The Term Structure of Real Rates and Expected Inflation

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Motivation

- Changes in nominal yields must be due to variation in
  - Real Rates
  - Expected Inflation
  - Inflation Risk Premia

$$\underbrace{y_t^{(n)}}_{\substack{\text{Nominal} \\ \text{Rate}}} = \underbrace{\hat{y}_t^{(n)}}_{\substack{\text{Real} \\ \text{Rate}}} + \underbrace{\mathrm{E}_t[\pi_{t+n,n}]}_{\substack{\text{Expected} \\ \text{Inflation}}} + \underbrace{\varphi_{t,n}}_{\substack{\text{Inflation Risk} \\ \text{Premium}}}$$

- But, for most of the history of the U.S., real rates are unobserved

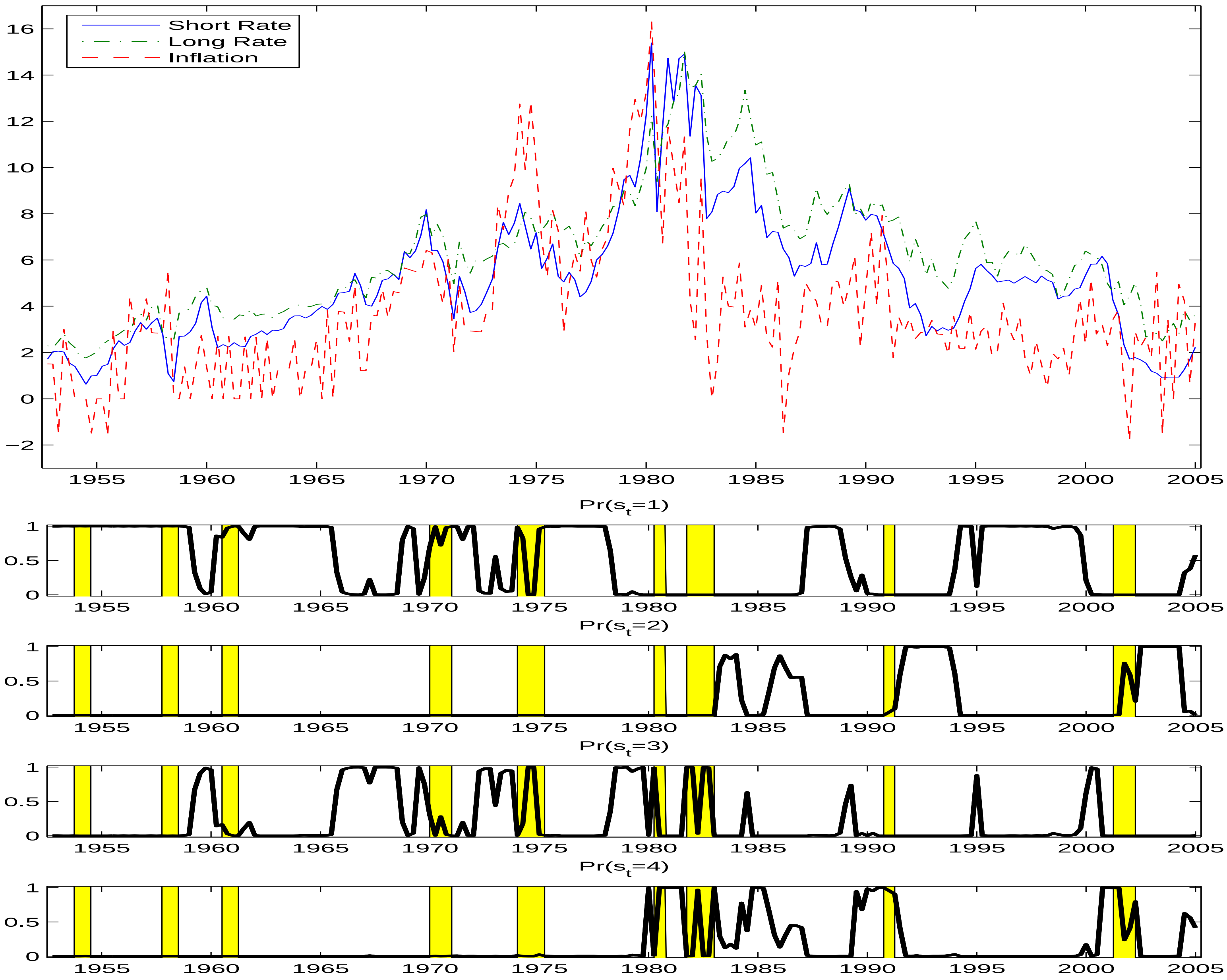
$\Rightarrow$ Use a term structure model with regime switches and time-varying prices of risk

Regime-Switching Term Structure Model

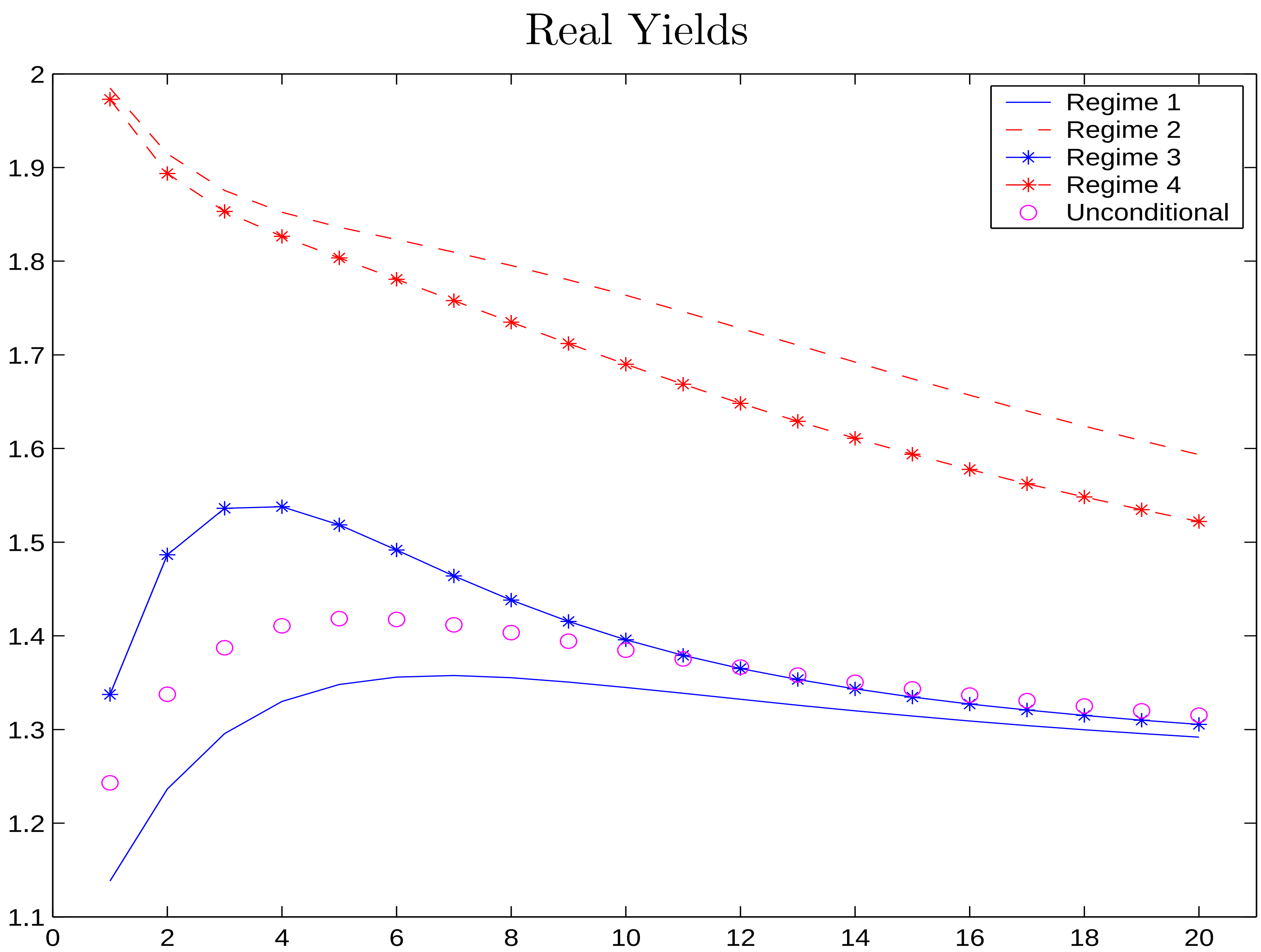
- No Arbitrage
- Differentiates between the real versus nominal pricing kernel
- Uses inflation (π_t) as an observed macro factor in addition to two latent variables:
  - q_t: captures variation in the price of risk
  - f_t: affects real rates and inflation
- Introduces persistent regime switches
  - Changes of regime in real factors
  - Changes of regime in inflation

Summary of Regimes

		Real Rates	Inflation	% Time
$s_t = 1$	$s_t^f = 1, s_t^\pi = 1$	Low and Stable	High and Stable	72%
	"Normal" regime			
$s_t = 2$	$s_t^f = 1, s_t^\pi = 2$	High and Volatile	Low and Stable	4%
	"Disinflation" regime; real curve downward sloping			
$s_t = 3$	$s_t^f = 2, s_t^\pi = 1$	Low and Volatile	Highest and Volatile	20%
	Volatile real rates and inflation; inflation is high			
$s_t = 4$	$s_t^f = 2, s_t^\pi = 2$	High and Most Volatile	Low and Volatile	4%
	"Disinflation" regime; real curve downward sloping			



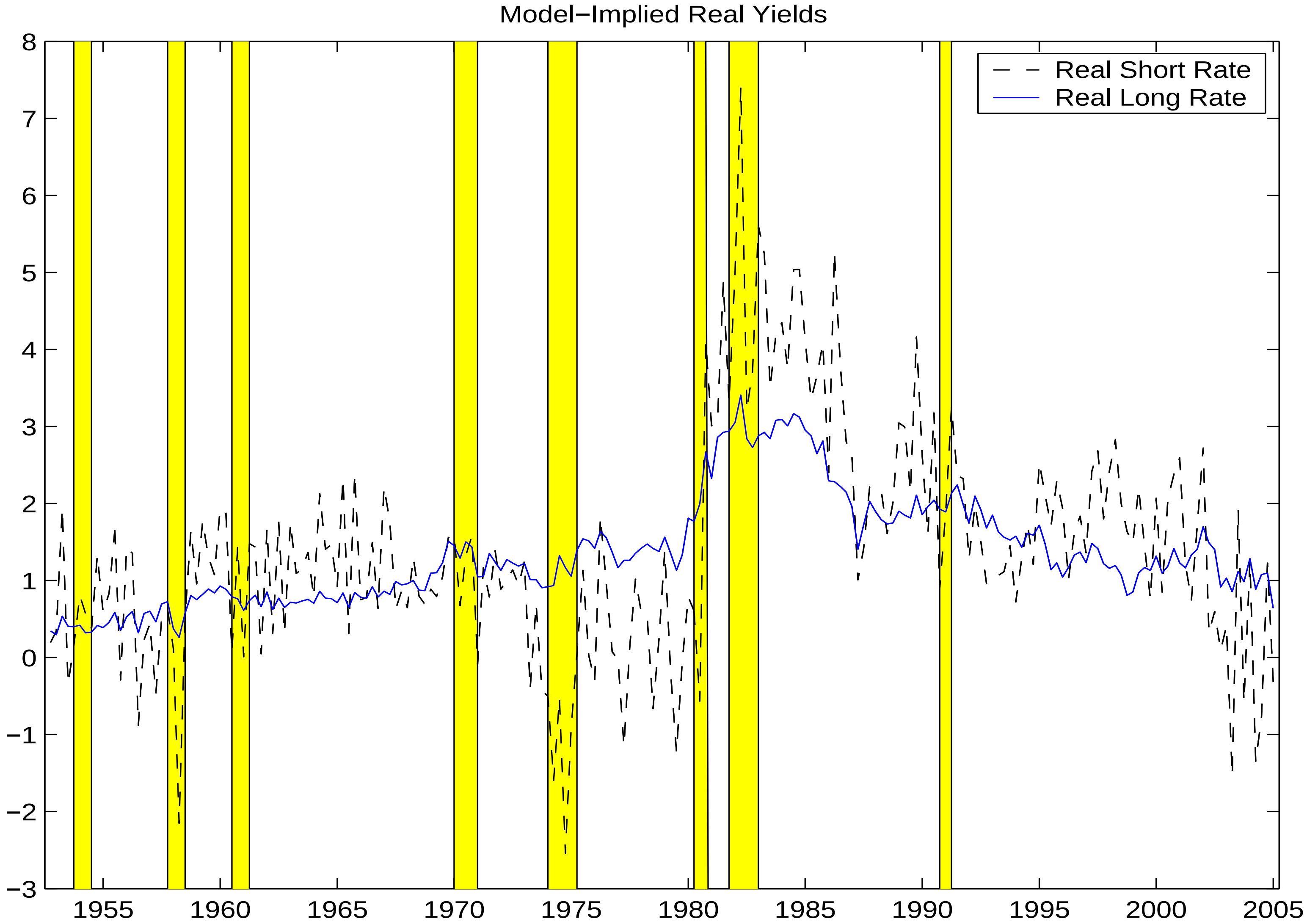
Short Rate
Long Rate
Inflation
16
14
12
10
8
6
4
2
0
−2
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
Pr(s_t=1)
Pr(s_t=2)
Pr(s_t=3)
Pr(s_t=4)
1
0.5
0


Real Yields
Regime 1
Regime 2
Regime 3
Regime 4
Unconditional
2
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
0
2
4
6
8
10
12
14
16
18
20

Summary of Findings

- **Unconditionally, the term structure of real rates assumes a fairly flat shape around 1.3%, with a slight hump, peaking at a 1-year maturity. However, there are some regimes in which the real rate curve is downward sloping.**

Real Yields



Model−Implied Real Yields
Real Short Rate
Real Long Rate
8
7
6
5
4
3
2
1
0
−1
−2
−3
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005

Summary of Findings

- Unconditionally, the term structure of real rates assumes a fairly flat shape around 1.3%, with a slight hump, peaking at a 1-year maturity. However, there are some regimes in which the real rate curve is downward sloping.
- **Real rates are quite variable at short maturities but smooth and persistent at long maturities. There is no significant real term spread.**

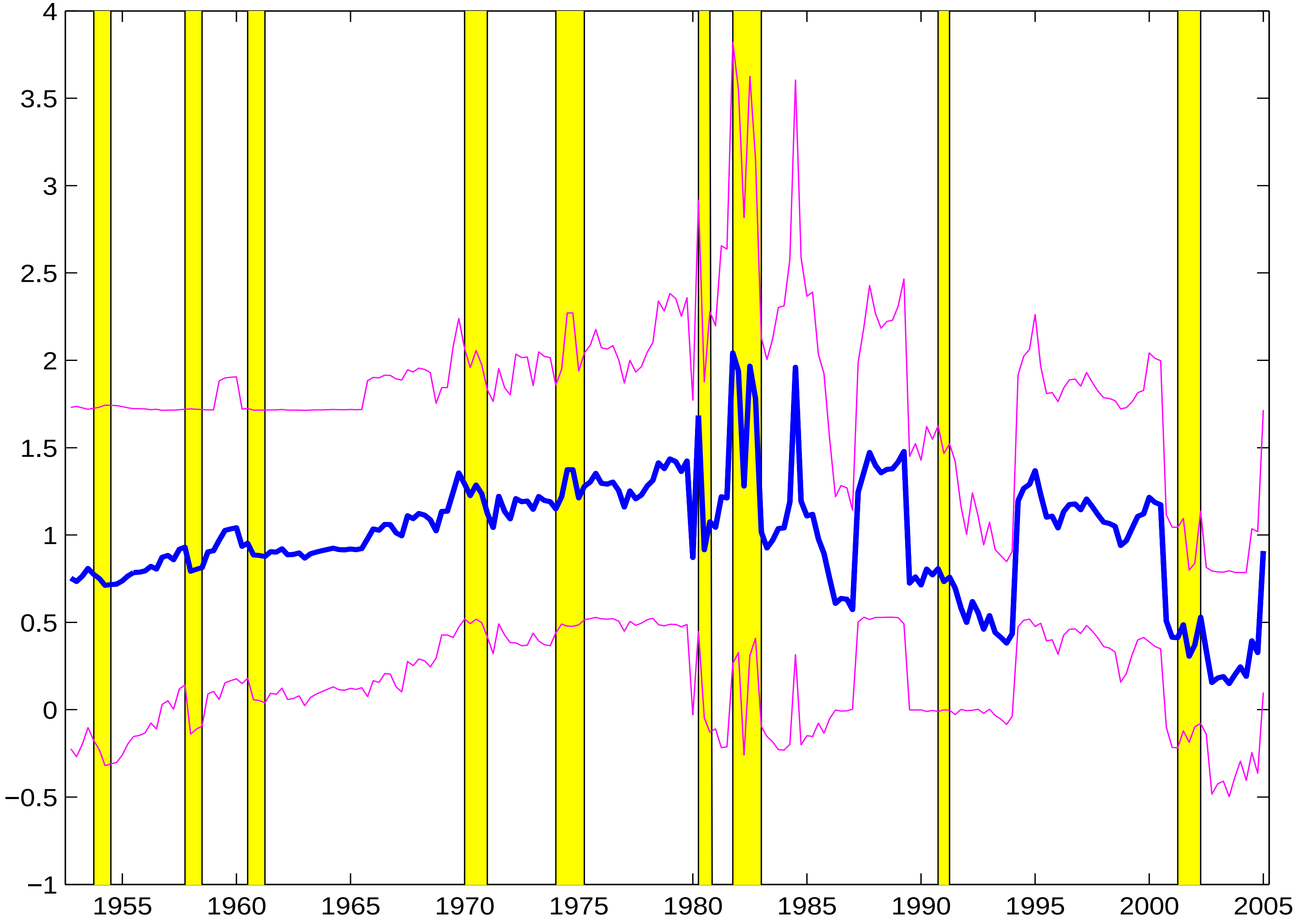
Expected Inflation and Inflation Risk

Qtrs	$s_t = 1$	$s_t = 2$	$s_t = 3$	$s_t = 4$	Unconditional
Expected Inflation $\mathrm{E}_t(\pi_{t+n,n})$					
1	3.93	2.47	4.44	3.21	3.94
4	3.89	2.63	4.48	3.47	3.94
20	3.91	3.39	4.20	3.82	3.94
Inflation Compensation $\pi^e_{t,n} = y_t^{(n)} - \hat{y}_t^{(n)}$					
1	3.92	2.46	4.43	3.20	3.94
4	4.20	2.49	4.95	3.34	4.25
20	5.09	3.80	5.45	4.36	5.08

Summary of Findings

- Unconditionally, the term structure of real rates assumes a fairly flat shape around 1.3%, with a slight hump, peaking at a 1-year maturity. However, there are some regimes in which the real rate curve is downward sloping.
- Real rates are quite variable at short maturities but smooth and persistent at long maturities. There is no significant real term spread.
- **The model matches an unconditional upward-sloping nominal yield curve by generating an inflation risk premium that is increasing in maturity.**

Inflation Risk Premium



Decomposition of Nominal Yield Levels

Maturity Qtrs	Real Rates	Expected Inflation	Inflation Risk
1	0.20	0.80	0.00
	(0.09)	(0.09)	(0.00)
20	0.20	0.71	0.10
	(0.09)	(0.09)	(0.08)

Summary of Findings

- **The decompositions of nominal yields into real yields and expected inflation at various horizons indicate that variation in expected inflation and inflation risk premiums explain about 80% of the variation in nominal rates at both short and long maturities.**

Decomposition of Nominal Yield Spreads

	Unconditional			Conditional on Regime 1		
Maturity n	Real	Exp Infl	Infl Prem	Real	Exp Infl	Infl Prem
4	0.44	0.56	-0.01	0.14	0.87	-0.01
	(0.15)	(0.15)	(0.00)	(0.19)	(0.19)	(0.00)
20	0.19	0.85	-0.05	0.04	1.03	-0.08
	(0.18)	(0.18)	(0.02)	(0.20)	(0.20)	(0.03)

Summary of Findings

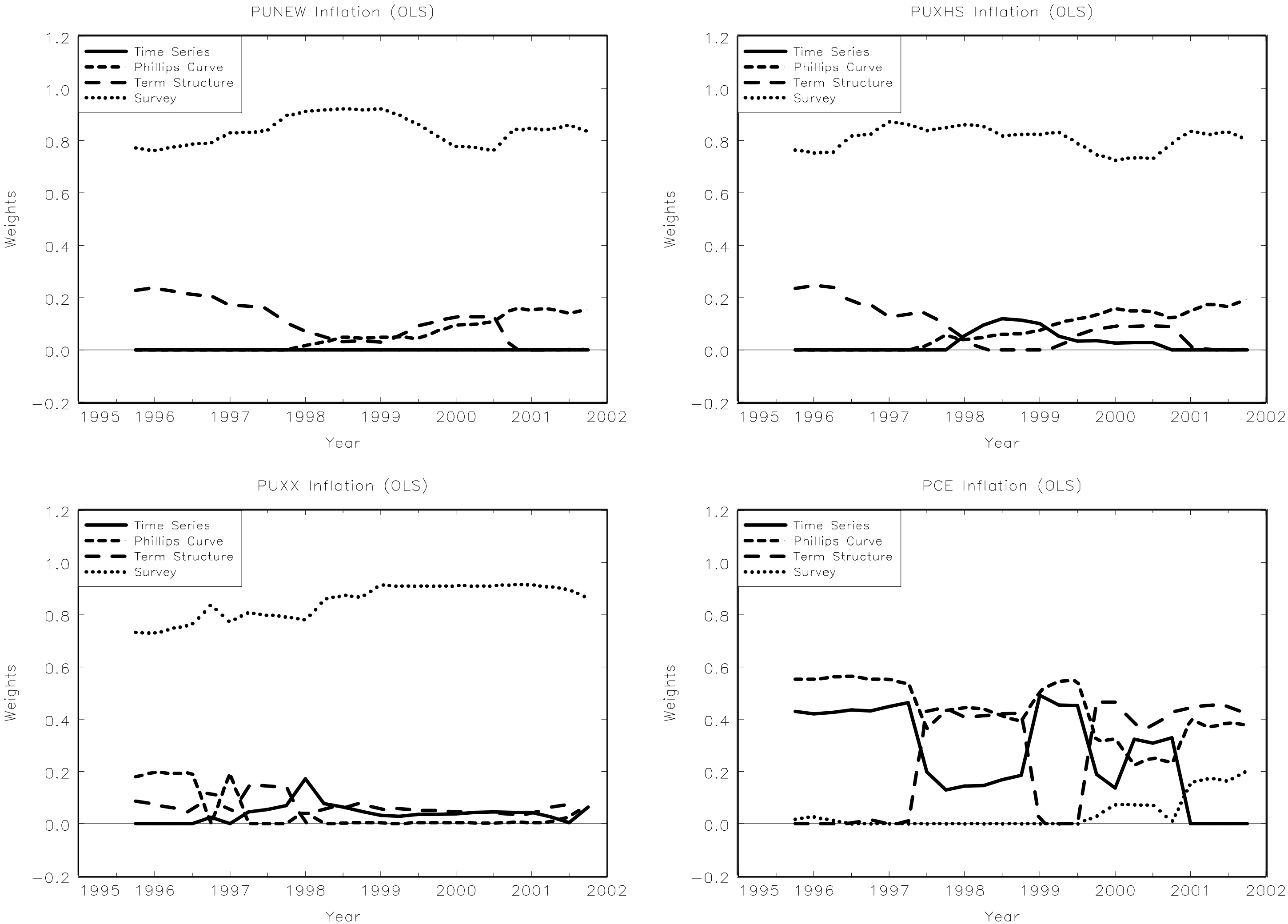
- The decompositions of nominal yields into real yields and expected inflation at various horizons indicate that variation in expected inflation and inflation risk premiums explain about 80% of the variation in nominal rates at both short and long maturities.
- **Inflation risk is the main determinant of nominal interest rate spreads.**

Forecasting Inflation Application

- Clearly inflation and inflation risk are important determinants of nominal yields

⇒ How does the model fare in forecasting future inflation?

- Advantages:
  - Can use all available term structure information
  - Estimates (time-varying) inflation risk
- Examined in Ang, Bekaert and Wei (2007, JME)


PUNEW Inflation (OLS)
PUXHS Inflation (OLS)
PUXX Inflation (OLS)
PCE Inflation (OLS)
Time Series
Phillips Curve
Term Structure
Survey
Weights
Year
1.2
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
1995
1996
1997
1998
1999
2000
2001
2002

Concluding Comments – The Way Ahead

- Use survey expectations to calibrate term structure models with inflation factors

  [Pennachchi (1991), Kim (2004), Chernov and Mueller (2007)]
- Why do surveys do so well?
- Use real bonds

  [Barr and Campbell (1997), Evans (2003)]
- Monetary versus econometric regimes
- Linking deviations from the Fisher Hypothesis with deviations from the Expectation Hypothesis