Are Bond Premia Countercyclical?

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Motivation

- stylized fact: excess returns on long bonds are predictable

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- definitions

  - log excess return on zero coupon bond of maturity n years, held for 1 year

    $= $ log price next year $-$ log price today $-$ 1 year interest rate

    $$= p_{t+1}^{(n-1)} - p_t^{(n)} - i_t^{(1)} := x_{t+1}^{(n)}$$

  - predictability: premium $E_t x_{t+1}^{(n)}$ moves around

    E_t computed from statistical model –> "*statistical* premium"

    e.g., fitted value from regressing $x_{t+1}^{(n)}$ on time-t variables

Motivation

- stylized fact: excess returns on long bonds are predictable

= statistical premium $E_t x_{t+1}^{(n)}$ moves around

  - higher after recessions, lower at end of booms
  - higher in early 1980s, low in 1970s

- common interpretation: statistical premium $E_t x_{t+1}^{(n)}$ is compensation for risk

  - more risk compensation after recessions & in early 1980s

$\Rightarrow$ economic models must explain changes in compensation for risk

requires large time variation in risk (e.g. heteroskedasticity in consumption) or time varying risk aversion (e.g. from habit formation)

This paper

- statistical premium $E_t x_{t+1}^{(n)}$ is based on statistical analysis and hindsight.

- investors face *subjective* premium at date t, $E_t^* x_{t+1}^{(n)}$

−> measure subjective premium from surveys

- decompose statistical premium

$$E_t x_{t+1}^{(n)} = E_t^* x_{t+1}^{(n)} + \left(E_t x_{t+1}^{(n)} - E_t^* x_{t+1}^{(n)} \right)$$

  ask how much of stylized fact is due to forecast differences?

- study economic model with subjective expectations, where
  - subjective premium $E_t^* x_{t+1}^{(n)}$ is compensation for risk
  - statistical premium $E_t x_{t+1}^{(n)}$ reflects forecast differences

Message

- It's hard to forecast in real time!

  Relative to regressions run today with hindsight, surveys miss changes in

  - the slope of the yield curve, e.g. decreases after recessions
  - the level of the yield curve, e.g. decreases in early 1980s

$\Rightarrow$ Different interpretation of stylized fact:

  - common interpretation:
    statistical premium $E_t x_{t+1}^{(n)}$ is risk compensation
    more risk compensation in recessions & early 1980s
  - our interpretation:
    statistical premium $E_t x_{t+1}^{(n)}$ partly due to measurement,
    larger forecast differences in recessions & early 1980s

Outline

1. document properties of interest-rate survey forecasts

   statistical premia move with forecast differences

2. reduced form model of interest rates & inflation

   (a) estimate distribution with data

   (b) estimate subjective distribution with survey data, many maturities & horizons

   ⇒ under subj. distribution, level & slope of yield curve are more persistent

   ⇒ subjective premium much less volatile & cyclical, especially for long maturities

3. economic model

   prices are functions of agents' expectations about payoffs & current positions

Related Literature

- predictability regressions

  Fama & Bliss 1987, Campbell & Shiller 1991, etc

- statistical analysis of interest rate survey data

  Froot 1989, Kim & Orphanides 2007, Chernov & Mueller 2008

- role of survey expectations in other markets

  Frankel & Froot 1989, Gourinchas & Tornell 2004, Bacchetta & al. 2008

- EZ preferences

  Epstein & Zin 1989, Bansal & Yaron 2004, Campbell & al. 2003

Properties of Survey Forecasts

- 2 datasets: Goldsmith-Nagan surveys 1970-1986 & Bluechip surveys 1983 - today

- each quarter, 40 market participants are asked about their interest-rate expectations

- max horizons: 2 quarters for GN, 1 year for Bluechip

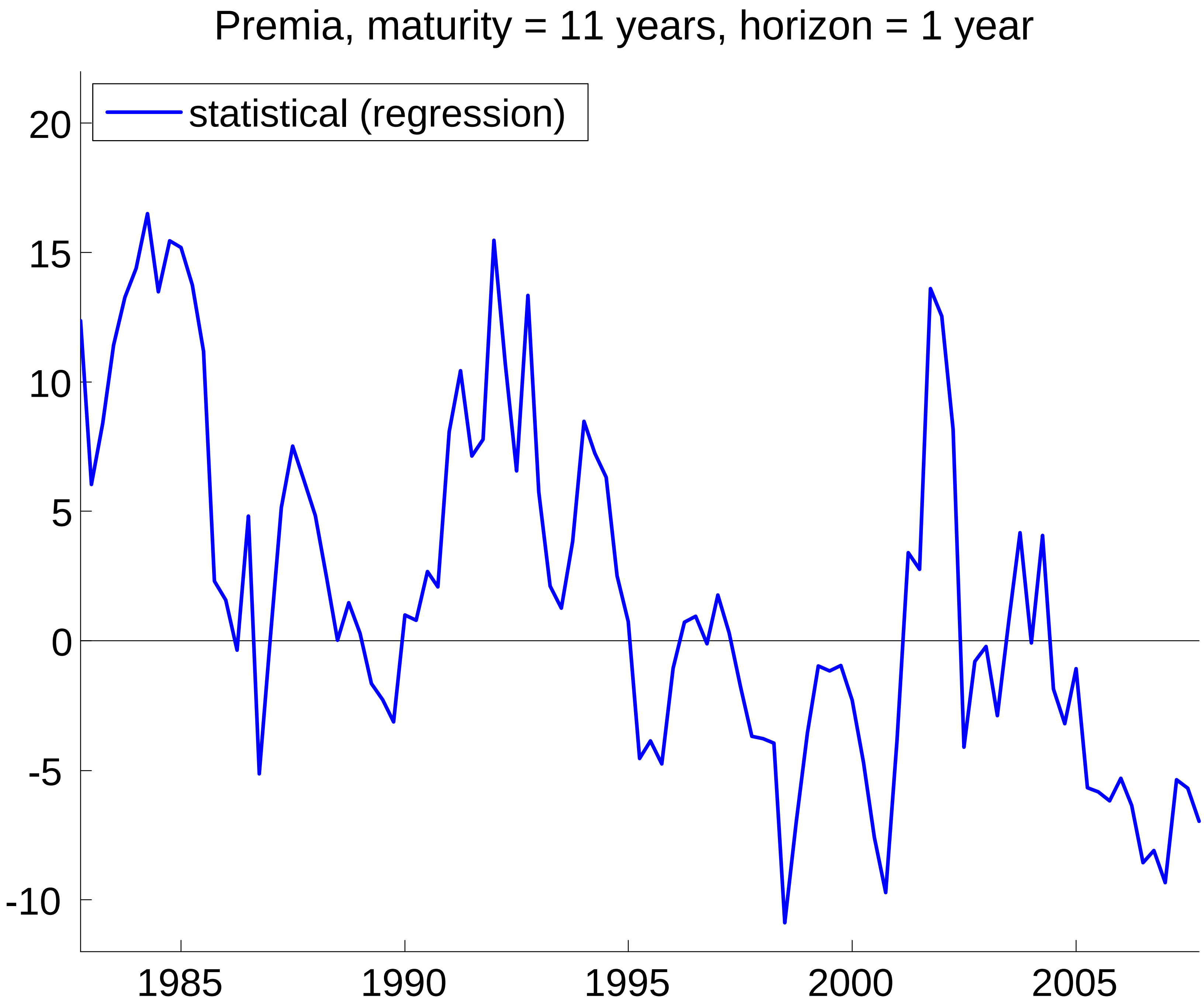
- decomposition for bond of maturity n years, held for horizon h years

$$E_t x_{t+h}^{(n)} = E_t^* x_{t+h}^{(n)} + \left(E_t x_{t+h}^{(n)} - E_t^* x_{t+h}^{(n)} \right)$$

  - measure $E_t x_{t+h}^{(n)}$ with regressions

  - measure $E_t^* x_{t+h}^{(n)} = E_t^* p_{t+h}^{(n-h)} - p_t^{(n)} - i_t^{(h)}$
    with interest-rate surveys $E_t^* p_{t+1}^{(n-1)} = -(n-1) E_t^* i_{t+1}^{(n-1)}$

evaluate for $n = 11$ years, $h = 1$ year for Bluechip


Premia, maturity = 11 years, horizon = 1 year
statistical (regression)
20
15
10
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0
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1985
1990
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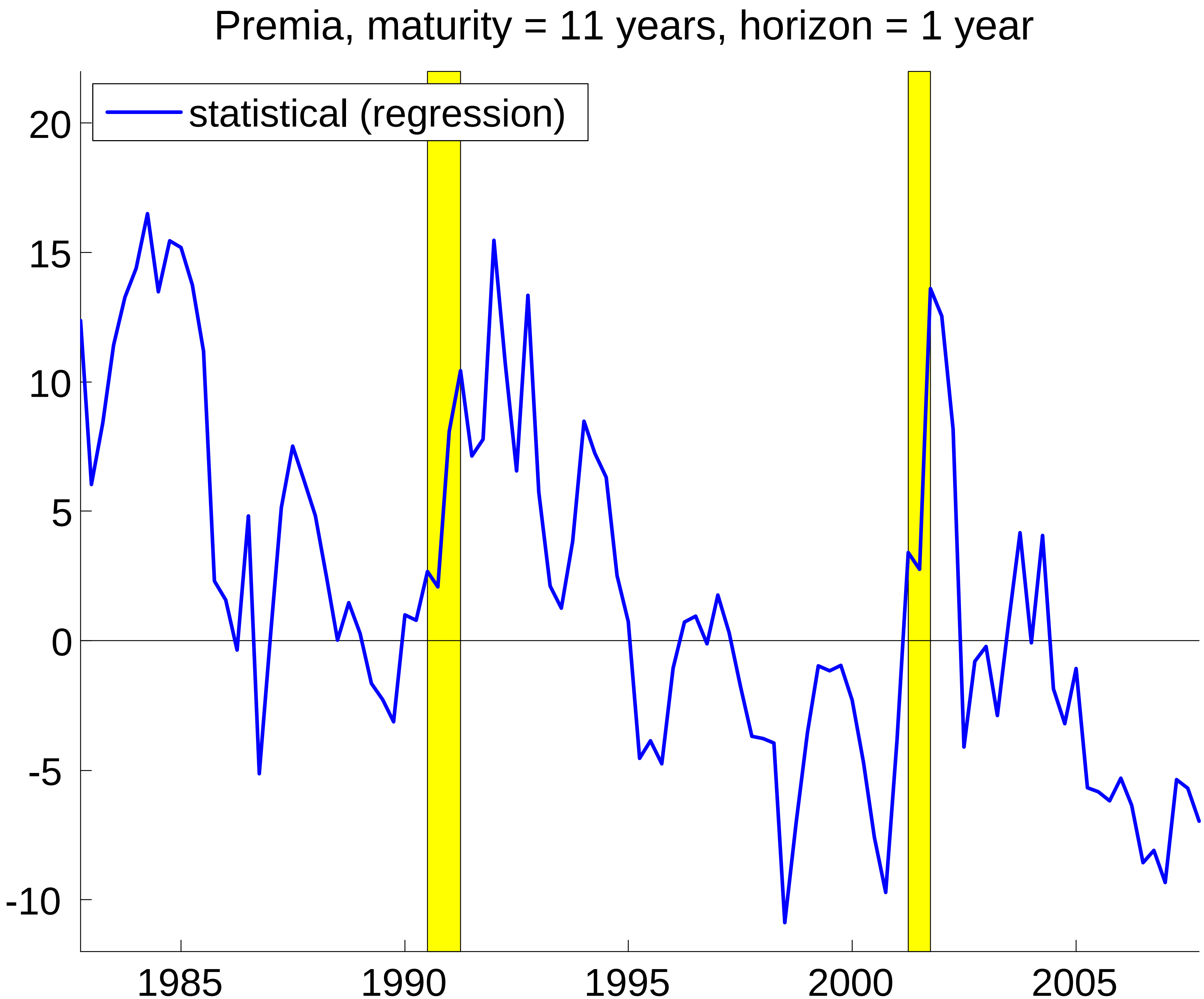
2005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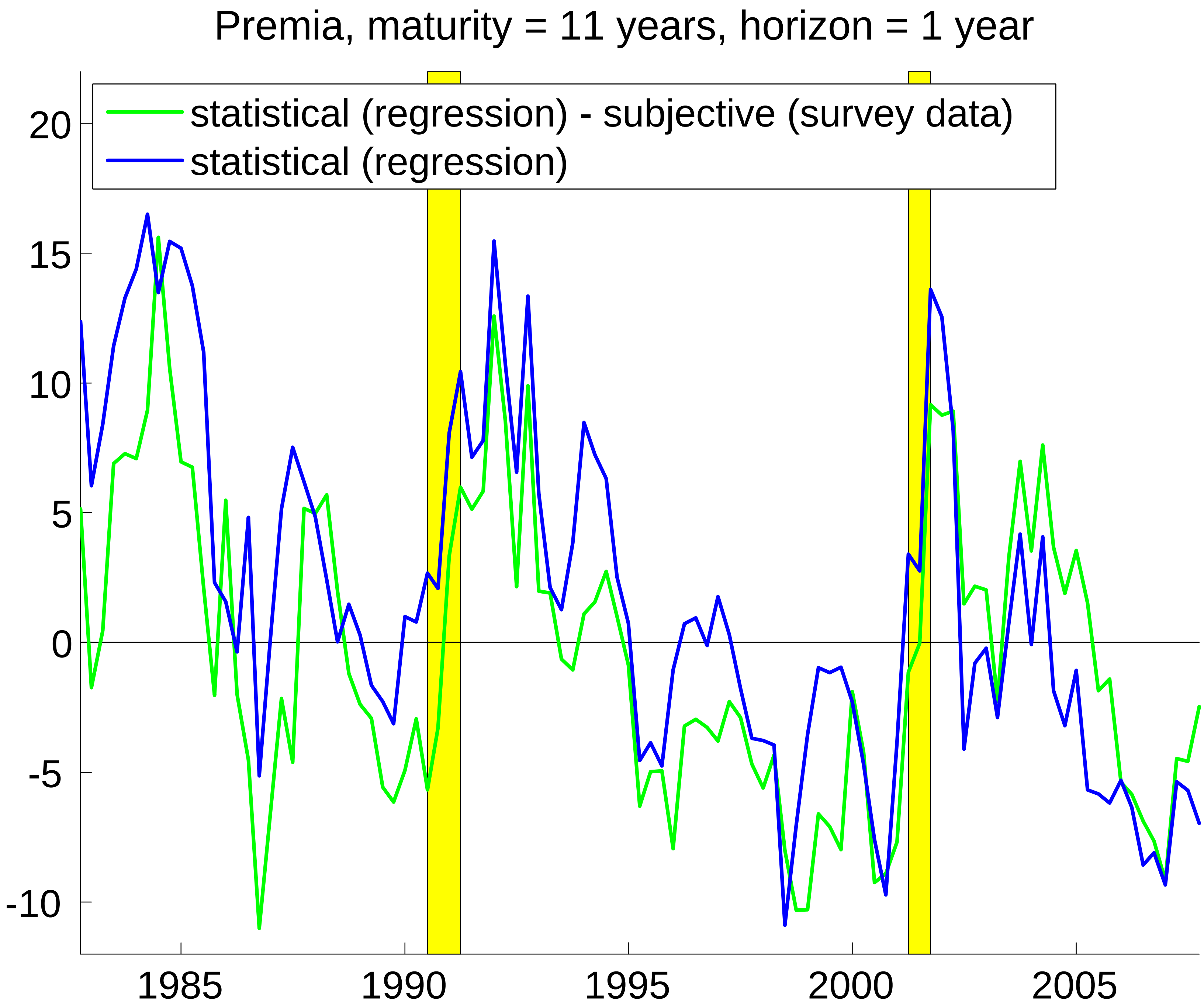
Premia, maturity = 11 years, horizon = 1 year
statistical (regression) - subjective (survey data)
statistical (regression)
20
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0
-5
-10
1985
1990
1995
2000
2005

Properties of Survey Forecasts

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- each quarter, 40 market participants are asked about their interest-rate expectations

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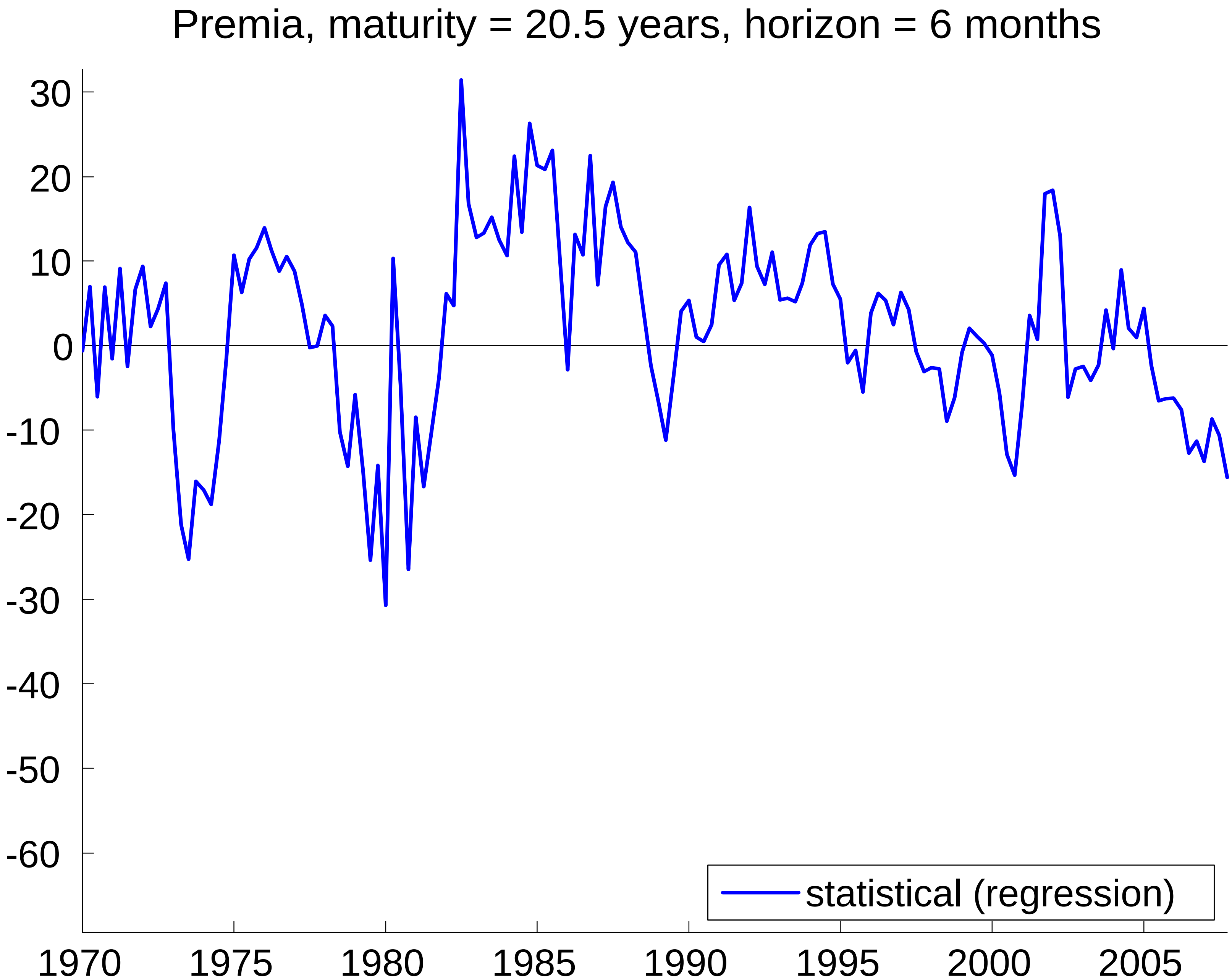
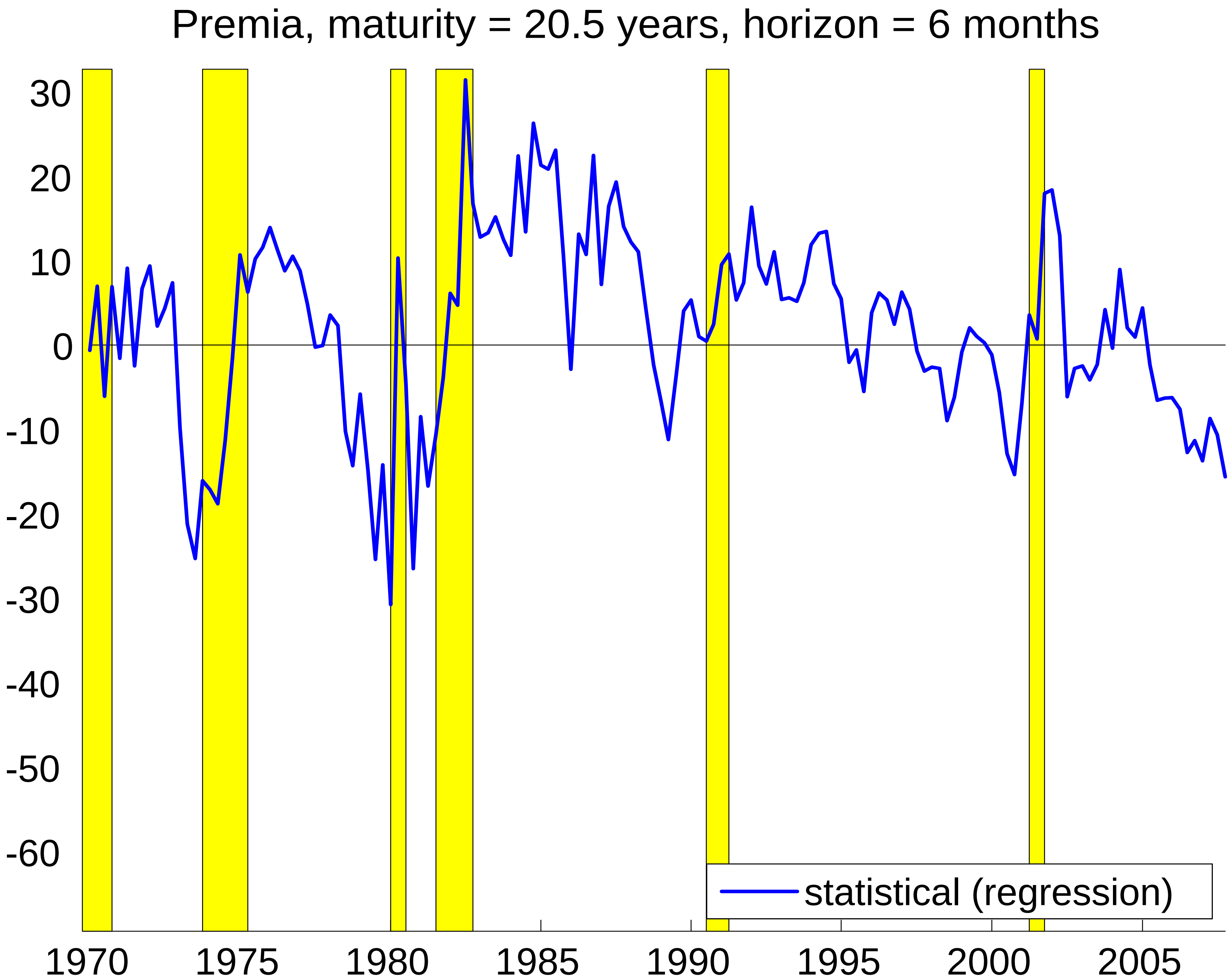
$$E_t x_{t+h}^{(n)} = E_t^* x_{t+h}^{(n)} + \left(E_t x_{t+h}^{(n)} - E_t^* x_{t+h}^{(n)} \right)$$

  – measure $E_t x_{t+h}^{(n)}$ with regressions

  – measure $E_t^* x_{t+h}^{(n)} = E_t^* p_{t+h}^{(n-h)} - p_t^{(n)} - i_t^{(h)}$
  with interest-rate surveys $E_t^* p_{t+1}^{(n-1)} = -(n-1)\, E_t^* i_{t+1}^{(n-1)}$

evaluate for $n = 20.5$ years, $h = .5$ years, combining GN & Bluechip


Premia, maturity = 20.5 years, horizon = 6 months
30
20
10
0
-10
-20
-30
-40
-50
-60
1970
1975
1980
1985
1990
1995
2000
2005
statistical (regression)



Premia, maturity = 20.5 years, horizon = 6 months
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0
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-20
-30
-40
-50
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1970
1975
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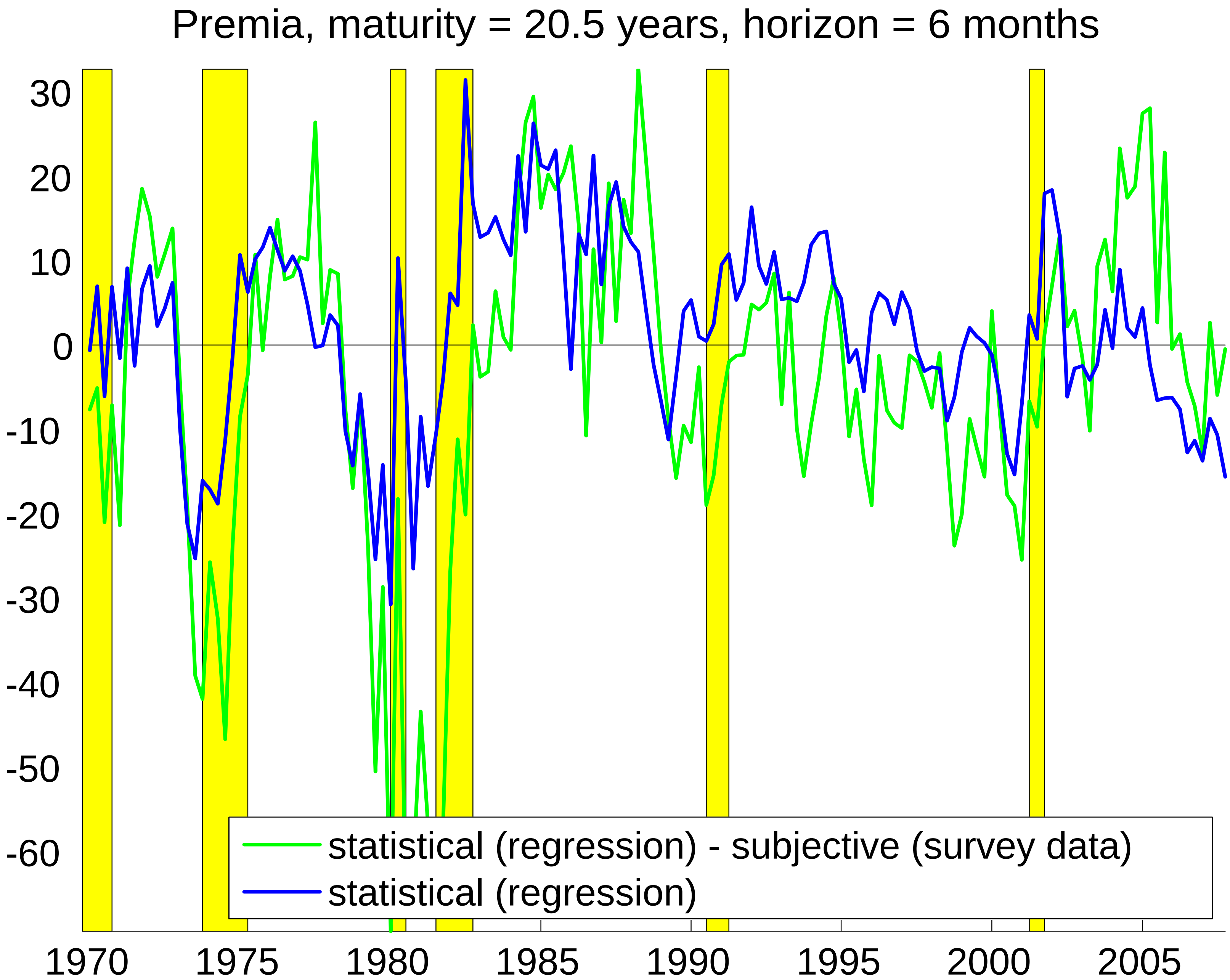
2005
statistical (regression)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-20
-30
-40
-50
-60
1970
1975
1980
1985
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1995
2000
2005
statistical (regression) - subjective (survey data)
statistical (regression)

Outline

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   statistical premia move with forecast differences

2. reduced form model of interest rates & inflation

   (a) estimate distribution with data

   (b) estimate subjective distribution with survey data, many maturities & horizons

   (c) under subj. distribution, level & slope of yield curve are more persistent

   (d) subjective premium much less volatile & cyclical, especially for long maturities

3. economic model

   prices are functions of agents' expectations about payoffs & current positions

Reduced form model

- capture distribution of bond returns of all maturities

- quarterly state space system

- observables: short rate $i_t^{(1)}$, spread $i_t^{(20)} - i_t^{(1)}$ and inflation

$$\begin{aligned} \text{observables}_t &= \mu_h + \eta_h \text{ state variables}_{t-1} + e_t \\ \text{state variables}_t &= \phi_s \text{ state variables}_{t-1} + \sigma_s e_t \end{aligned}$$

- estimate using MLE -$>$ statistical model

Subjective state space system

- *subjective* system

$$\text{observables}_t = \mu_h^* + \eta_h^* \text{state variables}_{t-1} + e_t^*$$
$$\text{state variables}_t = \phi_s^* \text{ state variables}_{t-1} + \sigma_s e_t^*$$

- estimation
  - compute conditional expectations from subjective system
  - identify *-parameters by matching these expectations to survey forecasts
  - survey data for *many maturities & horizons* from Goldsmith-Nagan, Bluechip inflation forecasts from Survey of Professional Forecasters

Yield Curve

- absence of arbitrage => existence of risk neutral probability measure Q such that

$$i_t^{(n)} = E_t^Q \left[\frac{1}{n} \sum_{i=0}^{n-1} i_{t+i}^{(1)} \right] \ + \text{Jensen's inequality term}$$

- *risk neutral* system

$$\begin{aligned} \text{observables}_t &= \mu_h^Q + \eta_h^Q \text{state variables}_{t-1} + e_t^Q \\ \text{state variables}_t &= \phi_s^Q \text{ state variables}_{t-1} + \sigma_s e_t^Q \end{aligned}$$

- estimation:
  - compute conditional expectations from risk neutral system
    -> $i_t^{(n)}$ linear in state variables
  - identify Q-parameters by matching these expectations to actual yields
    -> subjective & statistical distribution for all $i_t^{(n)}$

Properties of subjective state space system

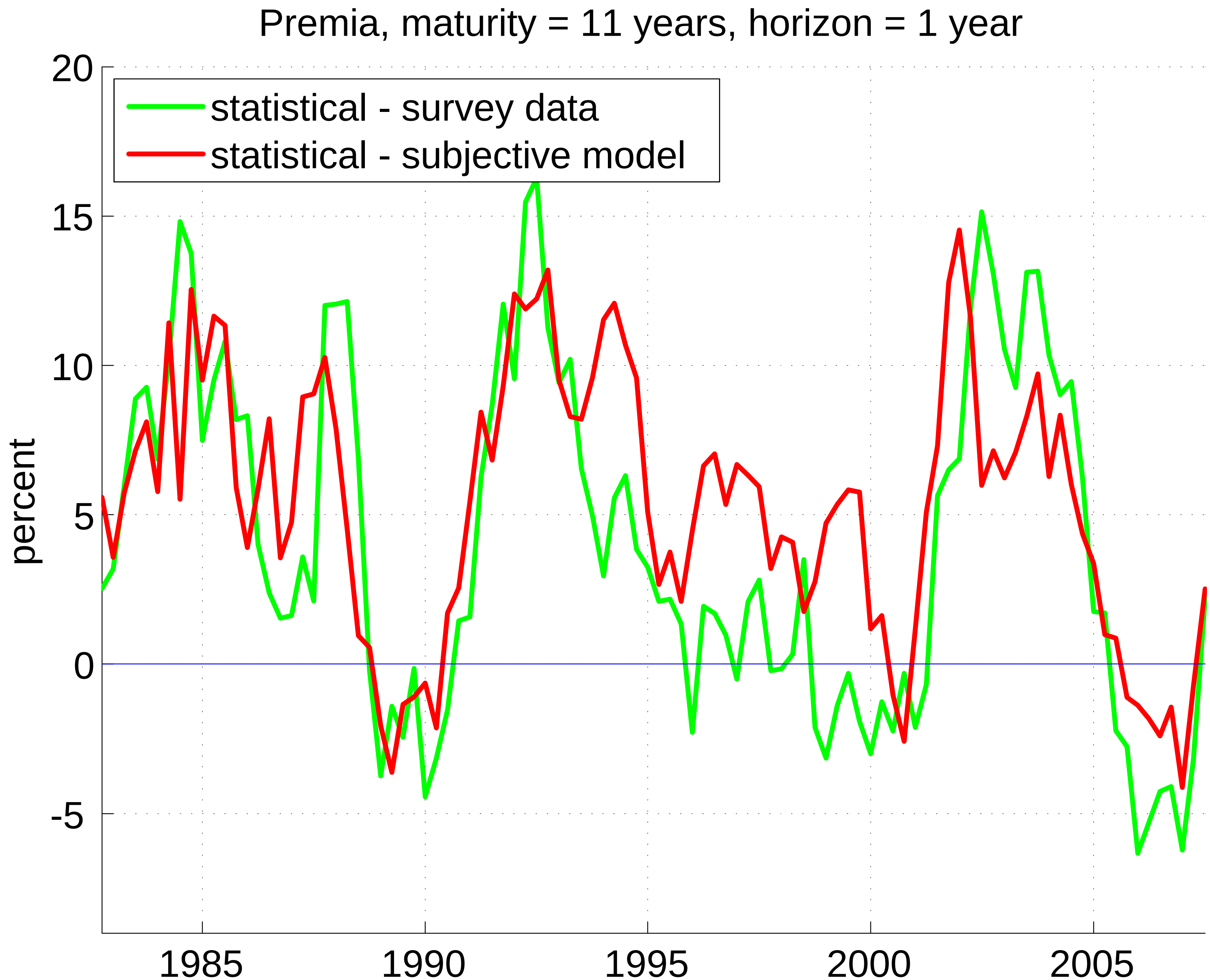
- subjective forecasts (computed from subjective system) match survey data well

- short rate and spread are more persistent than in statistical state space system

	short rate	spread
statistical system, diag$\{\phi_s\}$	0.88	0.76
subjective system, diag$\{\phi_s^*\}$	0.99	0.92

=> subjective system capture forecast differences:

$$E_t x_{t+h}^{(n)} = E_t^* x_{t+h}^{(n)} + \underbrace{E_t x_{t+h}^{(n)} - E_t^* x_{t+h}^{(n)}}_{\text{countercyclical}}$$


Premia, maturity = 11 years, horizon = 1 year
statistical - survey data
statistical - subjective model
percent
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1985
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Comparison of subjective & statistical premia

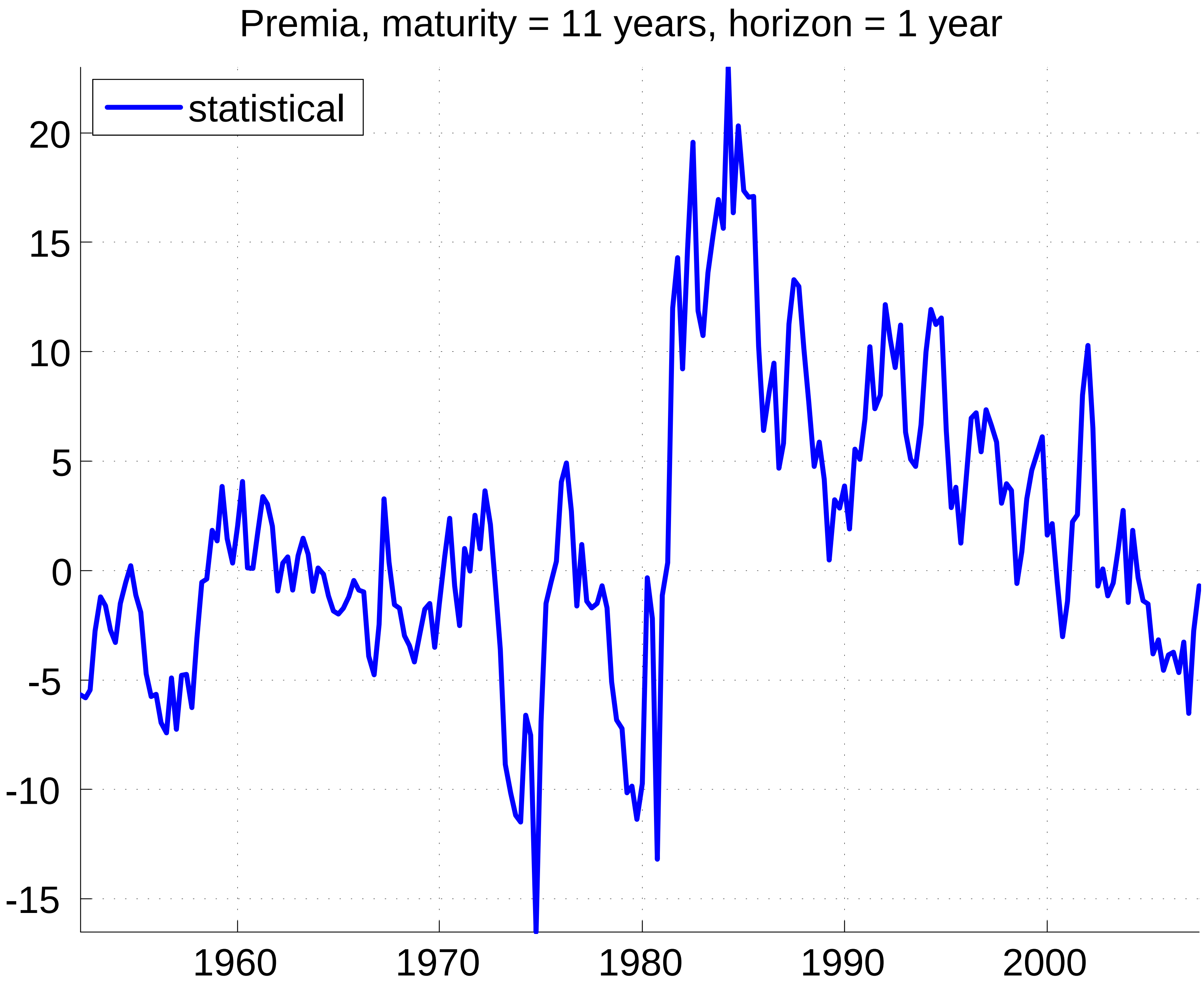
maturity 10 years

subjective premium

volatility	% trend	% cycle
3.63	65	17

statistical premium

7.48	45	33


Premia, maturity = 11 years, horizon = 1 year
statistical
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1960
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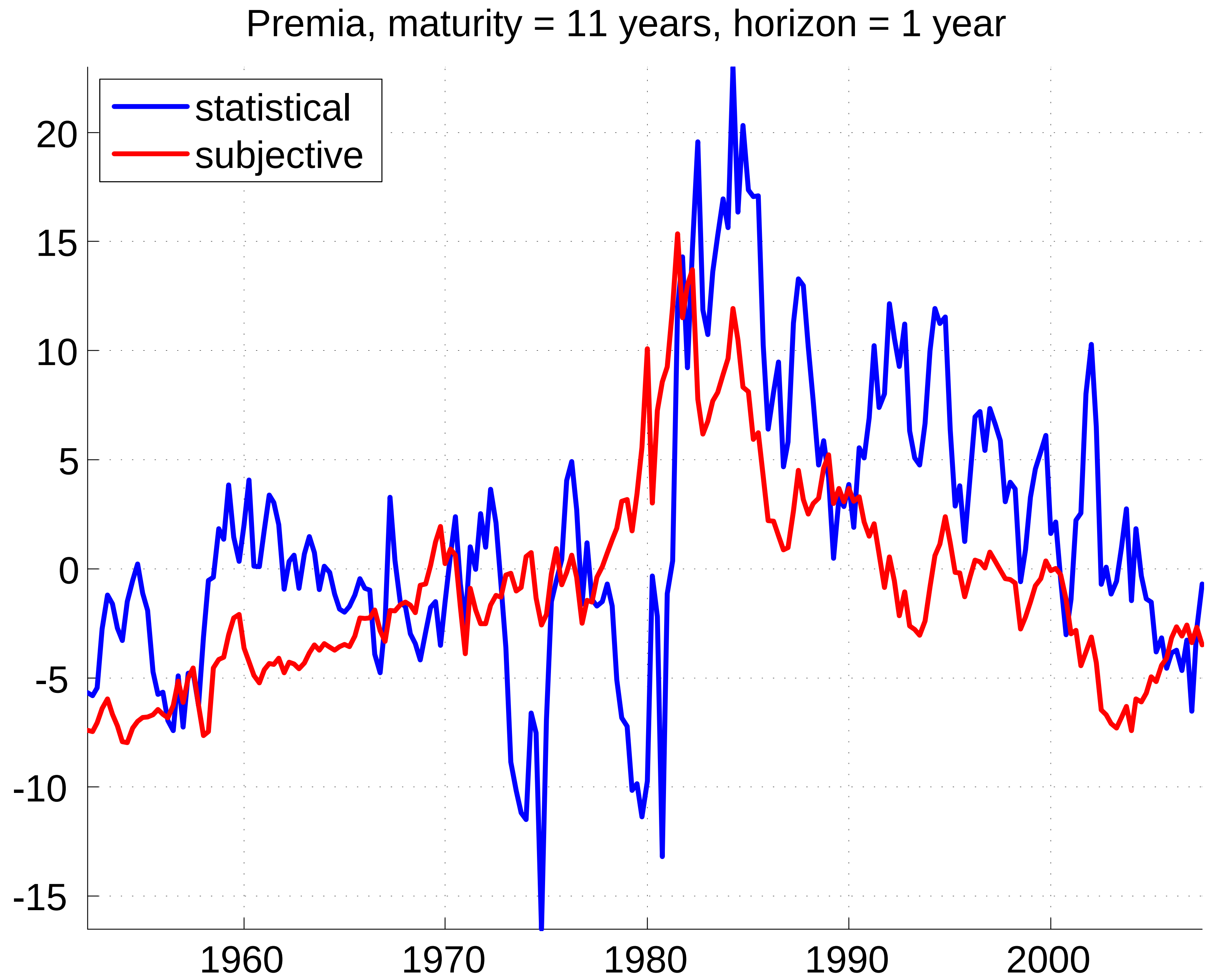
2000


Premia, maturity = 11 years, horizon = 1 year
statistical
subjective
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Asset pricing with subjective beliefs and positions

- Solve savings & portfolio choice problems for class of agents, given subjective beliefs

- in equilibrium,

$$\text{asset demand}\,(\text{prices}, \text{beliefs}) = \text{observed position}$$

- solve for asset prices

$$\text{prices} = f\,(\text{beliefs}, \text{positions})$$

- compare model-implied prices with observed prices

- Are observed prices consistent with optimizing behavior by class of agents who
  - hold observed positions
  - form expectations consistent with surveys?

Asset demand

- Infinite horizon portfolio choice problem with $N + 1$ assets
  - short bonds $=$ nominal bond that pays off $\exp(-\pi_{t+1})$
  - N longer bonds $=$ nominal bonds with longer maturities
- Epstein-Zin utility
- bond returns driven by subjective state space system

Observed positions

- many different nominal instruments, but many are close substitutes

- consider N factor model for interest rates

  e.g., $N = 2$ factor model does a good job explaining *quarterly* variation

- replicate observed nominal positions by portfolios with $N + 1$ spanning bonds

  spanning exact in continuous time, approximate in discrete time

- derive replicating portfolio for every zero-coupon bond

  contain short (1 quarter) bond and N long bonds

- extend to nominal instruments in FFA

  Doepke and Schneider 2006

Results

- choose preference parameters to match average yields

  CRRA $= 2$, IES $= 1$, $\beta = 0.97$

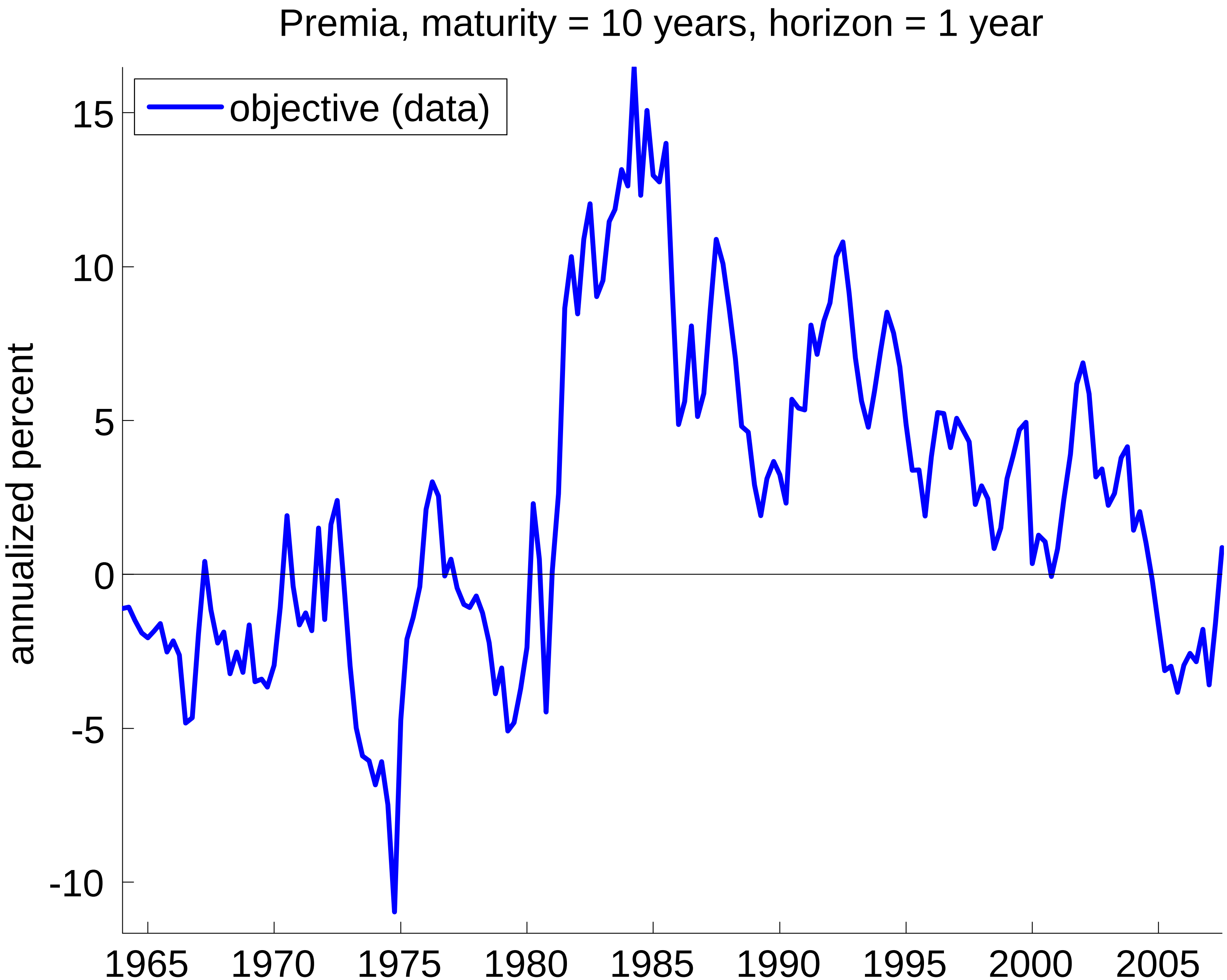
- pictures of model-implied premia

  - statistical premia

    are cyclical because of forecast differences

  - subjective premia

    move less & at lower frequencies


Premia, maturity = 10 years, horizon = 1 year
objective (data)
annualized percent
15
10
5
0
-5
-10
1965
1970
1975
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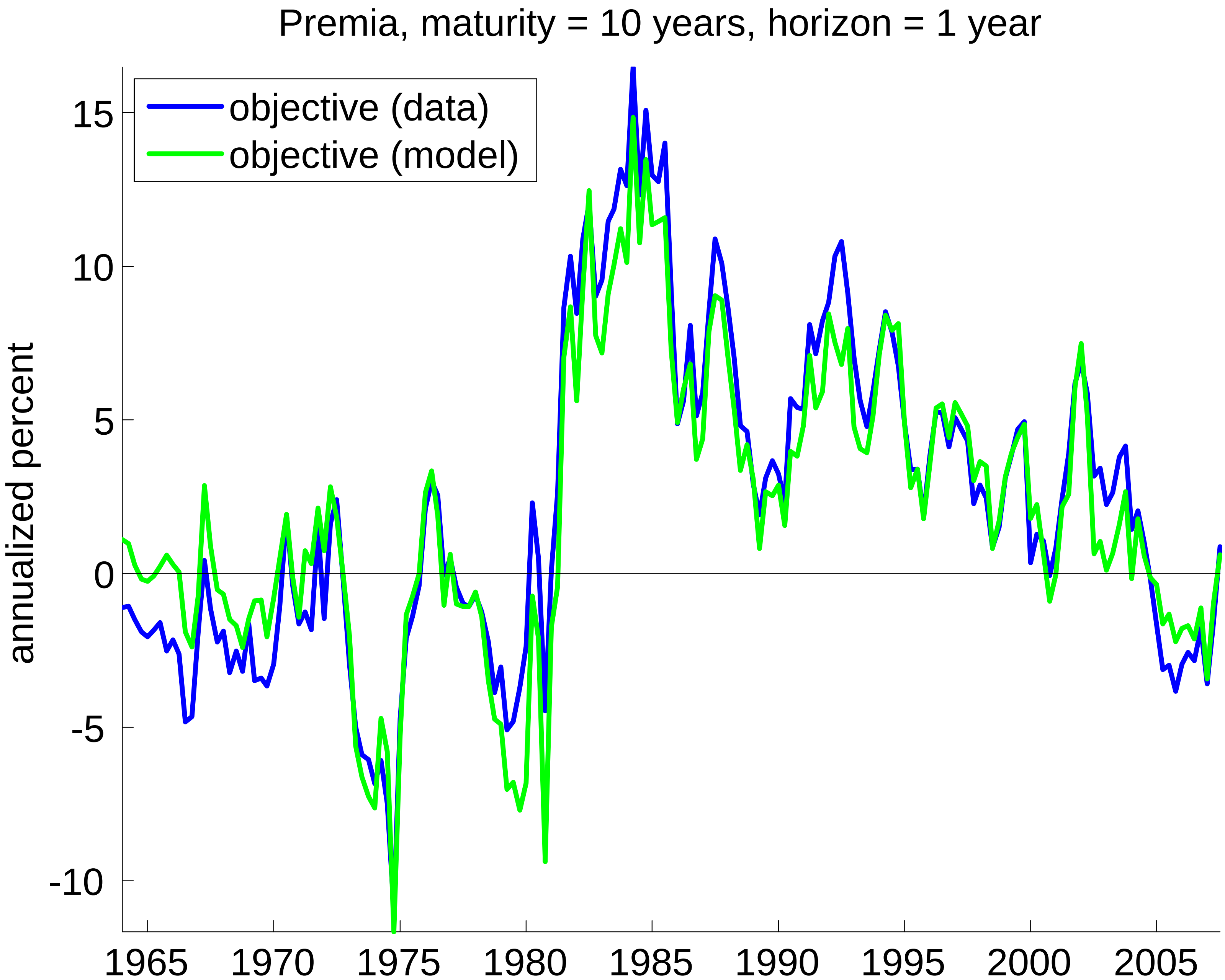
Premia, maturity = 10 years, horizon = 1 year
objective (data)
objective (model)
annualized percent
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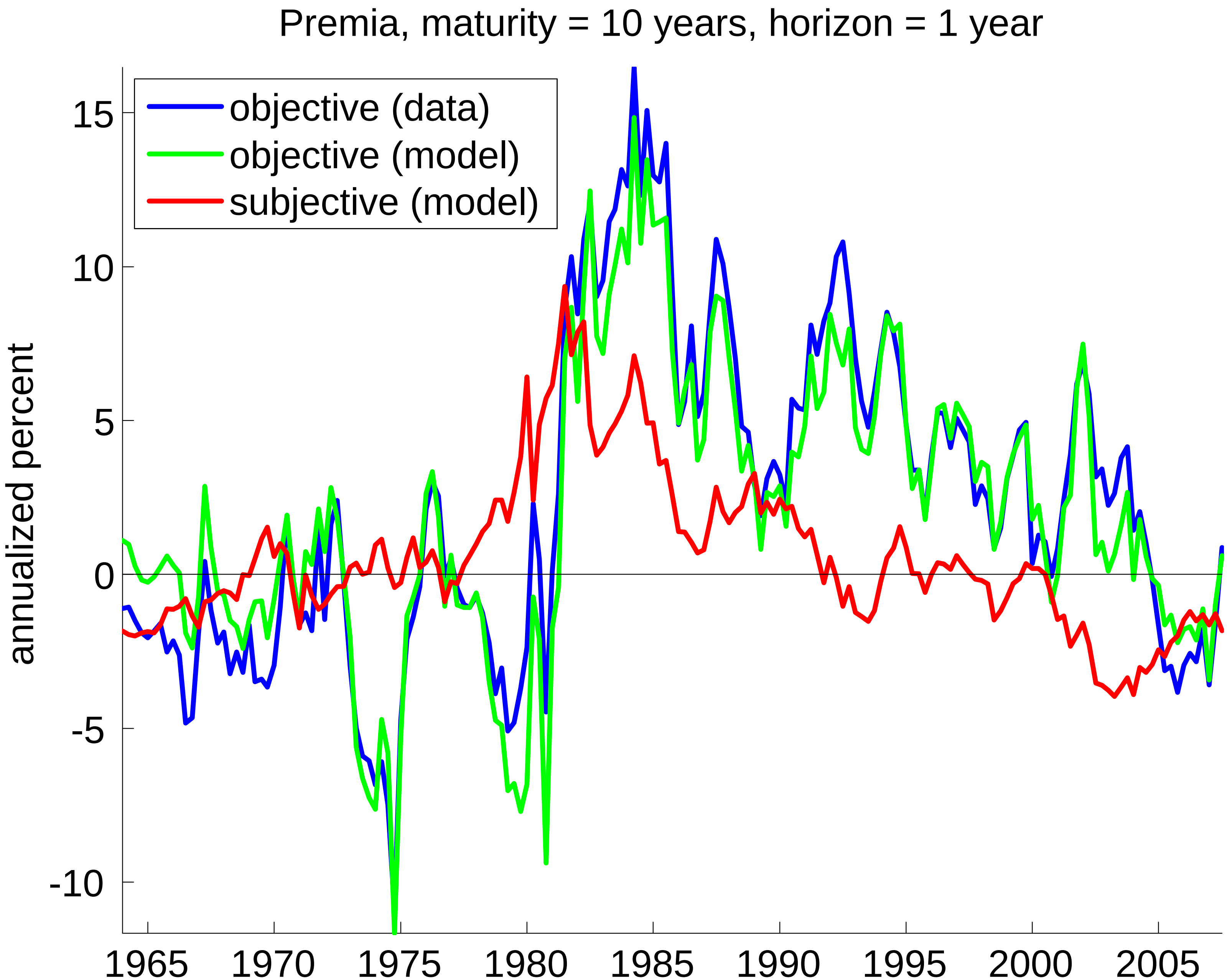
Premia, maturity = 10 years, horizon = 1 year
objective (data)
objective (model)
subjective (model)
annualized percent
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Conclusions

- Documented properties of survey forecasts

- Estimated statistical and subjective distributions of interest rates

- Studied structural model: prices related to expectations, positions

Findings

- Survey forecasters perceive level & slope as more persistent than statistical models

  preliminary findings: consistent with learning about the state-space parameters

- Predictability of excess returns in large part due to measurement issues

  (especially predictability at business cycle frequencies)

Lessons for economic modelling:

- need models of expectation formation...

  ...just as urgently as models of changes in risk compensation!

- to implement models, feed them subjective expectations