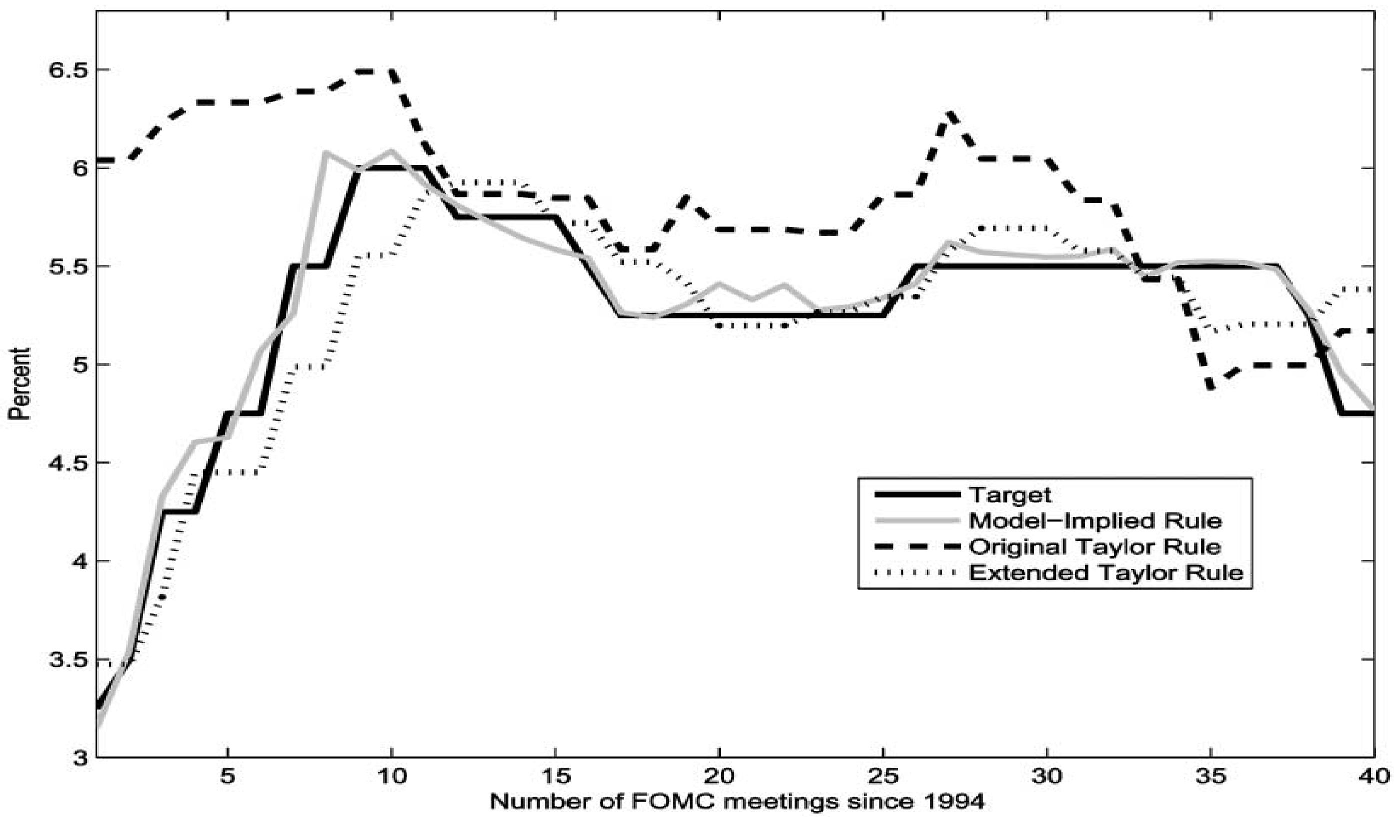


FIG. 3.—Target, model-implied policy rule, original Taylor rule, and extended Taylor rule at each of the 40 FOMC meetings (eight meetings per year) between 1994 and 1998.

- Model works better than Taylor rules:
  - z_t correlated with macro variables (but backed out from swap rates) $\Longrightarrow$ more info

Predicting Fed Fund Changes

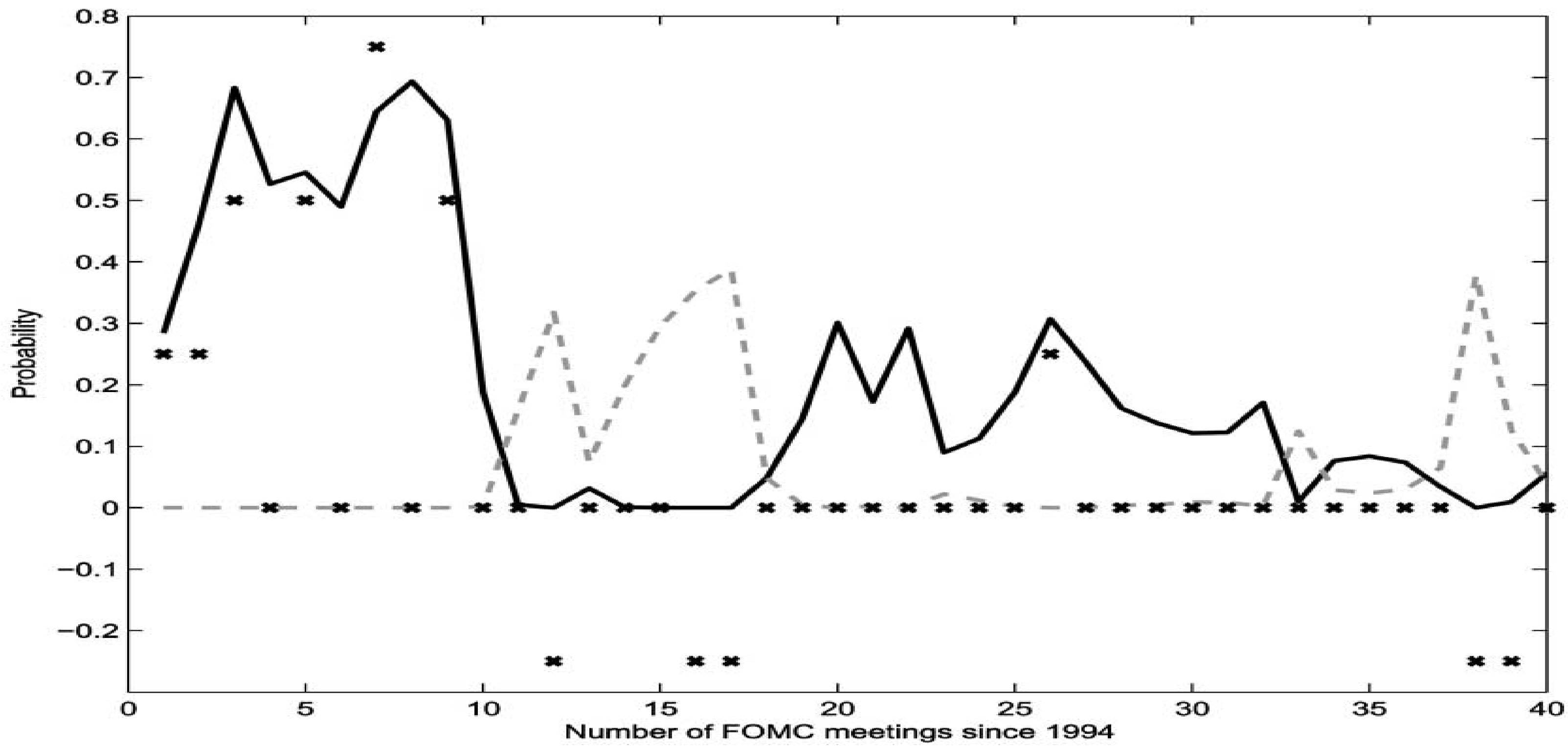


FIG. 4.—Conditional probabilities of up and down moves in the target at each of the 40 FOMC meetings (eight meetings per year) between 1994 and 1998. The solid line shows up moves, and the dashed line shows down moves. The *x*-marks indicate the actual target changes in percent.

Monetary Shocks and Yields

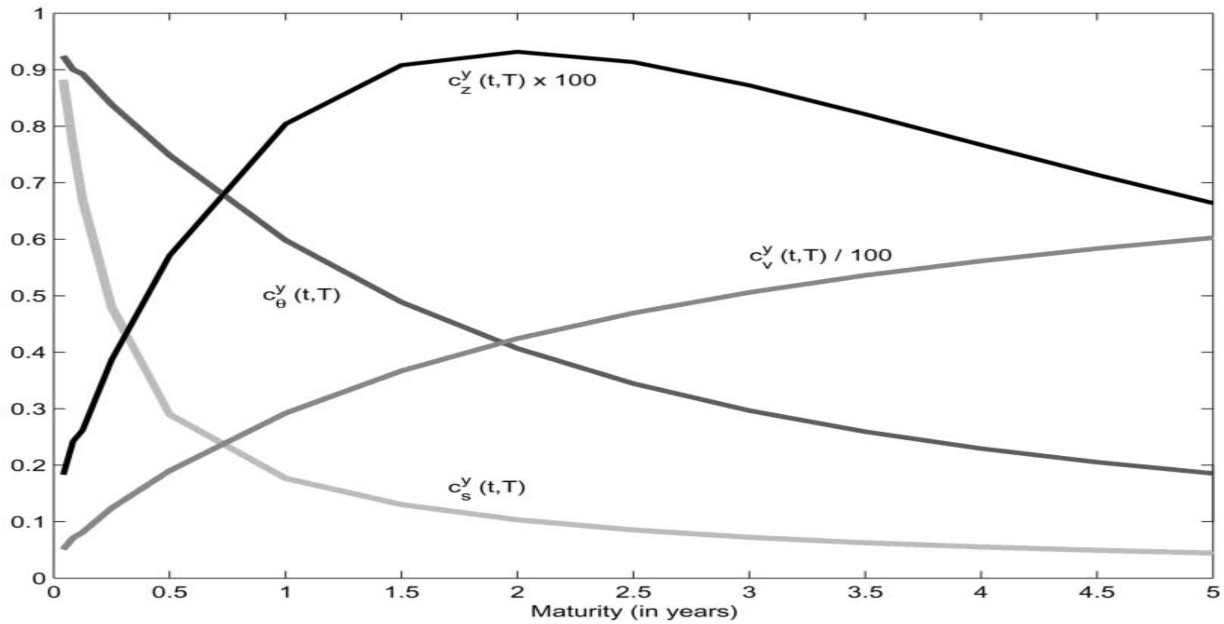


FIG. 5.—Responses of yields to monetary policy shocks $c_\theta^y(t, T)$, money market shocks $c_s^y(t, T)$, macroeconomic shocks $c_z^y(t, T)$, and volatility shocks $c_v^y(t, T)$. These coefficients are plotted as a function of maturity $T - t$, with t fixed to be the end of an FOMC meeting.

- Fed Target shocks at FOMC $(c_\theta^y(t;T))$: Strong for T small.
- Macro shocks $(c_z^y(t;T))$: Strong for medium T
- Noise shocks $(c_s^y(t;T))$: Die out quickly
- Volatility shocks $(c_v^y(t;T))$: almost flat $\Longrightarrow$
  * shock persistence is very high

Snake Shape in Volatility

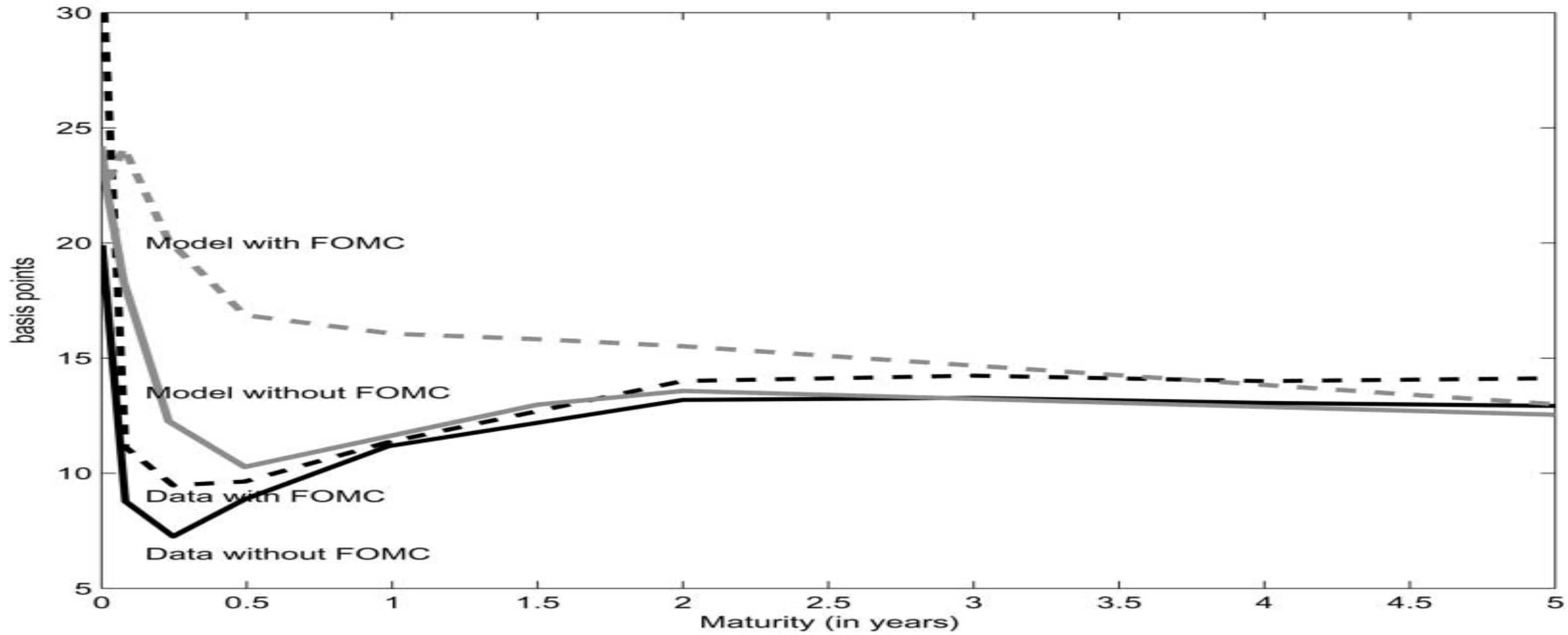


FIG. 6.—Snake shape and seasonality of the volatility curve. The four lines represent volatility curves during weeks with FOMC meetings and the remaining weeks computed from the data and the model as indicated.

– Yield volatility across maturity show a strange pattern: high, low, higher, lower
– Moreover, it is different depending on whether we are close to FOMC meeting
– Model replicates both effects, mainly due to *inertia in monetary policy*.

What Macro Factors?

- Piazzesi (2005) interprets z_t shocks as macro factors, but does not actually use any macro data.
- According to old version of paper, z_t is indeed related to CPI and employment forecasts.
- But why not use information from economic data in the model itself?
  - $\Longrightarrow$ the link between the term structure and economic variables is more apparent.
- The literature has been moving in that direction.
  - E.g. Ang Piazzesi (2003), Ang Piazzesi Wei (2005), Monch (2007), Palomillo (2007), Chen and Veronesi (2007)

Macro Factors and the Term Structure: Ang and Piazzesi (2003)

- The discrete time version of an affine models can be specified as follows

$$r_t = \delta_0 + \boldsymbol{\delta}_1' \mathbf{X}_t$$

- $\mathbf{X}_t$ is a set of factors, following an affine process, such as

$$\mathbf{X}_t = \boldsymbol{\mu} + \boldsymbol{\Phi}\mathbf{X}_{t-1} + \boldsymbol{\Sigma}\boldsymbol{\varepsilon}_t$$

- The pricing kernel is conditionally lognormal

$$\pi_{t+1} = \pi_t e^{-r_t - \boldsymbol{\lambda}_t \boldsymbol{\lambda}_t' - \boldsymbol{\lambda}_t' \boldsymbol{\varepsilon}}$$

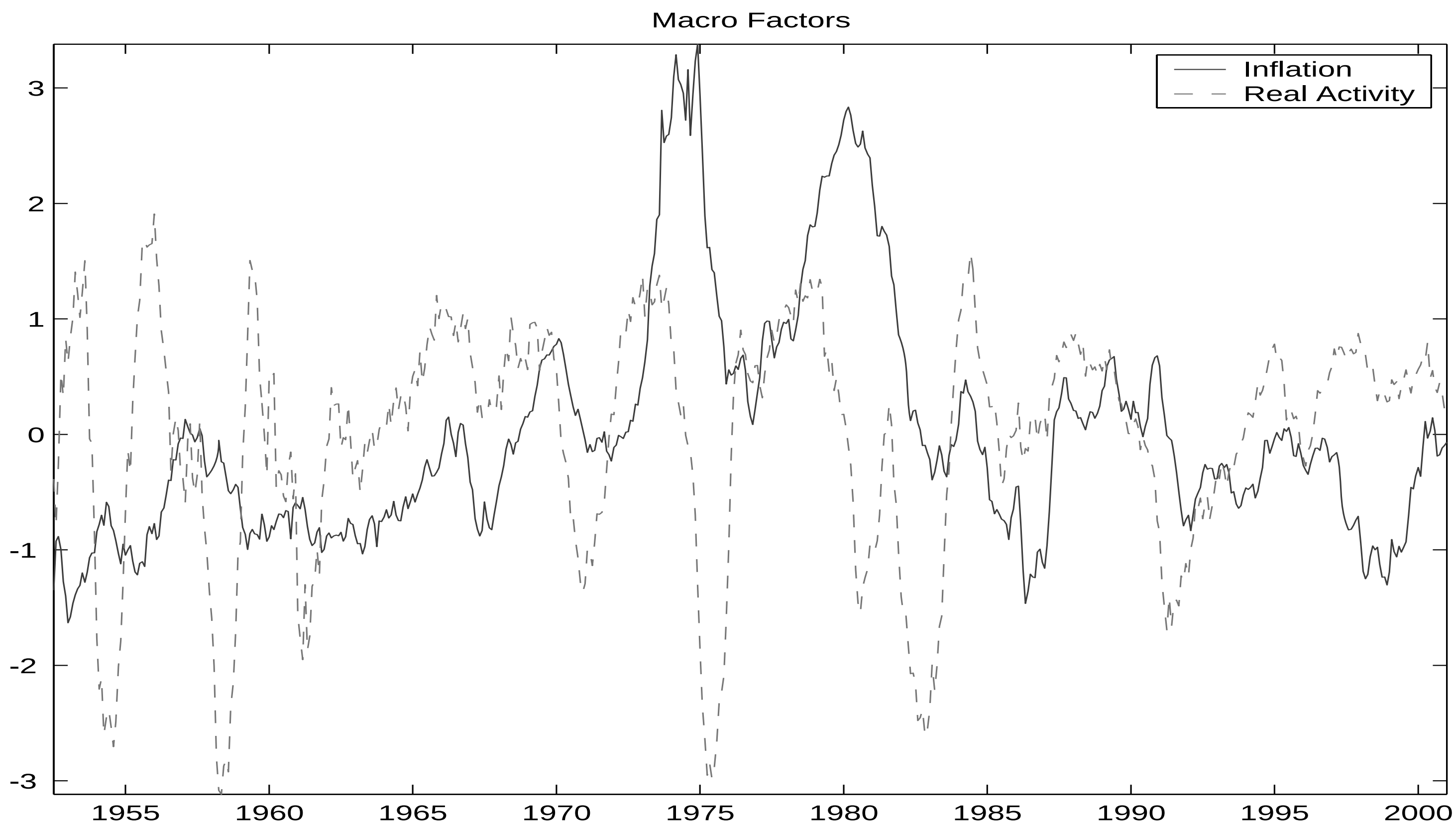
- The market price of risk is also affine

$$\boldsymbol{\lambda}_t = \boldsymbol{\lambda}_0 + \boldsymbol{\lambda}_1' \mathbf{X}_t$$

- In the models we have seen earlier, the factors $\mathbf{X}_t$ were "unobservable" to the econometrician, and thus were backed out in the estimation process from the yield curve.
- Ang and Piazzesi (2003) partition $\mathbf{X}_t$ in two groups: "Observable" macro factors $\mathbf{X}_t^o$ and latent factors $\mathbf{X}_t^u$

The Macro Variables

- Inflation and Real Activity.
  - Extract principal component from a set of inflation measures: CPI, PPI and PCOM.
  - Extract principal component from a set of real activity measures: Help advertise (HELP), unemployment (UE), employment growth (EMPLOY) and industrial production growth (IP).



Principal Component and Macro Variables

Table 2
Principal component analysis

	Principal components: inflation		
	1st	2nd	3rd
CPI	−0.6343	−0.3674	0.6802
PCOM	−0.4031	0.9080	0.1145
PPI	−0.6597	−0.2015	−0.7240
% variance explained	0.7143	0.9775	1.0000

	Principal components: real activity			
	1st	2nd	3rd	4th
HELP	−0.3204	−0.7365	−0.5300	0.2719
UE	0.3597	−0.6283	0.6871	0.0612
EMPLOY	−0.6330	−0.1648	0.2444	−0.7158
IP	−0.6060	0.1886	0.4327	0.6403
% variance explained	0.5202	0.7946	0.9518	1.0000

Taylor Rules and Affine Models

- The interest rate model is

$$r_t = \delta_0 + \boldsymbol{\delta}_t' \mathbf{X}_t$$

- Interpreting r_t as the Fed Fund rate, the model encompasses various Taylor rules.
  - Taylor (1993) Rule: $\mathbf{X}_t$ contains *only* contemporaneous macro variables

$$\mathbf{X}_t = [\text{inflation}_t, \text{gap}_t]$$

  - Forward Looking Taylor Rule: $\mathbf{X}_t$ contains lagged macro variables, useful to predict *future* inflation and gdp growth

$$\mathbf{X}_t = [\text{inflation}_t, \text{gap}_t, \text{lags}]$$

- In general, define $\mathbf{F}_t = [\mathbf{f}_t^o, \mathbf{f}_t^u]$ as a vector of macro (observable) factors $\mathbf{f}_t^o$ and latent factors $\mathbf{f}_t^u$.
- Specify the $p-$ VAR

$$\mathbf{F}_t = \boldsymbol{\Phi}_0 + \boldsymbol{\Phi}_1 \mathbf{F}_{t-1} + \boldsymbol{\Phi}_2 \mathbf{F}_{t-2} + ... + \boldsymbol{\Phi}_p \mathbf{F}_{t-p} + \boldsymbol{\theta} \mathbf{u}_t$$

- Define $\mathbf{X}_t = [\mathbf{f}_t^o, \mathbf{f}_{t-1}^o, ..., \mathbf{f}_{t-p}^o, \mathbf{f}_t^u]$, obtaining the state specification

$$\mathbf{X}_t = \boldsymbol{\mu} + \boldsymbol{\Phi} \mathbf{X}_{t-1} + \boldsymbol{\Sigma} \boldsymbol{\varepsilon}_t$$

Bond Pricing

- Given the specification of the pricing kernel, the price of a bond must satisfy

$$Z\left(\mathbf{X}_t, t; T\right) = E_t\left[\frac{\pi_{t+1}}{\pi_t} Z\left(\mathbf{X}_{t+1}, t+1; T\right)\right]$$

- **Claim:** The pricing formula is exponential affine

$$Z\left(\mathbf{X}_t, t; T\right) = e^{A(t;T)+\mathbf{B}(t;T)'\mathbf{X}_t}$$

  – where $A(t;T)$ and $\mathbf{B}(t;T)$ satisfy the difference equations

$$\begin{aligned} A\left(t;T\right) &= -\delta_0 + A\left(t+1;T\right) + \mathbf{B}\left(t+1;T\right)\left(\boldsymbol{\mu} - \boldsymbol{\Sigma}\boldsymbol{\lambda}_0\right) + \frac{1}{2}\mathbf{B}\left(t+1;T\right)\boldsymbol{\Sigma}\boldsymbol{\Sigma}'\mathbf{B}\left(t+1;T\right)' \\ \mathbf{B}\left(t;T\right)' &= -\boldsymbol{\delta}_1' + \mathbf{B}\left(t+1;T\right)'\left(\boldsymbol{\Phi} - \boldsymbol{\Sigma}\boldsymbol{\lambda}_1\right) \end{aligned}$$

  – with final condition $A(T;T) = 0$ and $\mathbf{B}(T;T) = \mathbf{0}$.

- To see this, simply plug in the formula for $Z(t+1, T)$ in the pricing equation, and use the properties of the log-normal distribution

$$\begin{aligned} Z\left(\mathbf{X}_t, t; T\right) &= E\left[\left(e^{-\delta_0 - \boldsymbol{\delta}_1\mathbf{X}_t - \frac{1}{2}\boldsymbol{\lambda}_t\boldsymbol{\lambda}_t' - \boldsymbol{\lambda}_t\varepsilon_{t+1}}\right) \times \left(e^{A(t+1;T)+B(t+1;T)\mathbf{X}_{t+1}}\right)\right] \\ \vdots\ [\text{Algebra}] &\ \vdots \\ &= e^{A(t;T)+\mathbf{B}(t;T)'\mathbf{X}_t} \end{aligned}$$

Bond Yields

- The mapping between yields and factors is then given by

$$Y(t;T) = -\frac{A(t;T)}{T-t} + \frac{B(t;T)}{T-t}\mathbf{X}_t$$

- In the estimation procedure, assume that as many yields as factors are observed without error, and use this equation to extract $\mathbf{X}_t$ from a set of yields $[Y(t,T_1), Y(t,T_2), Y(t,T_3)$.

- Other yields are assumed to be observed with error, so that

$$Y^{data}(t;T) = -\frac{A(t;T)}{T-t} + \frac{B(t;T)}{T-t}\mathbf{X}_t + \text{error}$$

- The likelihood function is computed using the observation errors as well.

Estimation

- Assume independence between macro factors and latent factors.
- Two stages:

1. Estimate observables coefficients (simple OLS)

$$\begin{aligned} r_t &= \delta_0 + \delta_{11}\mathbf{X}_t^o + \boldsymbol{\epsilon}_t \\ \mathbf{f}_t^o &= \boldsymbol{\rho}_0 + \boldsymbol{\rho}_1 \mathbf{f}_{t-1}^o + \ldots + \boldsymbol{\rho}_{12}\mathbf{f}_{t-12}^o + \boldsymbol{\Omega}\mathbf{u}_t \end{aligned}$$

2. Keep the parameters fixed, and estimate other parameters by ML.
   - As usual, use yields to back out latent factors $\mathbf{X}_t^u$ from

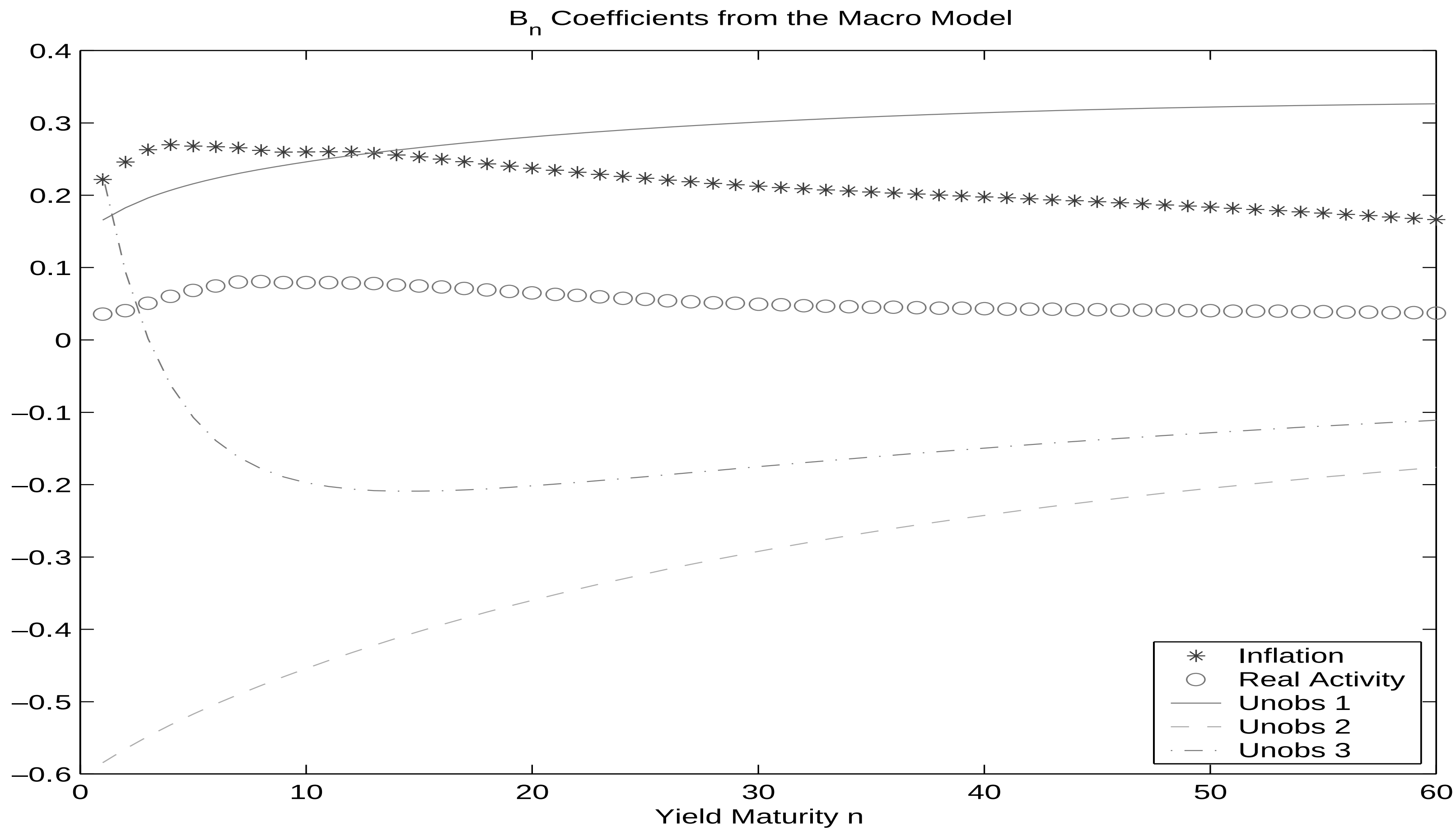
$$Y^{data}(t;T) = \overline{A}(t;T) + \overline{B}^o(t;T)\mathbf{X}_t^o + \overline{B}^u(t;T)\mathbf{X}_t^u$$

   - Build the Likelihood function

$$\begin{aligned} \mathcal{L} &= \prod_{t=2}^{T} f\left(\mathbf{Y}_t, \mathbf{X}_t | \mathbf{Y}_{t-1}, \mathbf{X}_{t-1}^o\right) \\ log(\mathcal{L}) &= \sum_{t=2}^{T} -log|det(J)| + log(f_X\left(\mathbf{X}_t^o, \mathbf{X}_t^u | \mathbf{X}_{t-1}^o, \mathbf{X}_{t-1}^u\right) + log(f_{u^m}(u_t^m)) \end{aligned}$$

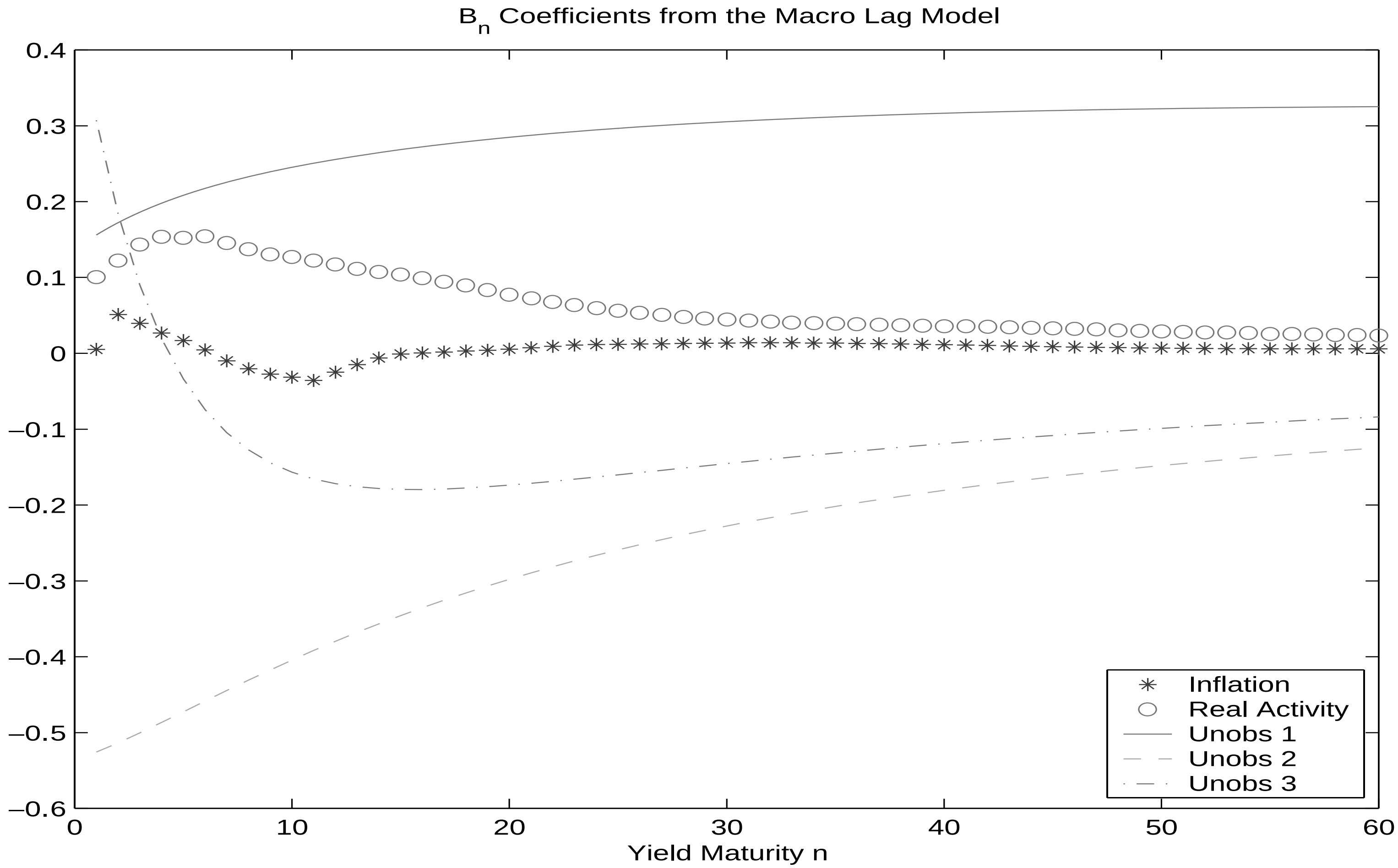
   - where the last term is the likelihood function from observation errors.
   - Note: this maximization is not simple, as the number of parameters is very large
   - E.g. λ_0 (5x1 vector) and λ_1 (5x5 matrix) have 30 parameters.
   - Ang and Piazzesi put in place strong restrictions to be able to estimate the system.

Empirical Results: Factors and Yields



- Level, Slope and (almost) Curvature are visible among unobservable factors.
- Inflation and real economy factors push up yields almost uniformly.

Empirical Results: Lagged Macro Factors and Yields



- Inflation and real economy (contemporaneous) factors have little impact.

Empirical Results: Model Specification

- Macro Model and Macro Lag Model imply different impact of macro factors on the yield curve.
  - The "Forward Looking" Taylor Rule (with lags) $r_t = \delta_0 + \delta_{1,1}\mathbf{X}_t^o$ show that lags are important in determining the variation in interest rates
    - $\Longrightarrow$ Contemporaneous shocks have less of an impact on the yields.
  - Estimated price of risk are more negative for Macro Model than Macro Lag Model

From Tables 6 and 7: The market price of risk $\boldsymbol{\lambda}_1$

	Macro Model		Macro Lag Model	
	Inflation	Real Activity	Inflation	Real Activity
Inflation	-0.4263	0.1616	0.8442	$-.0017$
Real Activity	1.9322	-0.1015	1.1209	0.2102

  - More negative price of risk in Macro model compared to Macro-Lag model imply that positive inflation and real activity shocks have a *stronger positive* impact on long end yields.
    - (shock $\Longrightarrow \boldsymbol{\lambda}_t \downarrow \Longrightarrow$ Expected return $\uparrow \Longrightarrow Z \downarrow \Longrightarrow Y(t;T) \uparrow$)

Yield Movements: Macro Factors or Latent Factors?

Table 8
Proportion of variance explained by macro factors

	Forecast horizon h			
	1 mth	12 mth	60 mth	∞
Macro model				
Short end	50%	78%	85%	83%
Middle	67%	79%	78%	73%
Long end	61%	63%	48%	38%
Macro lag model				
Short end	11%	57%	87%	85%
Middle	23%	52%	71%	64%
Long end	2%	8%	11%	7%

We list the contribution of the macro factors to the h-step ahead forecast variance of the 1 month yield (short end), 12 month yield (middle) and 60 month yield (long end) for the Macro and Macro Lag Models. These are the sum of the variance decompositions from the macro factors in Table 9.

- Macro Factors explain most of the variation at the short end (not surprisingly)
- Long end mainly explained by latent factors.
  - Latent factors are extremely persistent (almost unit root)

Forecasting the Yield Curve with Macro Factors

Table 10
Forecast comparisons

Yield (mths)	RW	Unconstrained VARs		VARs with cross-equation restrictions		
		VAR Yields Only	VAR with Macro	Yields Only	Macro model	Macro lag model
RMSE criteria						
1	0.3160	0.3905	0.3990	0.3012	**0.2889**	0.3906
3	**0.1523**	0.2495	0.2540	0.1860	0.2167	0.2876
12	0.1991	0.2776	0.2722	0.1914	**0.1851**	0.2274
36	0.2493	0.3730	0.3644	0.2489	**0.2092**	0.2665
60	0.2546	0.3793	0.3725	0.2497	**0.2333**	0.2530
MAD criteria						
1	0.2252	0.3076	0.3242	0.2155	**0.2039**	0.2981
3	**0.1159**	0.1987	0.2056	0.1442	0.1693	0.2344
12	0.1639	0.2176	0.2204	0.1616	**0.1559**	0.1870
36	0.1997	0.2991	0.2924	0.1974	**0.1604**	0.2111
60	0.2054	0.2957	0.2930	0.2017	**0.1883**	0.2064

- Out of sample forecasting performance.
  - RW = random walk
  - Unrestricted VARs do not impose cross-sectional no-arbitrage restrictions to VAR parameters.

Latent versus Macro Factors

- The necessity of latent factors to fit the term structure is somewhat unsatisfactory.
- It essentially implies that there is a (large) part of the variation in yields that depends on non-macroeconomic news.
  - This fact may be very reasonable: there are many types of news that affect expectations (and thus yields) but they are not observable in actual data.
  - For instance, Fed chairman (past or present) announcements, politicians expression of opinions, etc.
- On the other hand, today's markets are flooded with all kinds of news and data
  - There are 100s of macro news that are released every months
  - How do we process of all of this information and put it at work?

Forecasting Yields in a Data Rich Environment: Monch (2007)

- Same setting as Ang and Piazzesi (2003)

$$
\begin{array}{rrcl}
\text{interest rate} & r_t & = & \delta_0 + \boldsymbol{\delta}_1' \mathbf{X}_t \\
\text{factors} & \mathbf{X}_t & = & \boldsymbol{\mu} + \boldsymbol{\Phi} \mathbf{X}_{t-1} + \boldsymbol{\Sigma} \boldsymbol{\varepsilon}_t \\
\text{pricing kernel} & \pi_t & = & \pi_{t-1} e^{-rt - \frac{1}{2} \boldsymbol{\lambda}_t \boldsymbol{\lambda}_t' - \boldsymbol{\lambda}_t \boldsymbol{\varepsilon}_t} \\
\text{market price of risk} & \boldsymbol{\lambda}_\mathbf{t} & = & \boldsymbol{\lambda}_0 + \boldsymbol{\lambda}_1 \mathbf{X}_t
\end{array}
$$

- but:
  1. No latent variables
  2. A lot of macro variables
- Uses a dataset with about 160 monthly macro announcements (see attached pages from Giannone, Reichlin and Small (2005))
  - Large number of IP data, Inflation data, GDP growth data, Employment data, etc.
  - Monch eliminates any series directly related to interest rates
- How do we deal with such a large data set?

Estimation Methodology

1. Use first four principal components of variance-covariance matrix as macro-economic variables
   - Explain large part of the variation.
   - Use these principal components and lags as factors $\mathbf{X}_t$
2. As in Ang and Piazzesi (2003), first estimate the VAR, as all factors are observable
   - Selects four lags in the VAR specification.
3. Given Macro parameters, estimate the market price of risk parameters by

$$\min \sum_{t=1}^{T} \sum_{j=1}^{n} \left(Y^{data}(t;T_j) - Y(t;T_j) \right)^2$$

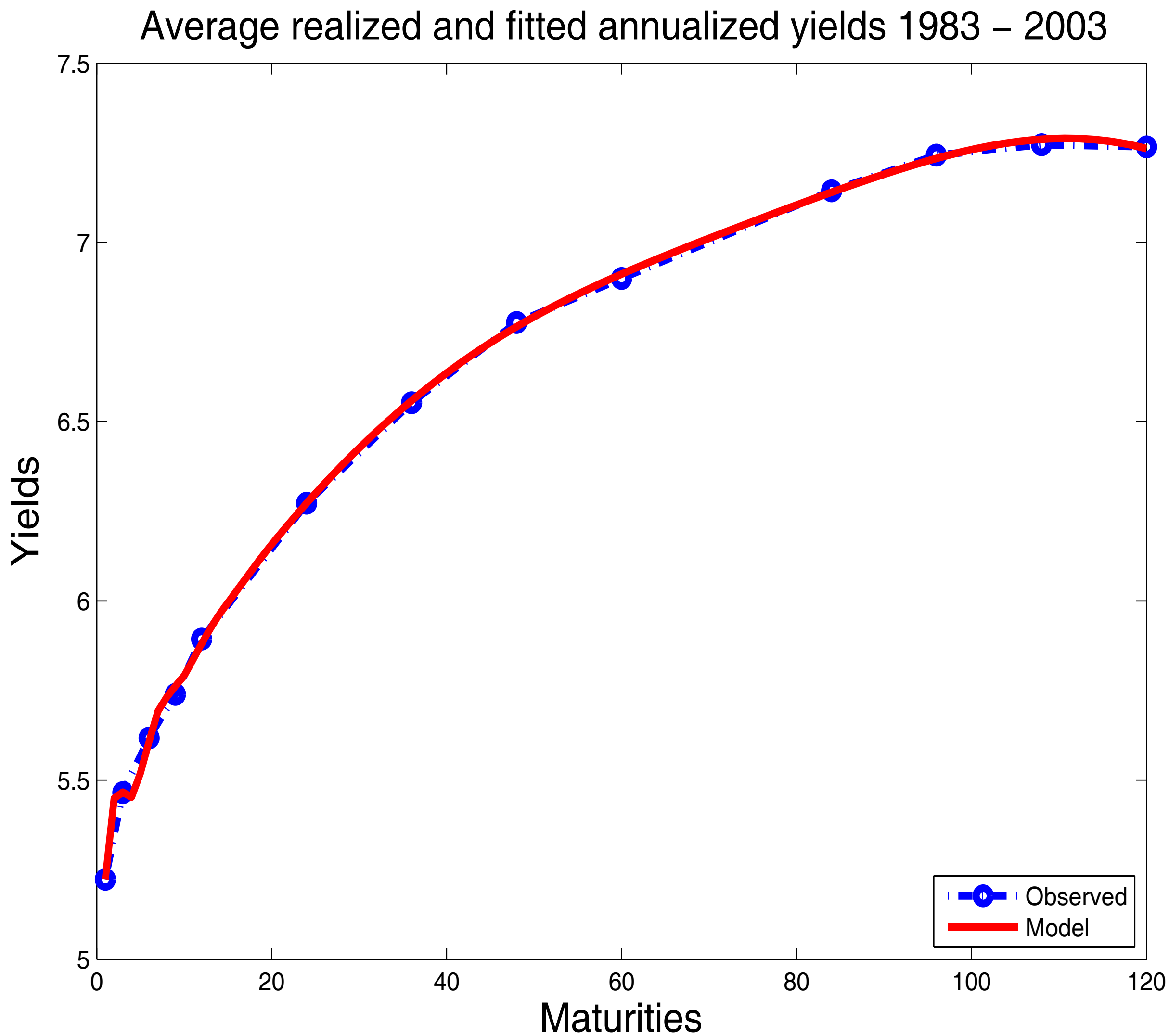
   - Again, need restrictions, as $\boldsymbol{\lambda}_0$ and $\boldsymbol{\lambda}_1$ have large dimensionality (30 parameters).

Table 1: **Share of Variance Explained by Factors and Factor Loadings**

This table summarizes R-squares of univariate regressions of the factors extracted from the panel of macro variables on all individual variables. For each factor, I list the five variables that are most highly correlated with it. Notice that the series have been transformed to be stationary prior to extraction of the factors, i.e. for most variables the regressions correspond to regressions on growth rates. The four factors together explain about 50% of the total variation of the time series in the panel.

Factor 1 (25.1% of total variance)	R^2
Index of IP: Total	0.84
Index of IP: Non-energy, total (NAICS)	0.84
Index of IP: Mfg (SIC)	0.84
Capacity Utilization: Total (NAICS)	0.81
Index of IP: Non-energy excl CCS (NAICS)	0.80
Factor 2 (10.9% of total variance)	
CPI: all items less medical care	0.85
CPI: commodities	0.83
CPI: all items (urban)	0.83
CPI: all items less shelter	0.82
CPI: all items ess food	0.79
Factor 3 (7.8% of total variance)	
CPI: medical care	0.66
PCE prices: total excl food and energy	0.48
PCE prices: services	0.45
M1 (in mil of current $)	0.39
Loans and Securities @ all comm banks: Securities, U.S. govt (in mil of $)	0.37
Factor 4 (5.0% of total variance)	
Employment on nonag payrolls: Financial activities	0.27
Employment on nonag payrolls: Other services	0.23
Employment on nonag payrolls: Service-producing	0.19
Employment on nonag payrolls: Mining	0.18
Employment on nonag payrolls: Retail trade	0.17

In Sample Fit



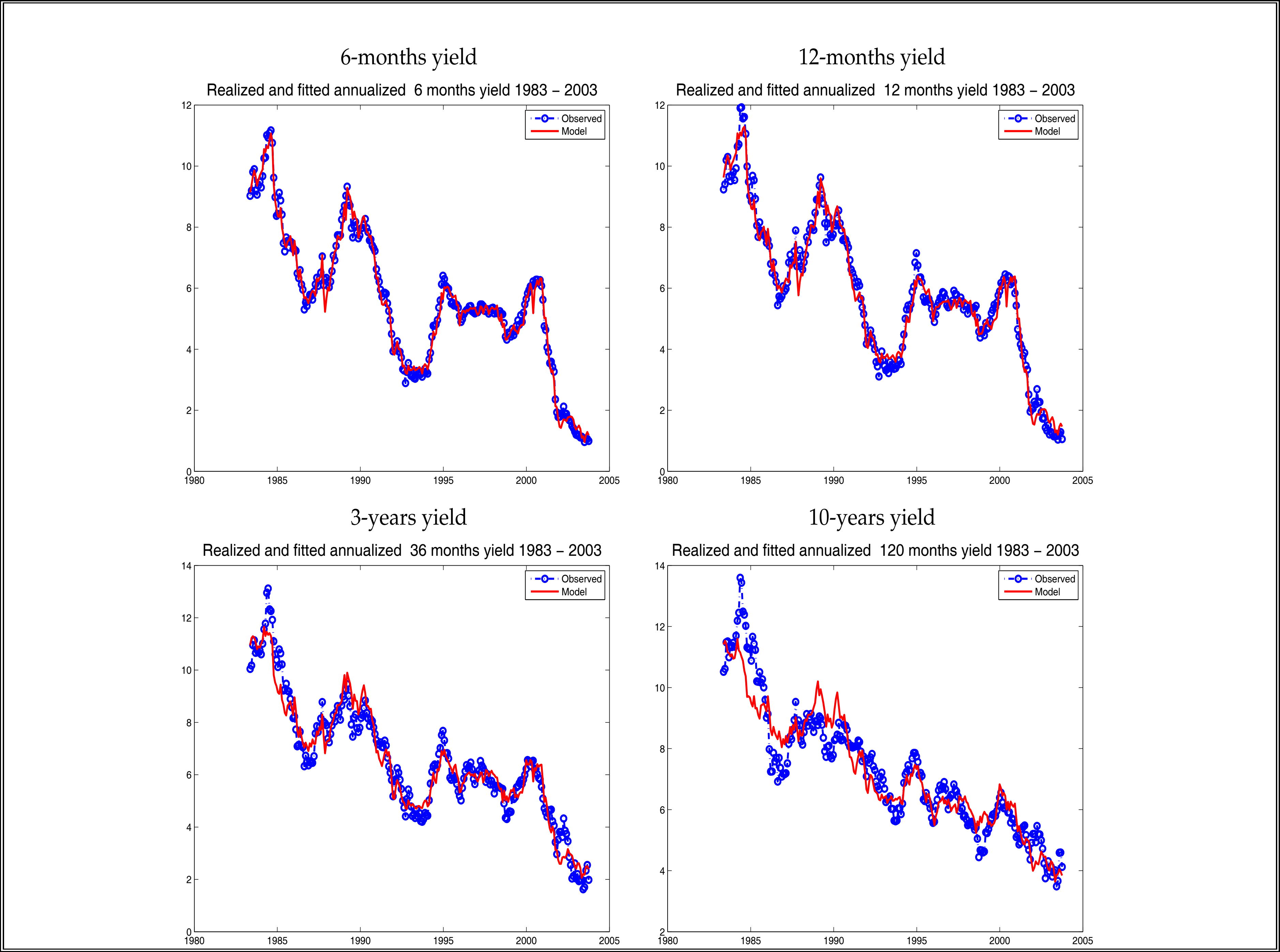

6-months yield
Realized and fitted annualized 6 months yield 1983 – 2003
Observed
Model
12-months yield
Realized and fitted annualized 12 months yield 1983 – 2003
Observed
Model
3-years yield
Realized and fitted annualized 36 months yield 1983 – 2003
Observed
Model
10-years yield
Realized and fitted annualized 120 months yield 1983 – 2003
Observed
Model
1980
1985
1990
1995
2000
2005

Table 9: **Out-of-sample RMSEs - Forecast Period 1994:01-2003:09**

This table summarizes the root mean squared errors obtained from out-of-sample yield forecasts. The models have been estimated using data from 1983:01 until the period when the forecast is made. The forecasting period is 1994:01-2003:09. "FAVAR" refers to the No-Arbitrage Factor-Augmented VAR model; "VAR" denotes an arbitrage-free Macro VAR model with IP growth, the index of help-wanted adds in newspapers, CPI growth, PPI growth and the short rate as factors; "VARylds" refers to a VAR(1) on yield levels; "NS(VAR)" and "NS(AR)" denote the Diebold-Li (2006) version of the three-factor Nelson-Siegel model with VAR and AR dynamics of the latent factors, respectively; "$A_0(3)$" refers to the essentially affine latent yield factor model of Duffee (2002), and "RW" denotes the random walk forecast.

$y^{(n)}$	FAVAR	VAR	VARylds	NS(VAR)	NS(AR)	$A_0(3)$	RW
			Panel A: 1-month ahead forecasts				
n=1	0.534	0.334	**0.249**	0.262	0.275	0.681	0.305
n=6	0.496	0.347	**0.204**	0.218	0.256	0.216	0.222
n=12	0.517	0.452	**0.250**	0.268	0.293	0.300	0.259
n=36	0.628	0.771	**0.308**	0.313	0.312	0.386	0.309
n=60	0.676	0.935	0.314	0.316	0.316	0.357	**0.307**
n=120	0.711	1.093	0.293	0.289	0.289	0.289	**0.282**
			Panel B: 6-months ahead forecasts				
n=1	**0.601**	0.707	0.779	0.745	0.838	1.189	0.856
n=6	**0.603**	0.898	0.904	0.871	0.931	0.977	0.853
n=12	**0.694**	1.040	1.006	0.958	0.981	1.059	0.876
n=36	**0.753**	1.278	1.021	0.958	0.922	0.962	0.873
n=60	**0.789**	1.377	0.969	0.915	0.870	0.848	0.830
n=120	0.823	1.435	0.872	0.764	0.720	**0.671**	0.696
			Panel C: 12-months ahead forecasts				
n=1	**0.919**	1.307	1.366	1.448	1.357	1.741	1.395
n=6	**0.977**	1.542	1.613	1.569	1.458	1.487	1.417
n=12	**1.053**	1.652	1.728	1.633	1.495	1.506	1.391
n=36	**1.062**	1.769	1.599	1.504	1.349	1.264	1.236
n=60	**1.066**	1.813	1.464	1.359	1.233	1.076	1.138
n=120	1.072	1.806	1.313	1.108	1.022	**0.853**	0.942

Conclusion: Taylor Rules and Macro Factors

- Piazzesi (2005) and Ang and Piazzesi (2003) show that including Macro Factors and the actions of the Federal Reserve help explaining the dynamics of the term structure.
- Most of the effect of macro factors seem to be concentrated on the short / middle term
  - This behavior makes some sense economically: we have seen from basic economic models that the level of long term bonds is strongly affected by investors' preferences, such as risk aversion.
  - Thus, unobservable factors may simply proxy for time variation in risk preferences, for instance.
- Monch (2007) show that only macro factors can explain most of the variation in yields, and the model forecast yields better than most alternatives.
  - The model implies a large stochastic variation in the market price of risk, supporting the view that macro-economic conditions affect the risk preferences of investors.
- Most of these models still assume the market price of risk exogenously specified.
  - Next step is to obtain preference-based models able to explain the dynamics of bond yields and returns as well as these models with exogenous market price of risk.
    - E.g. Wachter (2005), Buraschi and Jiltsov (2006) use habit formation.
    - E.g. Piazzesi and Schneider (2006) use Epstein and Zin preferences and adaptive learning.

C Blocks and Individual Series

Block Name	Release	Series	Transformation
Mixed 1	Consumer Credit	New car loans at auto finance companies (NSA): loan to value ratio	3
Mixed 1	Consumer Credit	New car loans at auto finance companies (NSA): Amount financed ($)	3
Mixed 1	Retail Sales	Sales: Retail & food services, total (mil of $)	3
Mixed 1	Treasury Statement	Federal govt deficit or surplus (bil of $) (NSA)	3
Mixed 1	U.S. Merchandise Trade	Total merchandise exports, total census basis (mil of $)	3
Mixed 1	U.S. Merchandise Trade	Total merchandise imports, total census basis (mil of $)	3
Mixed 1	U.S. Merchandise Trade	Total merchandise imports (CIF value) (mil of $) (NSA)	3
IP	IP Release	Total	3
IP	IP Release	Final Products and non-industrial supplies	3
IP	IP Release	Final products	3
IP	IP Release	Consumer goods	3
IP	IP Release	Durable consumer goods	3
IP	IP Release	Nondurable consumer goods	3
IP	IP Release	Business equipment	3
IP	IP Release	Materials	3
IP	IP Release	Materials, nonenergy, durables	3
IP	IP Release	Materials, nonenergy, nondurables	3
IP	IP Release	Mfg (NAICS)	3
IP	IP Release	Mfg, durables (NAICS)	3
IP	IP Release	Mfg, nondurables (NAICS)	3
IP	IP Release	Mining (NAICS)	3
IP	IP Release	Utilities (NAICS)	3
IP	IP Release	Energy, total (NAICS)	3
IP	IP Release	Non-energy, total (NAICS)	3
IP	IP Release	Motor vehicles and parts (MVP) (NAICS)	3
IP	IP Release	Computers, comm. equip., semiconductors (CCS) (NAICS)	3
IP	IP Release	Non-energy excl CCS (NAICS)	3
IP	IP Release	Non-energy excl CCS and MVP (NAICS)	3
IP	IP Release	Capacity Utilization: Total (NAICS)	2
IP	IP Release	Capacity Utilization: Mfg (NAICS)	2
IP	IP Release	Capacity Utilization: Mfg, durables (NAICS)	2
IP	IP Release	Capacity Utilization: Mfg, nondurables (NAICS)	2
IP	IP Release	Capacity Utilization: Mining	2
IP	IP Release	Capacity Utilization: Utilities	2
IP	IP Release	Capacity Utilization: Computers, comm. equip., semiconductors	2
IP	IP Release	Capacity Utilization: Mfg excl CCS	2
Mixed 2	New Residential Construction	Privately-owned housing, started: Total (thous)	3
Mixed 2	New Residential Construction	New privately-owned housing authorized: Total (thous)	3
Mixed 2	Philadelphia BOS	Outlook: General activity	2

Block Name	Release	Series	Transformation
Mixed 2	Philadelphia BOS	Outlook: New orders	2
Mixed 2	Philadelphia BOS	Outlook: Shipments	2
Mixed 2	Philadelphia BOS	Outlook: Inventories	2
Mixed 2	Philadelphia BOS	Outlook: Unfilled orders	2
Mixed 2	Philadelphia BOS	Outlook: Prices paid	2
Mixed 2	Philadelphia BOS	Outlook: Prices received	2
Mixed 2	Philadelphia BOS	Outlook Employment	2
Mixed 2	Philadelphia BOS	Outlook: Work hours	2
PPI	Producer Prices	PPI: finished goods (1982=100 for all PPI data)	4
PPI	Producer Prices	PPI: finished goods less food and energy	4
PPI	Producer Prices	PPI: finished consumer goods	4
PPI	Producer Prices	PPI: intermediate materials	4
PPI	Producer Prices	PPI: crude materials	4
PPI	Producer Prices	PPI: finished goods excl food	4
PPI	Producer Prices	PPI: crude nonfood materials less energy	4
PPI	Producer Prices	PPI: crude materials less energy	4
CPI	Consumer Prices	CPI: all items (urban)	4
CPI	Consumer Prices	CPI: food and beverages	4
CPI	Consumer Prices	CPI: housing	4
CPI	Consumer Prices	CPI: apparel	4
CPI	Consumer Prices	CPI: transportation	4
CPI	Consumer Prices	CPI: medical care	4
CPI	Consumer Prices	CPI: commodities	4
CPI	Consumer Prices	CPI: commodities, durables	4
CPI	Consumer Prices	CPI: services	4
CPI	Consumer Prices	CPI: all items less food	4
CPI	Consumer Prices	CPI: all items less food and energy	4
CPI	Consumer Prices	CPI: all items less shelter	4
CPI	Consumer Prices	CPI: all items less medical care	4
GDP & Income	GDP - release	Real GDP growth (annualized quarterly change)	0
GDP & Income	GDP - release	GDP price index	4
GDP & Income	GDP - detail	Sales: Mfg & Trade : Total (mil of chained 96$)	3
GDP & Income	GDP - detail	Sales: Mfg & Trade : Mfg, total (mil of chained 96$)	3
GDP & Income	GDP - detail	Sales: Mfg & Trade : Mfg, durables (mil of chained 96$)	3
GDP & Income	GDP - detail	Sales: Mfg & Trade : Mfg, nondurables (mil of chained 96$)	3
GDP & Income	GDP - detail	Sales: Mfg & Trade : Merchant wholesale (mil of chained 96$)	3
GDP & Income	GDP - detail	Sales: Mfg & Trade : Merchant wholesale, durables (mil of chained 96$)	3
GDP & Income	GDP - detail	Sales: Mfg & Trade : Merchant wholesale, nondurables (mil chained 96$)	3
GDP & Income	GDP - detail	Sales: Mfg & Trade : Retail trade (mil of chained 96$)	3
GDP & Income	GDP - detail	Inventories: Mfg & Trade, Total (mil of chained 96$)	3
GDP & Income	GDP - detail	Inventories: Mfg & Trade, Mfg (mil of chained 96$)	3
GDP & Income	GDP - detail	Inventories: Mfg & Trade, Mfg, durables (mil of chained 96$)	3

Block Name	Release	Series	Transformation
GDP & Income	GDP - detail	Inventories: Mfg & Trade, Mfg, nondurables (mil of chained 96$)	3
GDP & Income	GDP - detail	Inventories: Mfg & Trade, Merchant wholesale (mil of chained 96$)	3
GDP & Income	GDP - detail	Inventories: Mfg & Trade, Retail trade (mil of chained 96$)	3
GDP & Income	Personal Income	Real disposable personal income	3
GDP & Income	Personal Income	PCE: Total (bil of chained 96$)	3
GDP & Income	Personal Income	PCE: Durables (bil of chained 96$)	3
GDP & Income	Personal Income	PCE: Nondurables (bil of chained 96$)	3
GDP & Income	Personal Income	PCE: Services (bil of chained 96$)	3
GDP & Income	Personal Income	PCE: Durables - MVP - New autos (bil of chained 96$)	3
GDP & Income	Personal Income	PCE chain weight price index: Total	4
GDP & Income	Personal Income	PCE prices: total excl food and energy	4
GDP & Income	Personal Income	PCE prices: durables	4
GDP & Income	Personal Income	PCE prices: nondurables	4
GDP & Income	Personal Income	PCE prices: services	4
Housing	Manufactured Homes	Mobile homes – mfg shipments (thous)(SA)	3
Housing	New Residential Sales	New 1-family houses sold: Total (thous)	3
Housing	New Residential Sales	New 1-family houses – months supply @ current rate	3
Housing	New Residential Sales	New 1-family houses for sale at end of period (thous)	3
Surveys 1	Chicago Fed MMI Survey	Chicago Fed Midwest Mfg Survey: General activity	3
Surveys 1	Consumer Confidence Index	Index of consumer confidence	2
Surveys 1	Michigan Survey	Michigan Survey: Index of consumer sentiment	2
Initial Claims	Claims (wkly Thurs.)	Avg weekly initial claims	3
Interest Rates	Freddie Mac (wkly Wed.)	Primary market yield on 30-year fixed mortgage	2
Interest Rates	H.15 (daily)	Interest rate: federal funds rate	2
Interest Rates	H.15 (daily)	Interest rate: U.S. 3-mo Treasury (sec. Market)	2
Interest Rates	H.15 (daily)	Interest rate: U.S. 6-mo Treasury (sec. Market)	2
Interest Rates	H.15 (daily)	Interest rate: 1-year Treasury (constant maturity)	2
Interest Rates	H.15 (daily)	Interest rate: 5-year Treasury (constant maturity)	2
Interest Rates	H.15 (daily)	Interest rate: 7-year Treasury (constant maturity)	2
Interest Rates	H.15 (daily)	Interest rate: 10-year Treasury (constant maturity)	2
Interest Rates	H.15 (daily)	Bond yield: Moodys AAA corporate	2
Interest Rates	H.15 (daily)	Bond yield: Moodys BAA corporate	2
Financial	H.10	Nominal effective exchange rate	3
Financial	H.10	Spot Euro/US (2)	3
Financial	H.10	Spot SZ/US	3
Financial	H.10	Spot Japan/US	3
Financial	H.10	Spot UK/US	3
Financial	H.10	Spot CA/US	3
Financial	London PM Fix (daily)	Price of gold ($/oz) on the London market (recorded in the p.m.)	4
Financial	NYSE	NYSE composite index	3
Financial	NYSE	NYSE : industrial	3
Financial	NYSE	NYSE: utilities	3

Block Name	Release	Series	Transformation
Financial	S&P	S&P composite	3
Financial	S&P (wkly)	S&P dividend yield	3
Financial	S&P (wkly)	S&P P/E ratio	3
Financial	Wilshire (daily)	Wilshire composite index	3
Surveys 2	PMGR-Manufacturing	Purchasing Managers Index (PMI)	2
Surveys 2	PMGR-Manufacturing	ISM mfg index: production (Institute for Supply Management)	2
Surveys 2	PMGR-Manufacturing	ISM mfg index: Employment	2
Surveys 2	PMGR-Manufacturing	ISM mfg index: inventories	2
Surveys 2	PMGR-Manufacturing	ISM mfg index: new orders	2
Surveys 2	PMGR-Manufacturing	ISM mfg index: suppliers deliveries	2
Mixed 3	Commercial Paper	Commercial paper month-end outstanding: Total (mil of $)	3
Mixed 3	Construction Put in Place	Construction put in place: Total (mil of current $)	3
Mixed 3	Construction Put in Place	Construction put in place: Private (mil of current $)	3
Mixed 3	Advance Durables / M3	New Orders: Durable goods industries (mil of $)	3
Mixed 3	Advance Durables / M3	New Orders: Nondefense capital goods (mil of $)	3
Mixed 3	M3	New Orders: All manufacturing industries (mil of $)	3
Mixed 3	M3	New Orders: All manuracturing industries w/unfilled orders (mil of $)	3
Mixed 3	M3	New Orders: Nondurable goods industries (mil of $)	3
Mixed 3	M3	Unfilled Orders: All manufacturing industries (mil of $)	3
Money & Credit	Consumer Delinq. Bulletin	Delinquency rate on bank-held consumer installment loans	3
Money & Credit	H.3	Monetary base (mil of $)	3
Money & Credit	H.3	Depository institutions reserves: Total (mil of $)	3
Money & Credit	H.3	Depository institutions: nonborrowed (mil of $)	3
Money & Credit	H.6	M1 (mil of $)	3
Money & Credit	H.6	M2 (mil of $)	3
Money & Credit	H.6	M3 (mil of $)	3
Money & Credit	H.8	Loans and Securities @ all commercial banks: Total (mil of $)	3
Money & Credit	H.8	Loans and Securities @ all comm banks: Securities, total (mil of $)	3
Money & Credit	H.8	Loans and Securities @ all comm banks: Securities, U.S. govt (mil of $)	3
Money & Credit	H.8	Loans and Securities @ all comm banks: Real estate loans (mil of $)	3
Money & Credit	H.8	Loans and Securities @ all comm banks: Comm and Indus loans (mil of $)	3
Money & Credit	H.8	Loans and Securities @ all comm banks: Consumer loans (mil of $)	3
Labor & Wages	Employment Situation	Unemployment rate	2
Labor & Wages	Employment Situation	Participation rate	2
Labor & Wages	Employment Situation	Mean duration of unemployment	3
Labor & Wages	Employment Situation	Persons unemployed less than 5 weeks	3
Labor & Wages	Employment Situation	Persons unemployed 5 to 14 weeks	3
Labor & Wages	Employment Situation	Persons unemployed 15 to 26 weeks	3
Labor & Wages	Employment Situation	Persons unemployed 15+ weeks	3
Labor & Wages	Employment Situation	Employment on nonag payrolls: Total	3
Labor & Wages	Employment Situation	Employment on nonag payrolls: Total private	3
Labor & Wages	Employment Situation	Employment on nonag payrolls: Goods-producing	3

Block Name	Release	Series	Transformation
Labor & Wages	Employment Situation	Employment on nonag payrolls: Mining	3
Labor & Wages	Employment Situation	Employment on nonag payrolls: Construction	3
Labor & Wages	Employment Situation	Employment on nonag payrolls: Manufacturing	3
Labor & Wages	Employment Situation	Employment on nonag payrolls: Manufacturing, durables	3
Labor & Wages	Employment Situation	Employment on nonag payrolls: Manufacturing, nondurables	3
Labor & Wages	Employment Situation	Employment on nonag payrolls: Service-producing	3
Labor & Wages	Employment Situation	Employment on nonag payrolls: Transportation and warehousing	3
Labor & Wages	Employment Situation	Employment on nonag payrolls: Utilities	3
Labor & Wages	Employment Situation	Employment on nonag payrolls: Retail trade	3
Labor & Wages	Employment Situation	Employment on nonag payrolls: Wholesale trade	3
Labor & Wages	Employment Situation	Employment on nonag payrolls: Financial activities	3
Labor & Wages	Employment Situation	Employment on nonag payrolls: Professional and business services	3
Labor & Wages	Employment Situation	Employment on nonag payrolls: education and health services	3
Labor & Wages	Employment Situation	Employment on nonag payrolls: leisure and hospitality	3
Labor & Wages	Employment Situation	Employment on nonag payrolls: Other services	3
Labor & Wages	Employment Situation	Employment on nonag payrolls: Government	3
Labor & Wages	Employment Situation	Avg weekly hrs. of production of nonsupervisory workers: Total private	3
Labor & Wages	Employment Situation	Avg weekly hrs of PNW: Mfg	3
Labor & Wages	Employment Situation	Avg weekly overtime hrs of PNW: Mfg	3
Labor & Wages	Employment Situation	Avg hourly earnings: Total nonagricultural ($)	4
Labor & Wages	Employment Situation	Avg hourly earnings: construction ($)	4
Labor & Wages	Employment Situation	Avg hourly earnings: Mfg ($)	4
Labor & Wages	Employment Situation	Avg hourly earnings: Transportation ($)	4
Labor & Wages	Employment Situation	Avg hourly earnings: Retail trade ($)	4
Labor & Wages	Employment Situation	Avg hourly earnings: wholesale trade ($)	4
Labor & Wages	Employment Situation	Avg hourly earnings: finance, insurance, and real estate ($)	4
Labor & Wages	Employment Situation	Avg hourly earnings: professional and business services ($)	4
Labor & Wages	Employment Situation	Avg hourly earnings: education and health services ($)	4
Labor & Wages	Employment Situation	Avg hourly earnings: other services ($)	4