Inflation risk premia in the US and the euro area

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Motivation

- Nominal and real bond yields are often used by central banks to extract information of relevance for monetary policy.

- Break-even inflation rates used as an indicator of markets' inflation expectations / a measure of central bank credibility

- Break-even rates are a noisy measure due to the existence of premia; notably: inflation risk premia (but also zero-coupon effects, liquidity premia)

- How large are inflation premia in the US and the euro area? What are their properties/determinants?

Outline of the presentation

- Methodology
- Data and estimation
- Results: inflation risk premia; raw vs. premium-adjusted break-even rates; properties and macro determinants

Inflation risk premia: what can we expect?

- Inflation risk premium filtered from the overall term premium filtered from yields: plenty of measurement uncertainty

- Guidance from intuition/theory? Inflation risk premium should be proportional to inflation variability; positive and increasing in maturity

  – in theory a negative premium is possible; sign depends on covariance between inflation (real returns on bonds) and SDF (consumption)

  – recent empirical results point to mostly positive inflation premia, but the magnitude varies: + and sizeable in Buraschi and Jiltsov (2005) and Ang et al. (2008); small but + for long maturities in Durham (2006) and D'Amico et al. (2008). Euro evidence in Garcia and Werner (2008): small and +.

Methodology

- Important to include relevant information: index-linked and macro data; survey data

- Consistency with macro dynamics: inflation expectations derived from a "structural," empirically plausible macro-model

- No-arbitrage restrictions added to the macro structure: the nominal and real term structures are modelled to be arbitrage-free and mutually consistent

$\Longrightarrow$Macro-based interpretations of term structure dynamics, including dynamic responses of yields, premia, and break-even inflation rates to structural shocks

The model: Macro

inflation: $\pi_t = \bar{\pi} + \mu_\pi E_t \pi_{t+} + (1 - \mu_\pi)\,\delta_\pi \pi_{t-} + \delta_x x_t + \varepsilon_t^\pi$

output gap: $x_t = \mu_x E_t x_{t+} + (1 - \mu_x)\,\zeta_x x_{t-} - \zeta_r\,(r_t - E_t\,[\pi_{t+1}]) + \varepsilon_t^x$

short rate: $r_t = \bar{r} + (1 - \rho)\,[\beta\,(E_t \pi_{t+12} - \pi_t^*) + \gamma x_t] + \rho r_{t-1} + \eta_t$

infl. target: $\pi_t^* = \phi_{\pi^*} \pi_{t-1}^* + u_t^{\pi^*}$

Key ingredients of the model

Macro: REE solution

State variables $(\pi, x, r, \pi^*, ...)$ $\quad$ $\mathbf{Z}_t = \mathbf{M}\mathbf{Z}_{t-1} + \boldsymbol{\xi}_t$

Policy rate $\quad$ $r_t = \boldsymbol{\delta}\mathbf{Z}_t$

Finance: assumption on stochastic discount factor

Market prices of risk $\quad$ $\boldsymbol{\lambda}_t = \boldsymbol{\lambda}_\mathbf{0} + \boldsymbol{\lambda}_\mathbf{1}\mathbf{Z}_t$

$\Longrightarrow$ Nominal yields $\quad$ $\mathbf{Y}_{n,t} = \mathbf{A}_n + \mathbf{B}_n\mathbf{Z}_t$

$\Longrightarrow$ Real yields $\quad$ $\mathbf{Y}^*_{n,t} = \mathbf{A}^*_n + \mathbf{B}^*_n\mathbf{Z}_t$

Estimation

- Bayesian Maximum Likelihood using Kalman Filter; we exploit prior information on structural economic relationships

- Real yields enter the likelihood function late in the sample (US - 2003; euro area - 2004) to reduce initial liquidity problems

- Survey data information (inflation and short-term interest rate) explicitly included in the estimation

- Estimation using simulated annealing to reduce risk of local maxima

Data - US sample: January 1990 – April 2008

- Macro data: y-o-y inflation, output gap (log-GDP in deviations from CBO estimate of potential; ARIMA forecast/interpolation)

- Nominal yields: 1-, 3-, 6-, 12-m, 3-, 5-, 10-y zero-coupon rates (Fed Board)

- Real yields: 3-, 5-, 7-, and 10-y zero-coupon rates extracted from US TIPS (as of 2003)

- Survey data: 3-m rate and inflation in 2/4 quarters and next 10 years (SPF)

Data - euro sample: January 1999 – April 2008

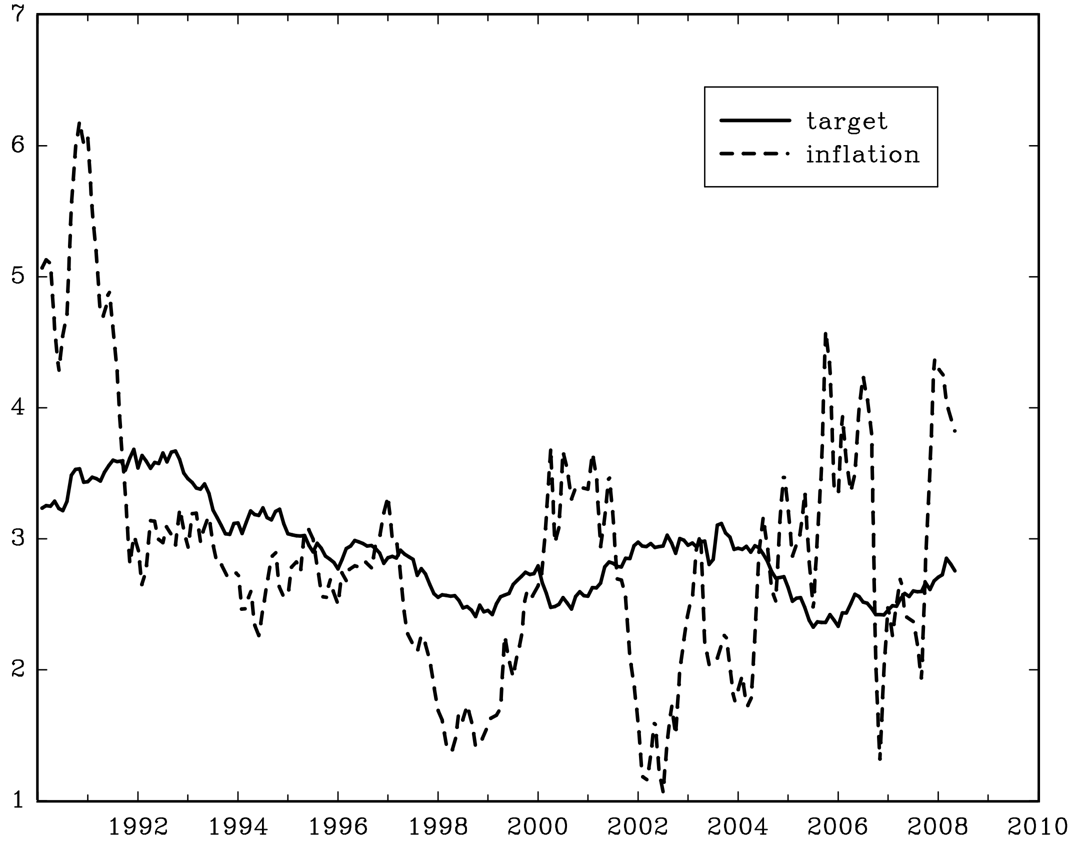
- Macro data: y-o-y inflation, output gap (log-GDP in deviations from a quadratic trend, as in CGG98; ARIMA forecast/interpolation)

- Nominal yields: 1-, 3-, 6-, 12-m, 3-, 5-, 10-y zero-coupon rates extracted from German bond prices and EUR money market rates

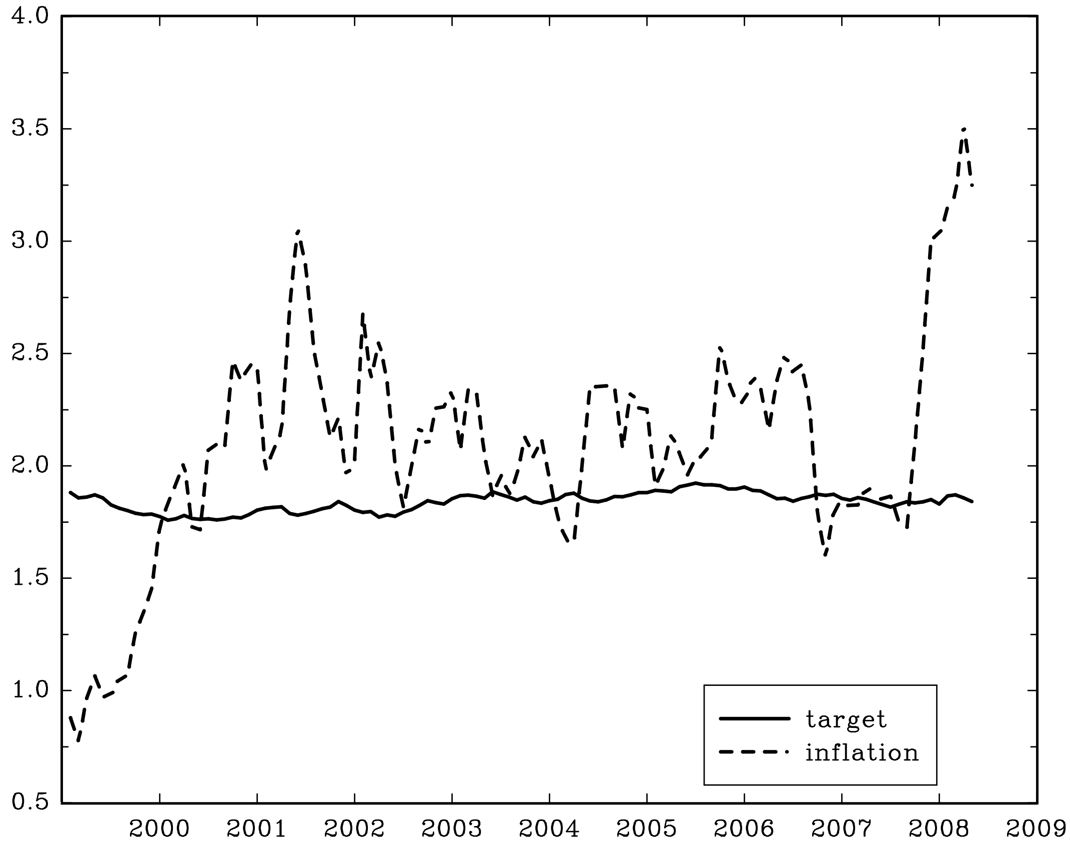
- Real yields: 3-, 5-, 7-, and 10-y zero-coupon rates extracted from French and German HICP-linked bonds

- Survey data: 3-m rate in 3/12 months (Consensus); inflation 1, 2, 5 years ahead (SPF)

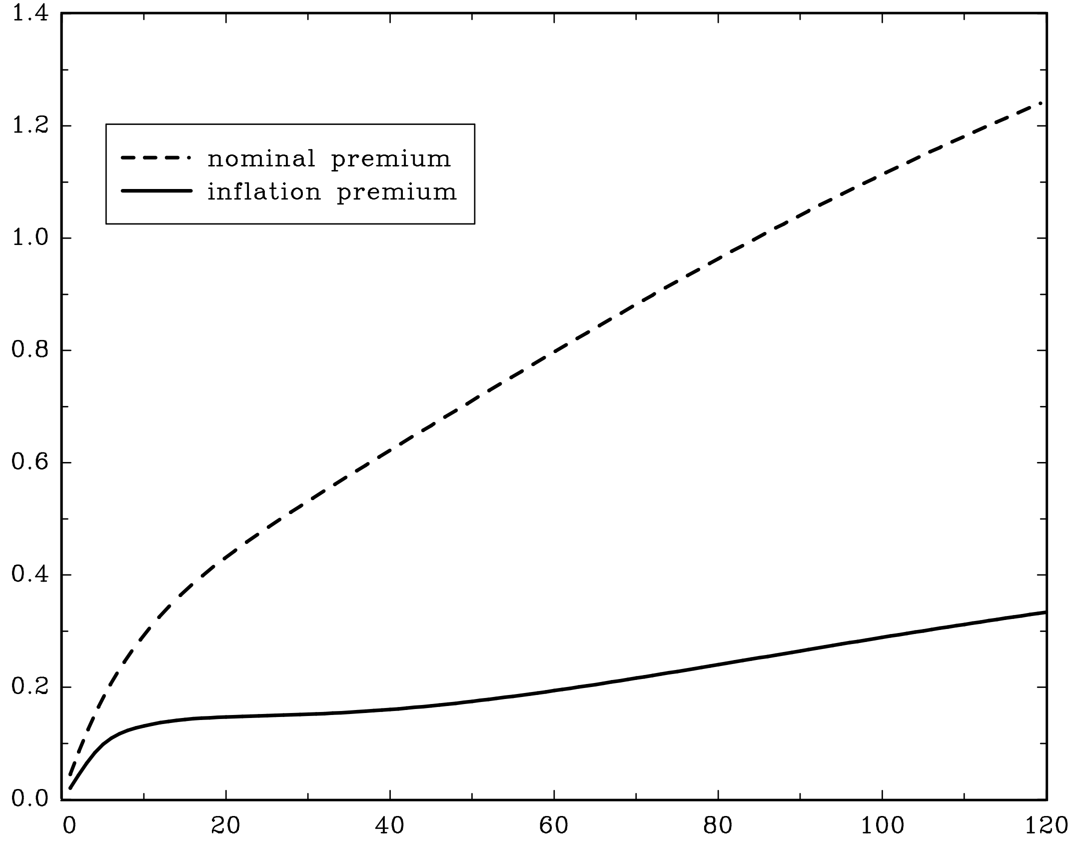
Results: Inflation and estimated inflation target - US



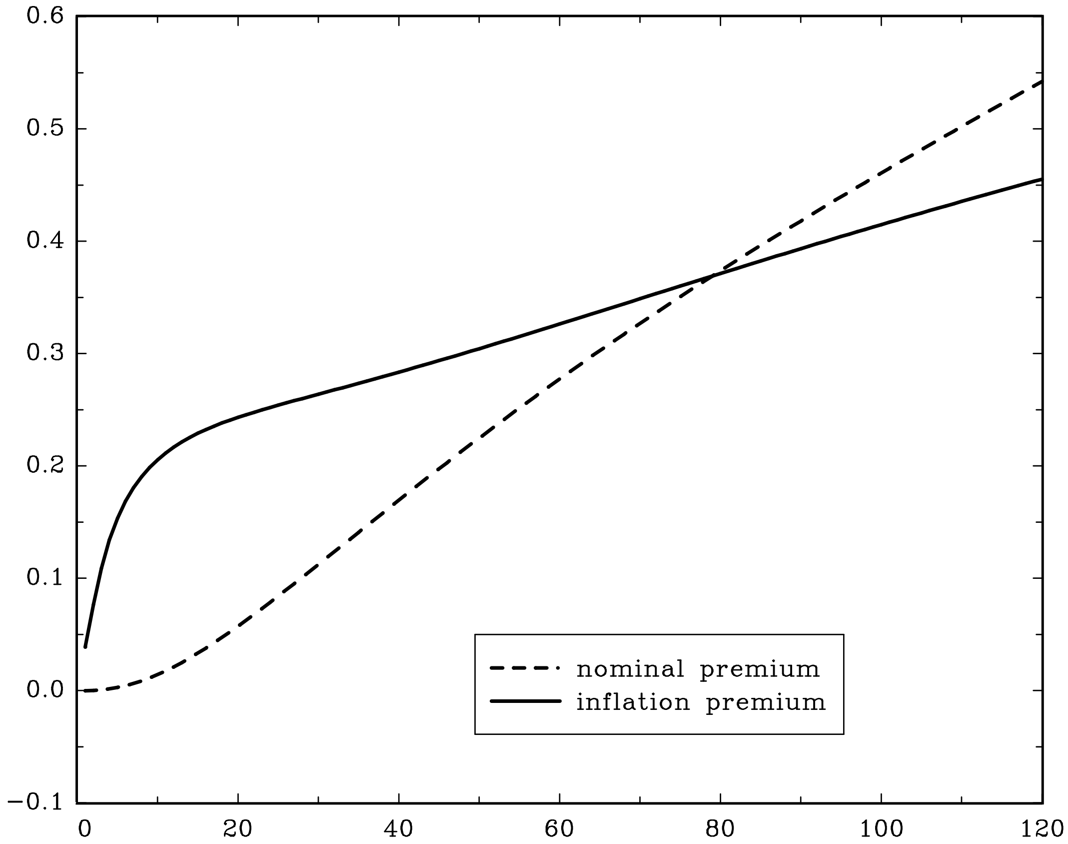
Inflation and estimated inflation target: euro area



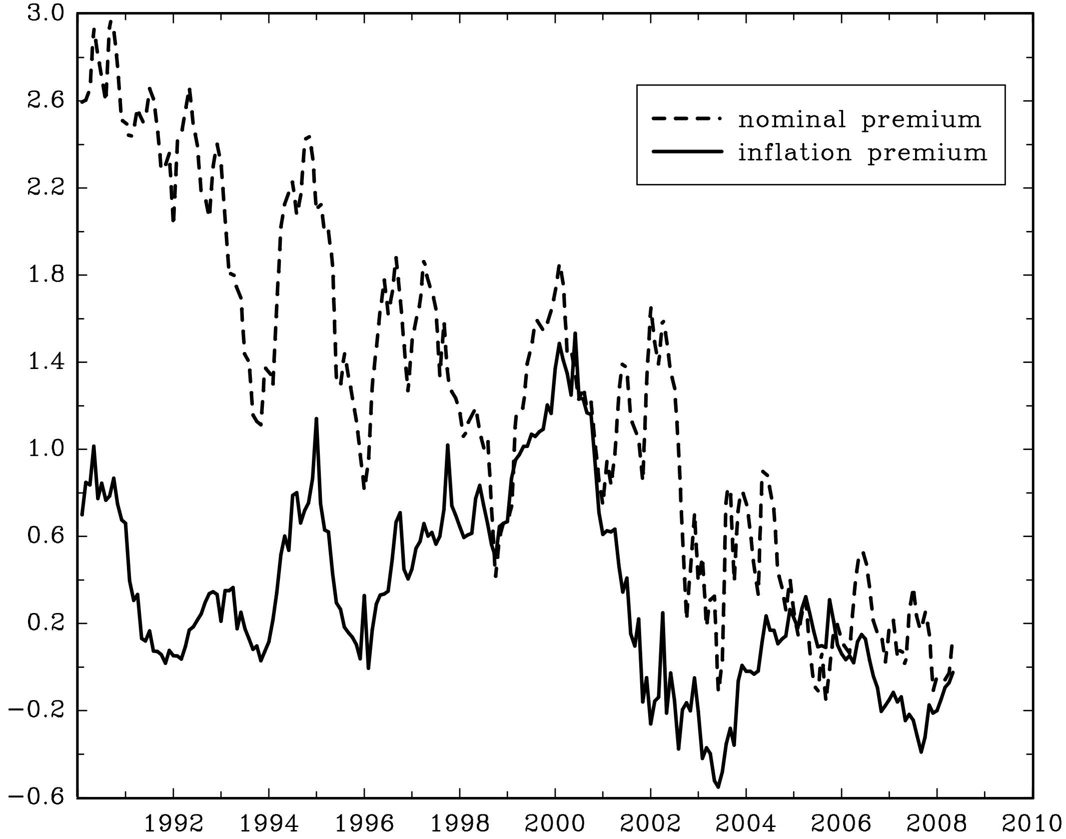
Term structure of average risk premia: US



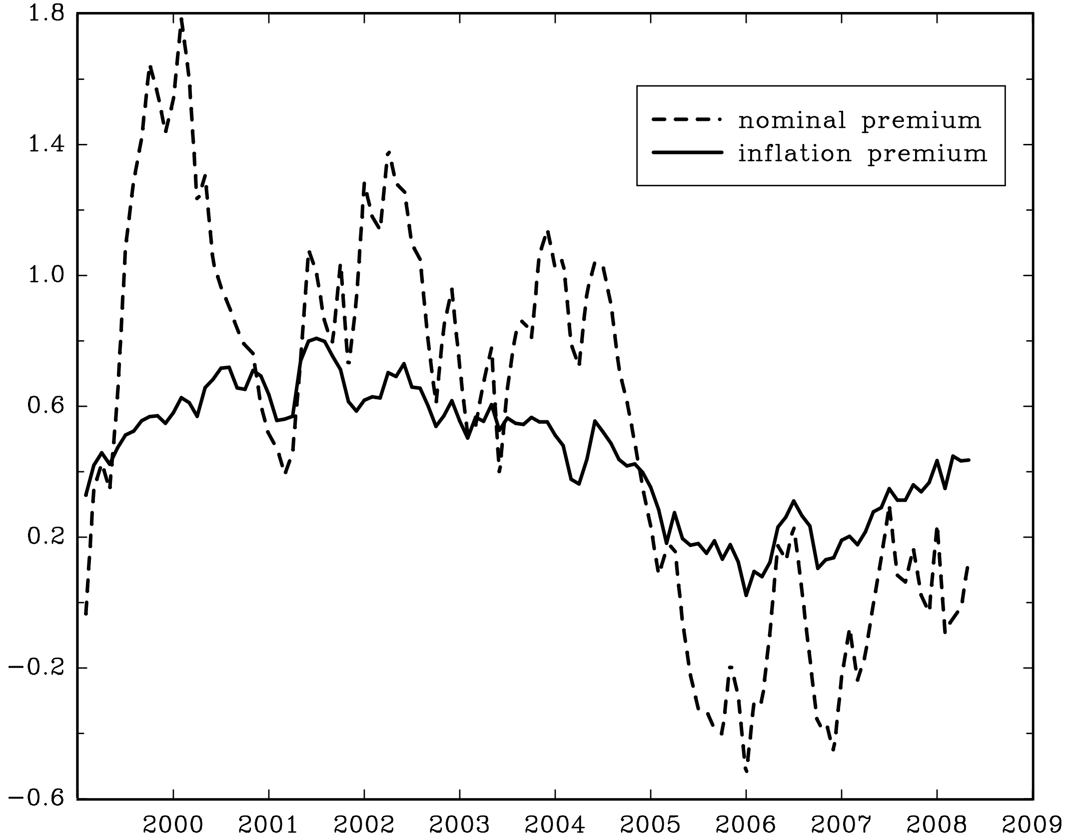
Term structure of average risk premia: euro area



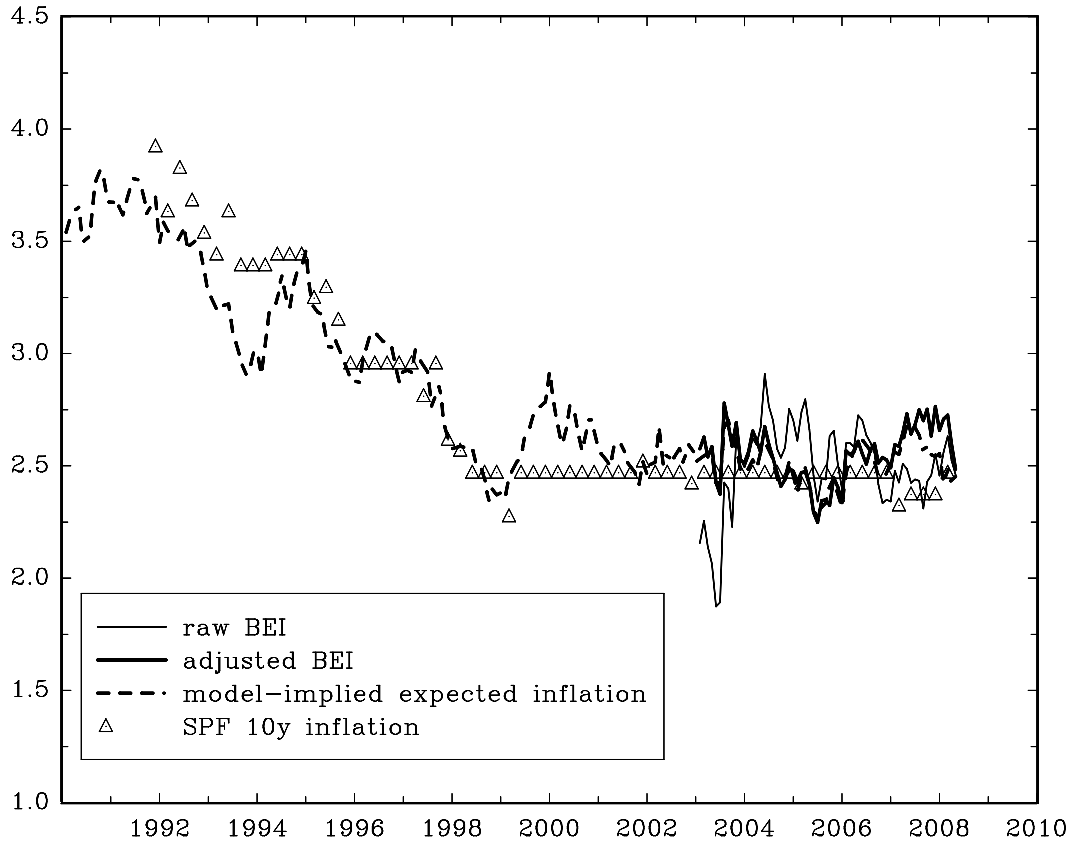
Estimated 10-year US premia



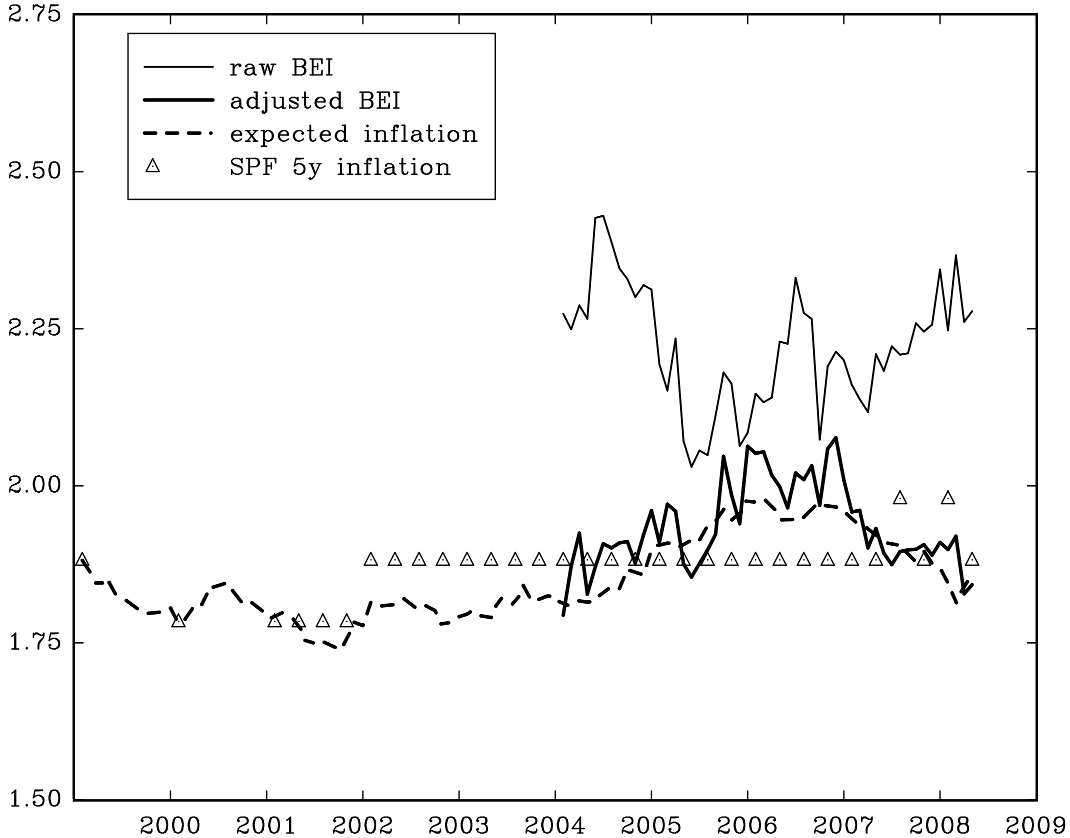
Estimated 10-year euro area premia



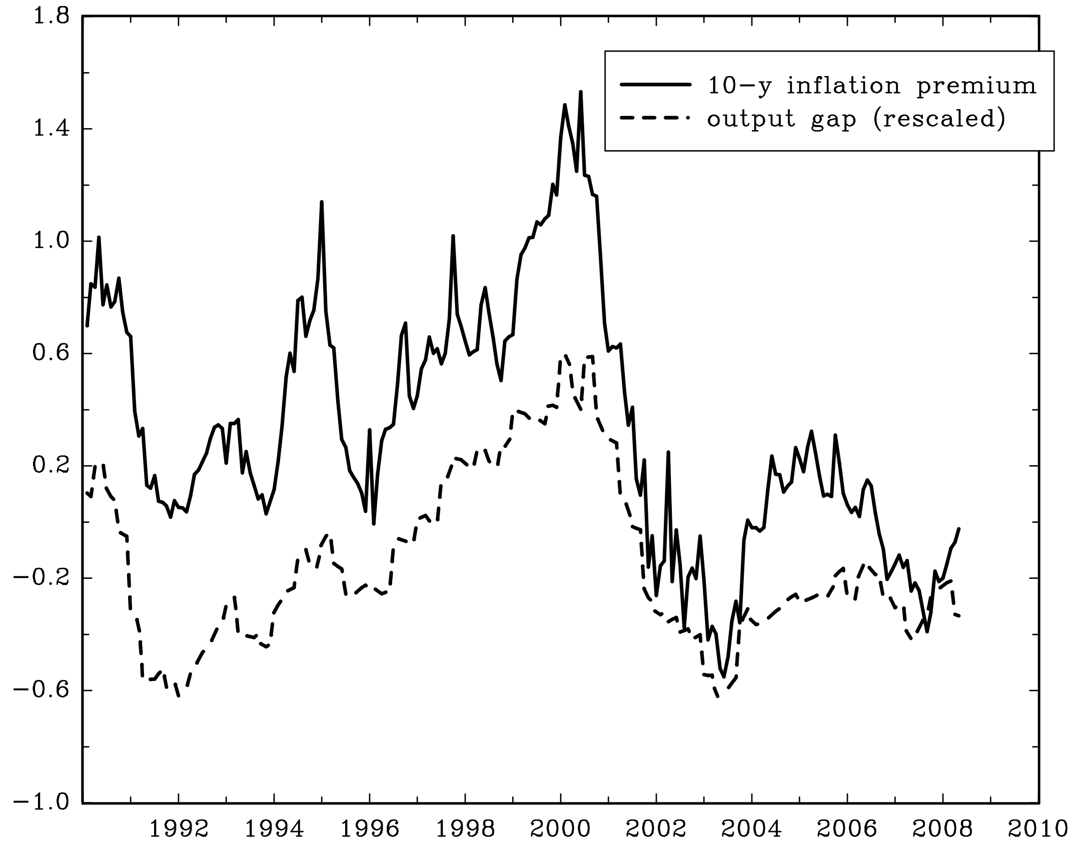
US 10-year break-even inflation rates and survey inflation forecasts



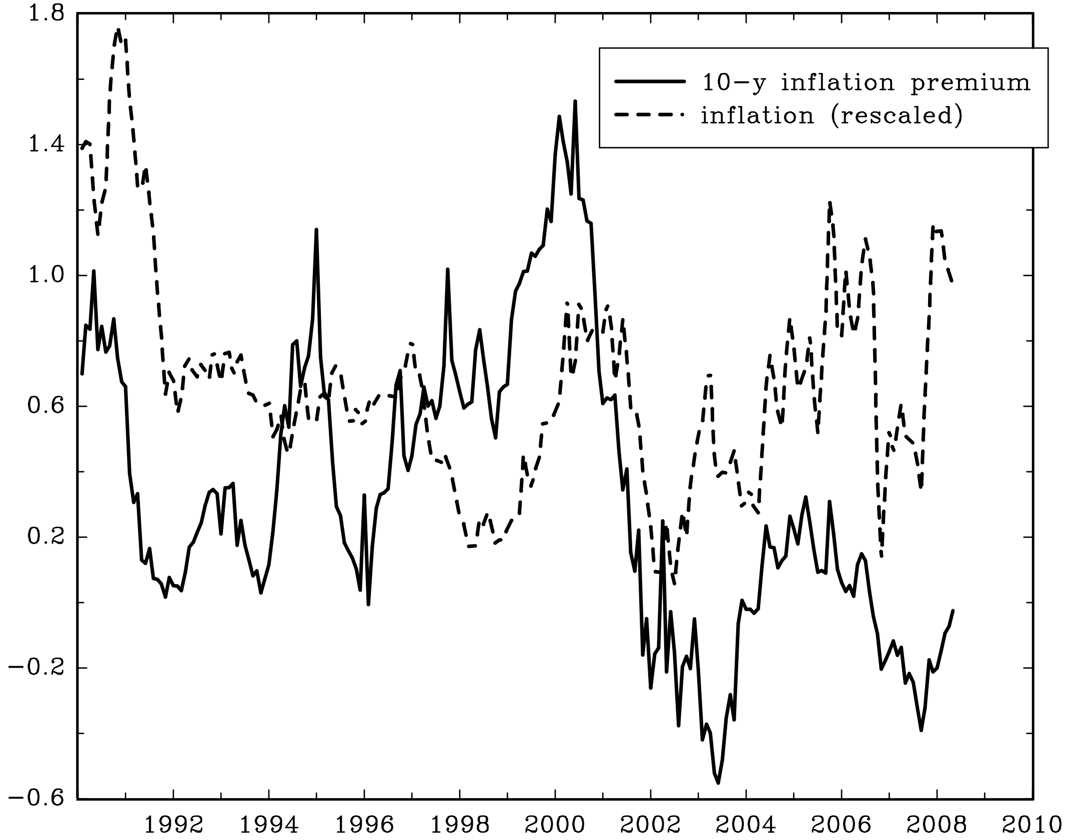
Euro area 10-year break-even inflation rates and survey inflation forecasts



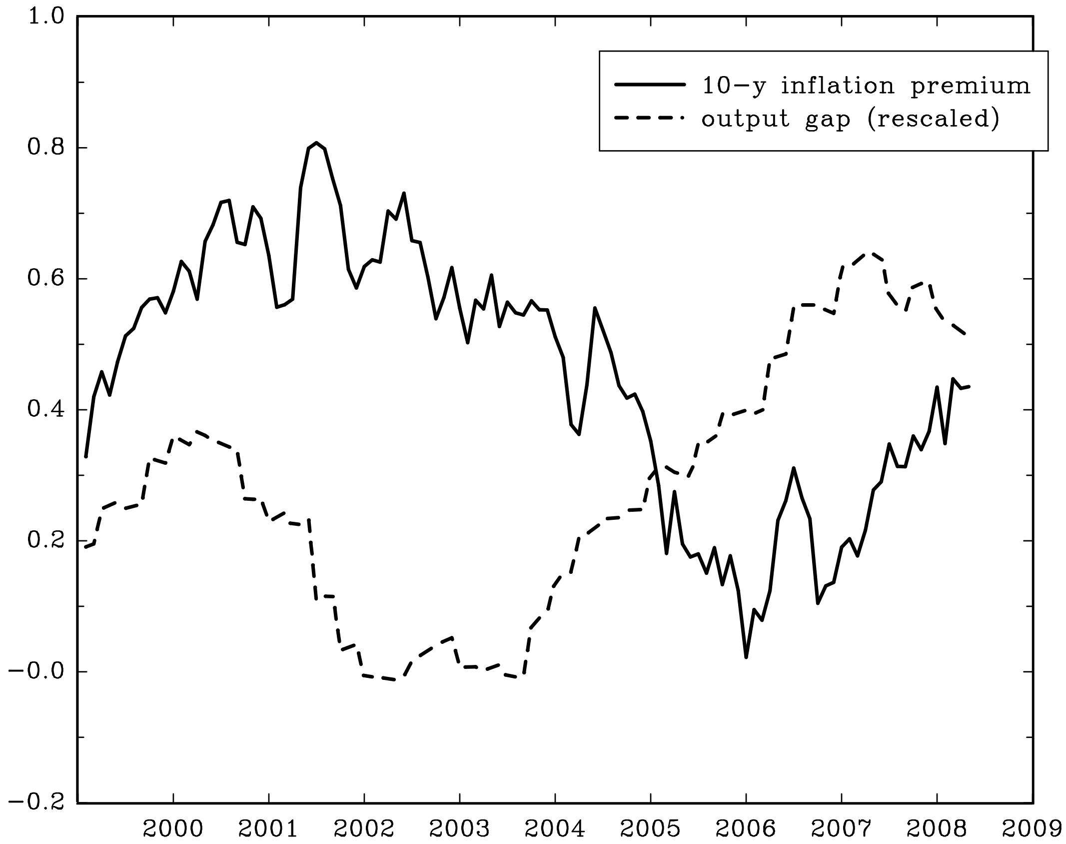
Estimated US 10-year inflation risk premium and output gap



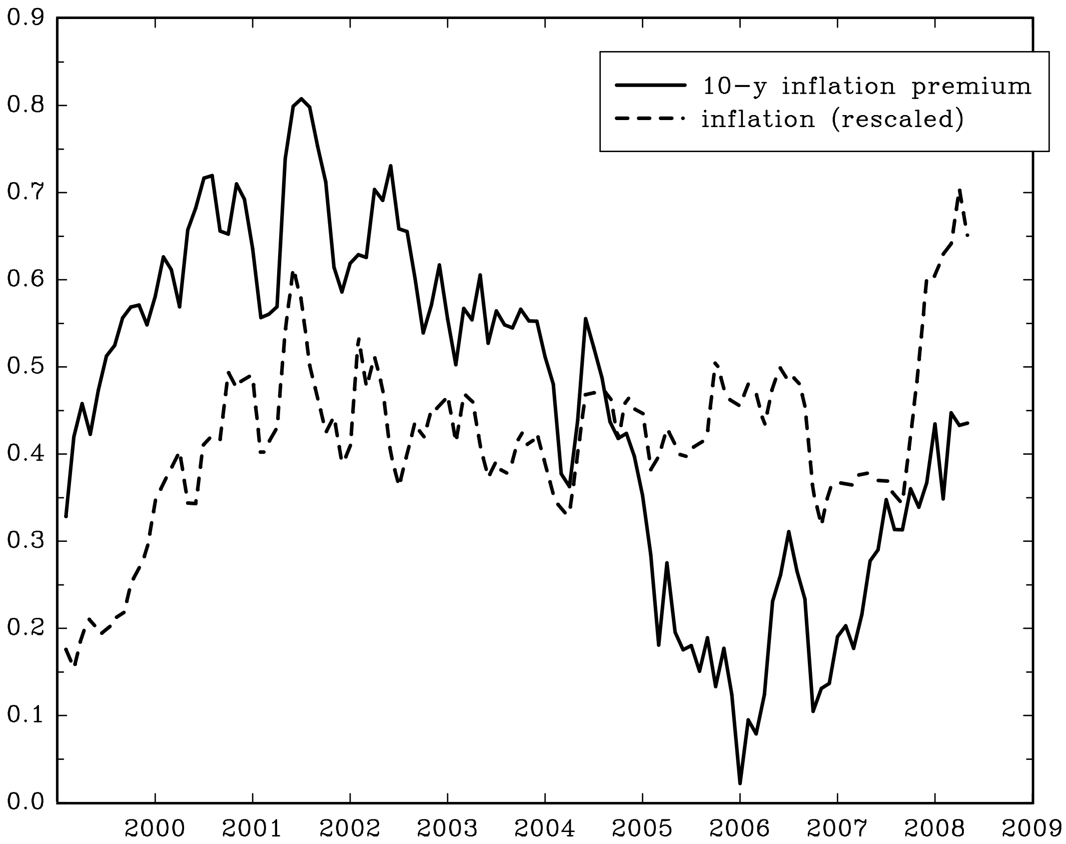
Estimated US 10-year inflation risk premium and inflation

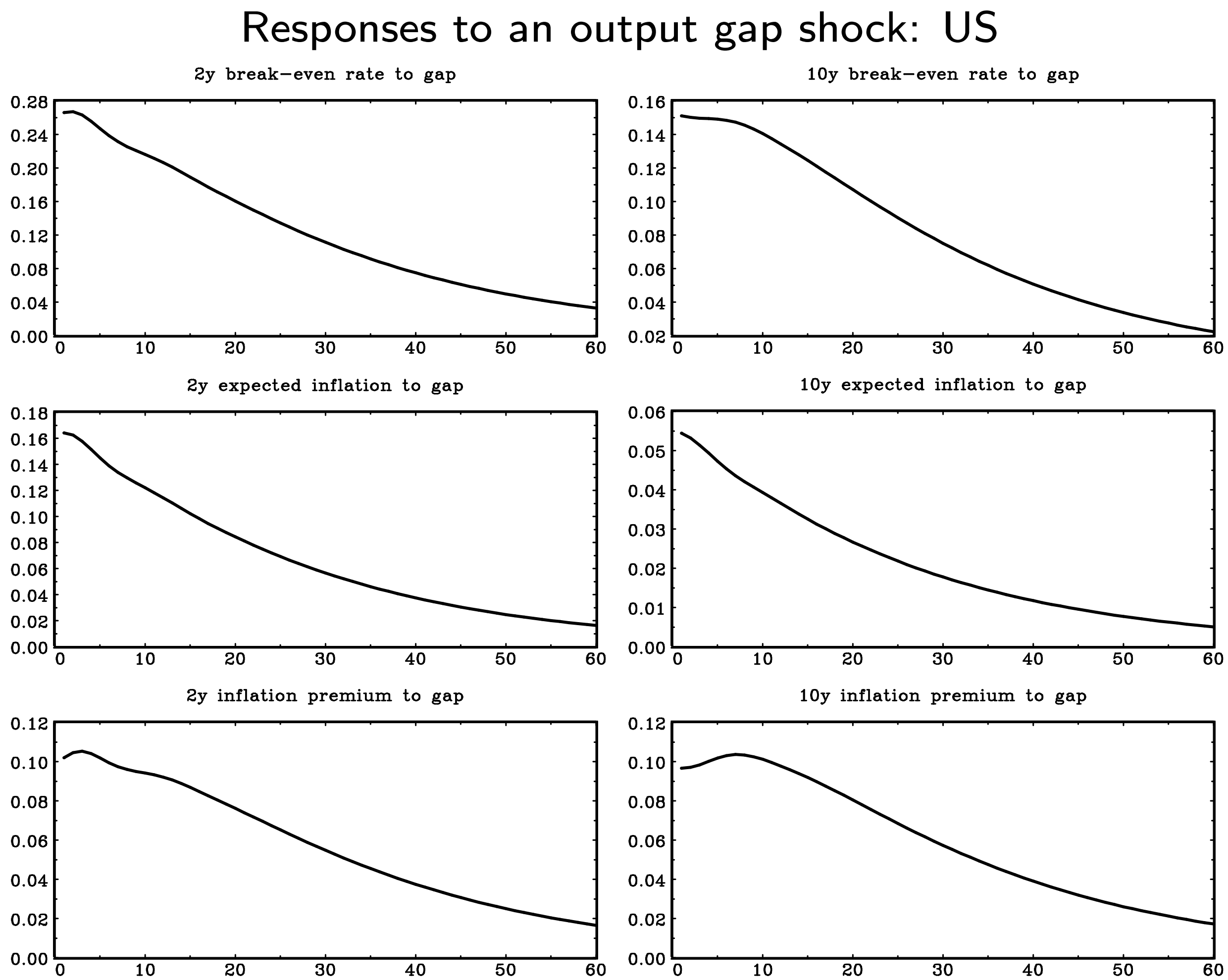


Estimated euro 10-year inflation risk premium and output gap

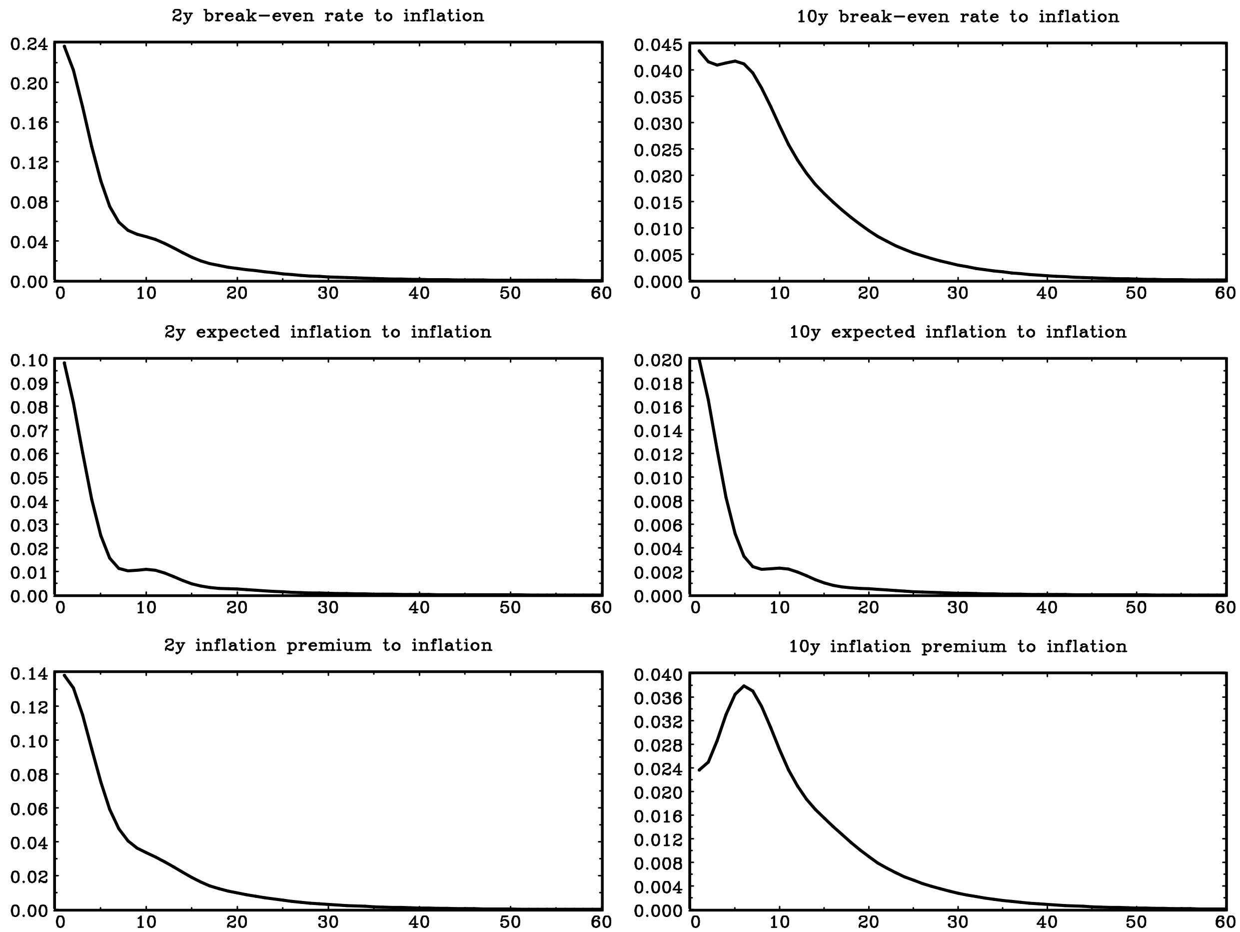


Estimated euro 10-year inflation risk premium and inflation

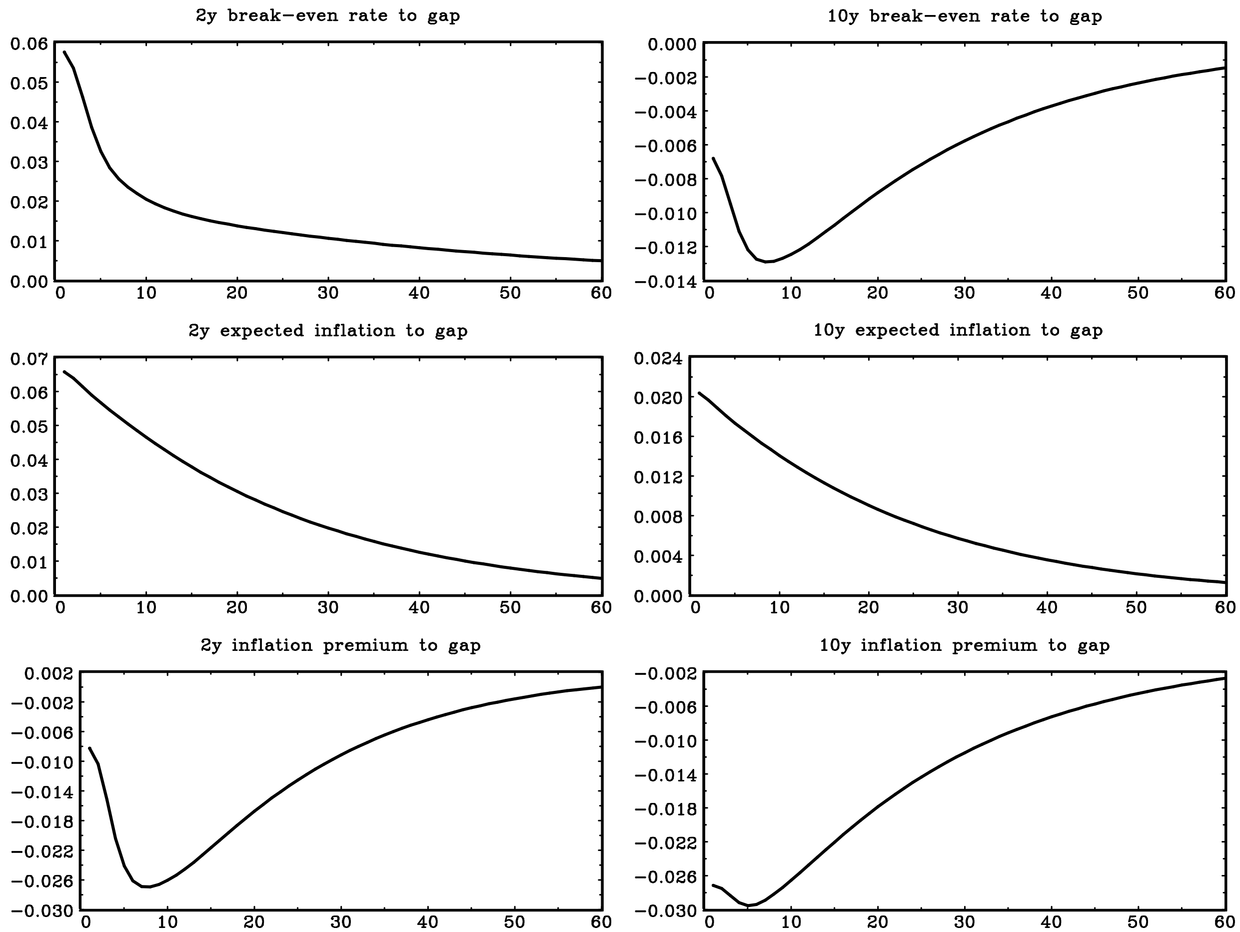



Responses to an output gap shock: US
2y break−even rate to gap
10y break−even rate to gap
2y expected inflation to gap
10y expected inflation to gap
2y inflation premium to gap
10y inflation premium to gap
0.28
0.24
0.20
0.16
0.12
0.08
0.04
0.00
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.18
0.06
0.05
0.03
0.01
0
10
20
30
40
50
60

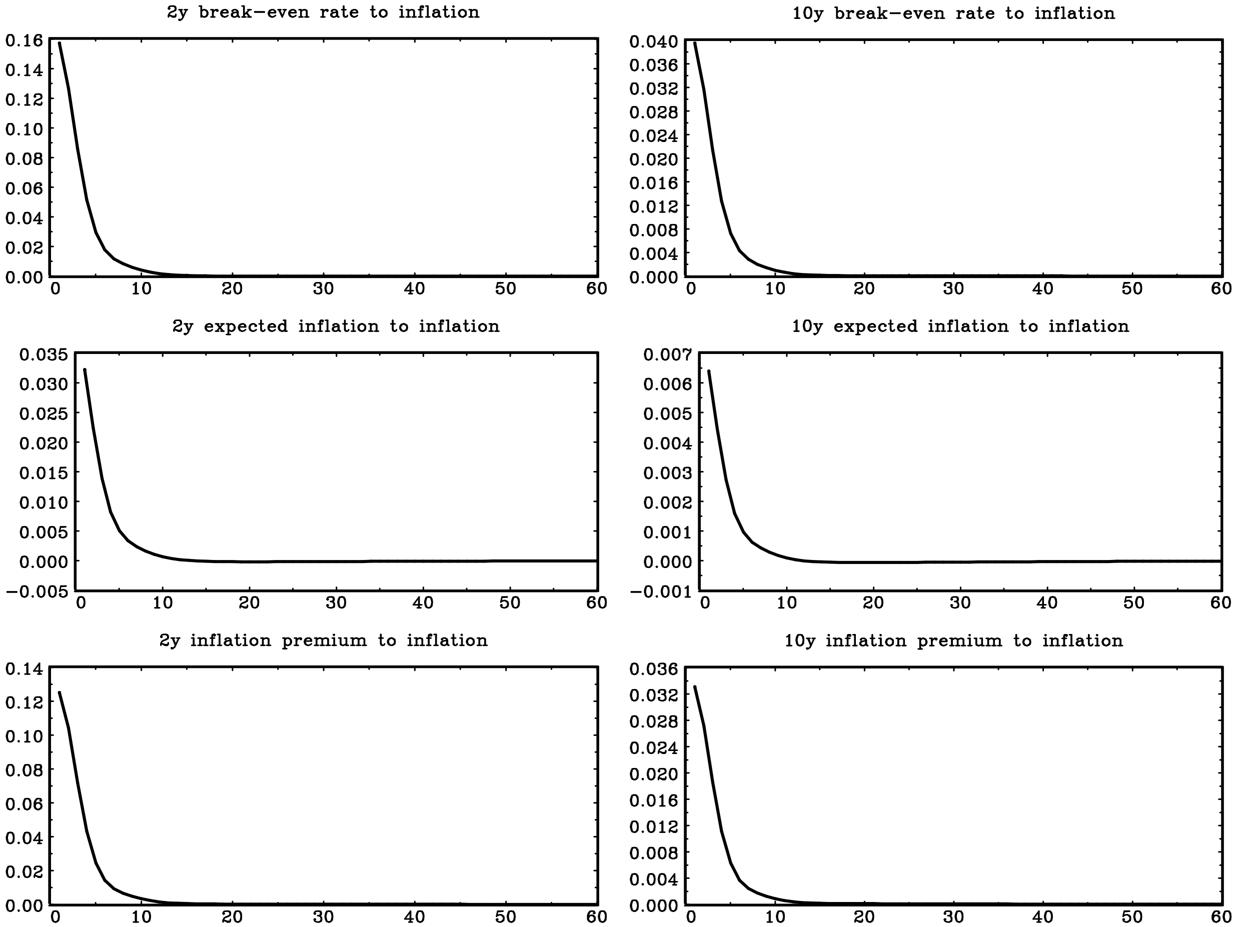
Responses to an inflation shock: US



Responses to an output gap shock: euro area



Responses to an inflation shock: euro area



Conclusions

- Using a macro-finance model for real and nominal term structure dynamics, we provide estimates of the size and dynamics of inflation risk premia in the US and the euro area

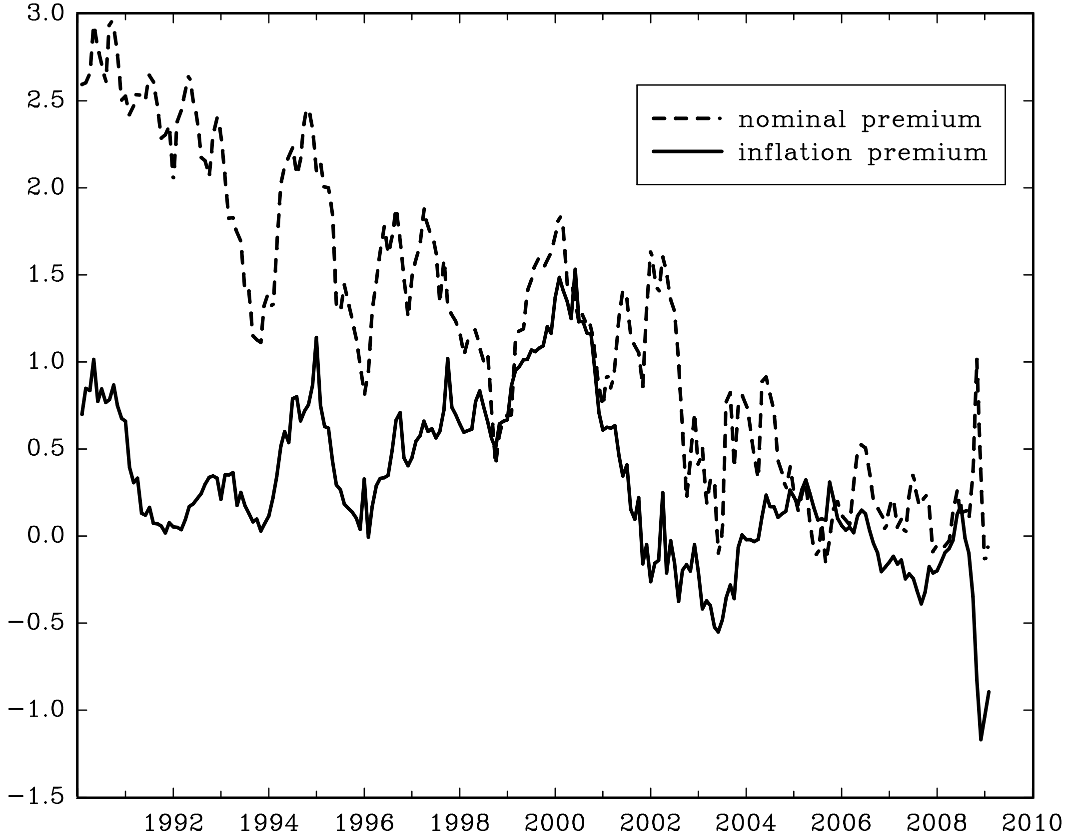
- Our framework allows us to obtain macro interpretations of term structure and premia dynamics

- Inflation risk premia are positive and relatively small on average; they vary over time, mostly in response to output gap and inflation changes

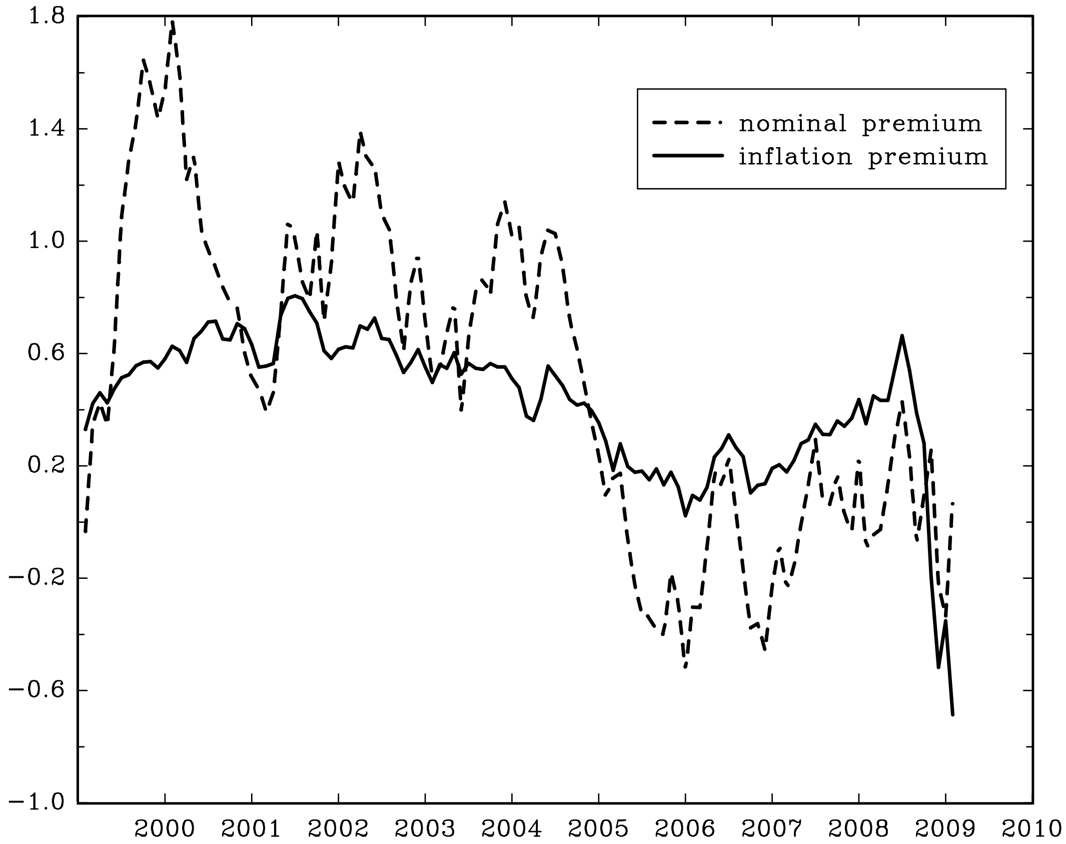
- Break-even inflation rates are therefore a noisy measure of inflation expectations, but, inparticular in the US, much of their variation seem to be due to changes in expected inflation

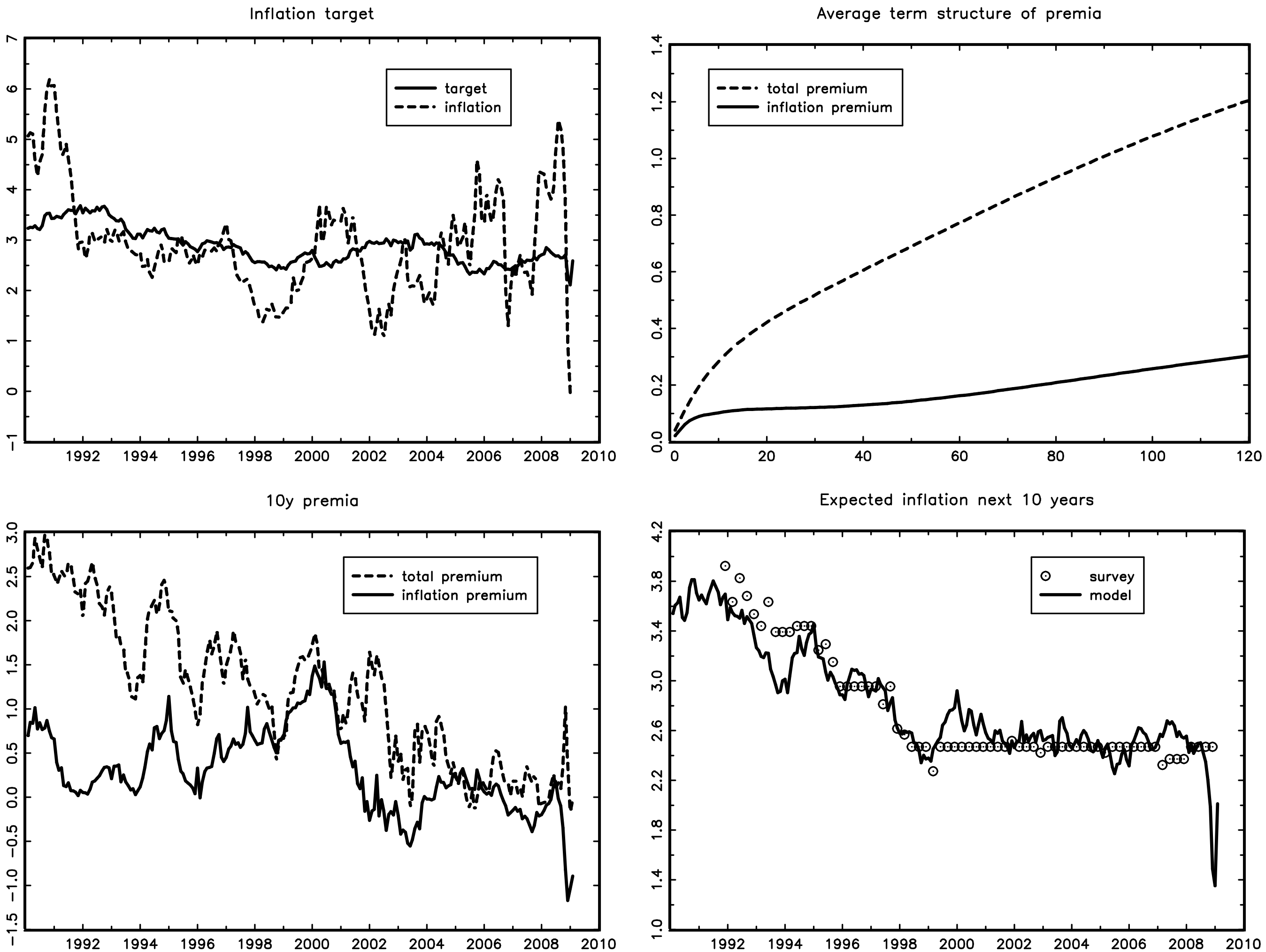
Extra slides

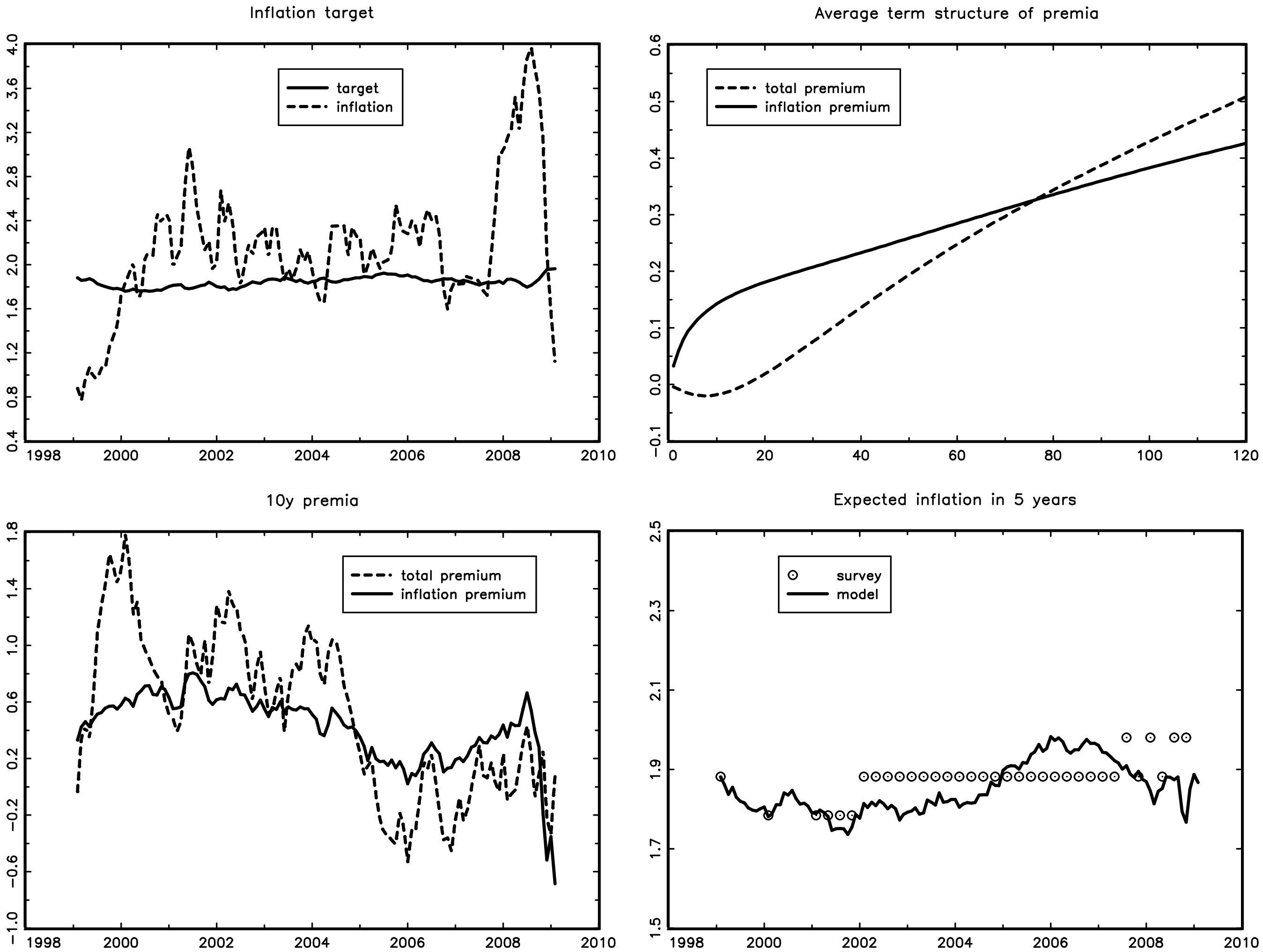
Estimated 10-year US premia



Estimated 10-year euro area premia




Inflation target
target
inflation
Average term structure of premia
total premium
inflation premium
10y premia
total premium
inflation premium
Expected inflation next 10 years
survey
model
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
0
20
40
60
80
100
120


Inflation target
target
inflation
4.0
3.6
3.2
2.8
2.4
2.0
1.6
1.2
0.8
0.4
1998
2000
2002
2004
2006
2008
2010
Average term structure of premia
total premium
inflation premium
0.6
0.5
0.4
0.3
0.2
0.1
0.0
−0.1
0
20
40
60
80
100
120
10y premia
total premium
inflation premium
1.8
1.4
1.0
0.6
0.2
−0.2
−0.6
−1.0
1998
2000
2002
2004
2006
2008
2010
Expected inflation in 5 years
survey
model
2.5
2.3
2.1
1.9
1.7
1.5
1998
2000
2002
2004
2006
2008
2010

The inflation risk premium

For the short-rate, we can write

$$r_t = r_t^* + E_t\left[\pi_{t+1}\right] + prem^1_{\pi,t} + \frac{1}{2}\boldsymbol{\Sigma}_\pi \boldsymbol{\Sigma}_\pi{}'$$

where

$$\begin{aligned}
prem^1_{\pi,t} &= -\boldsymbol{\Sigma}_\pi \left(\lambda_0 + \lambda_1 \mathbf{X}_{1,t}\right) && \text{inflation premium} \\
\boldsymbol{\Sigma}_\pi &\equiv \mathbf{C}_\pi \boldsymbol{\Sigma} && \text{“amount of risk”} \\
\boldsymbol{\lambda}_t &= \boldsymbol{\lambda}_0 + \boldsymbol{\lambda}_1 \mathbf{X}_{1,t} && \text{“price of risk”}
\end{aligned}$$

The model: Market prices of risk

Market prices of risk determined empirically as affine functions of the states

$$\boldsymbol{\lambda}_t = \boldsymbol{\lambda_0} + \boldsymbol{\lambda_1} \times States_t$$

We use

$$\boldsymbol{\lambda}_t = \begin{pmatrix} \lambda_{01} \\ \lambda_{02} \\ \lambda_{03} \\ \lambda_{04} \end{pmatrix} + \begin{pmatrix} \lambda_{11} & \lambda_{12} & \lambda_{13} & \lambda_{14} \\ \lambda_{21} & \lambda_{22} & \lambda_{23} & \lambda_{24} \\ \lambda_{31} & \lambda_{32} & \lambda_{33} & \lambda_{34} \\ \lambda_{41} & \lambda_{42} & \lambda_{43} & \lambda_{44} \end{pmatrix} \begin{pmatrix} \pi_t^* \\ r_t \\ \pi_t \\ x_t \end{pmatrix}$$

Each row of $\boldsymbol{\lambda}_t$ determines the price of risk associated with each of the states; these vary over time with the level of the states

Figure 1a: US nominal zero-coupon yields

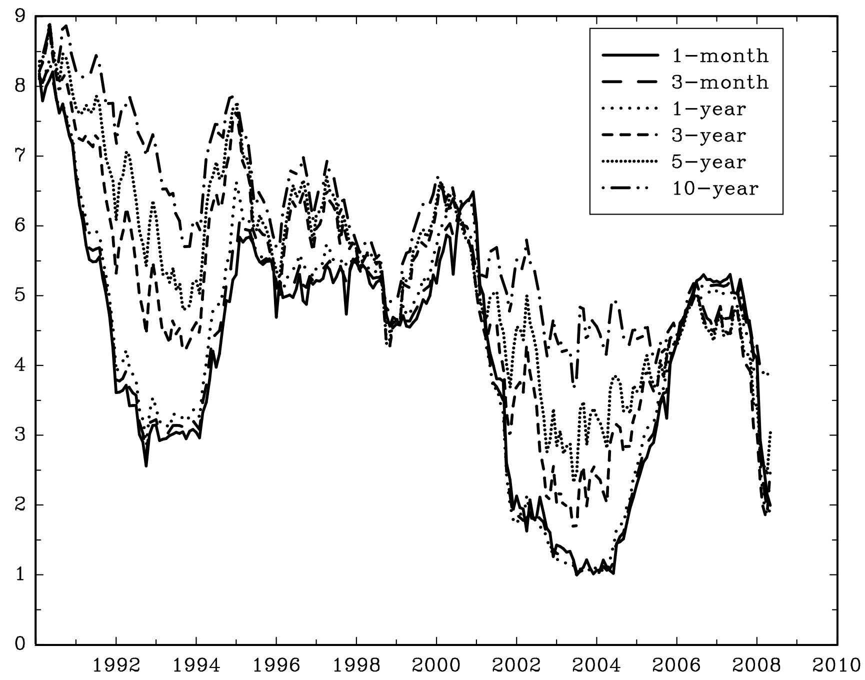


Figure 1b: Euro area nominal zero-coupon yields

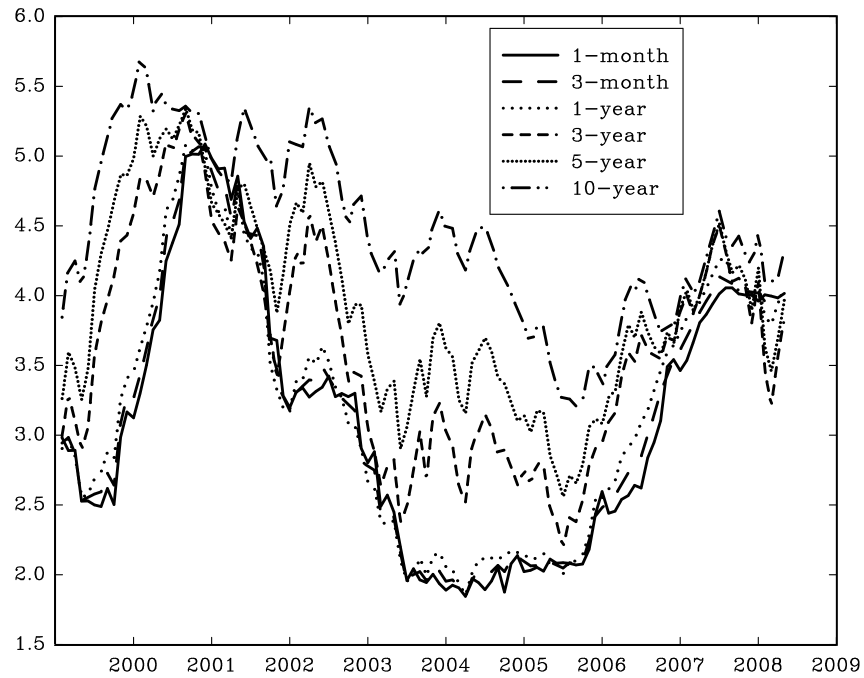


Figure 2a: US real zero-coupon yields

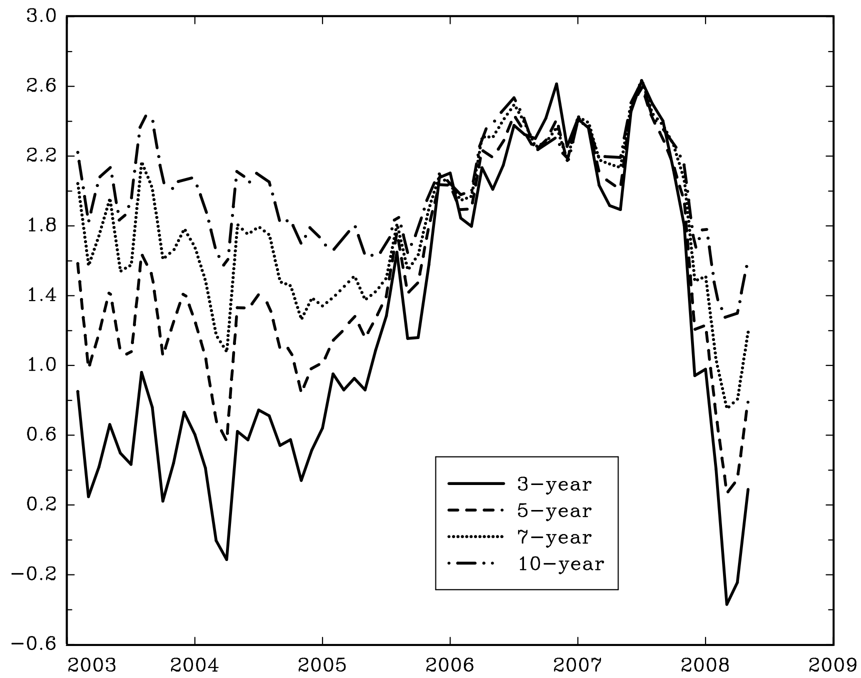


Figure 2b: Euro area real zero-coupon yields

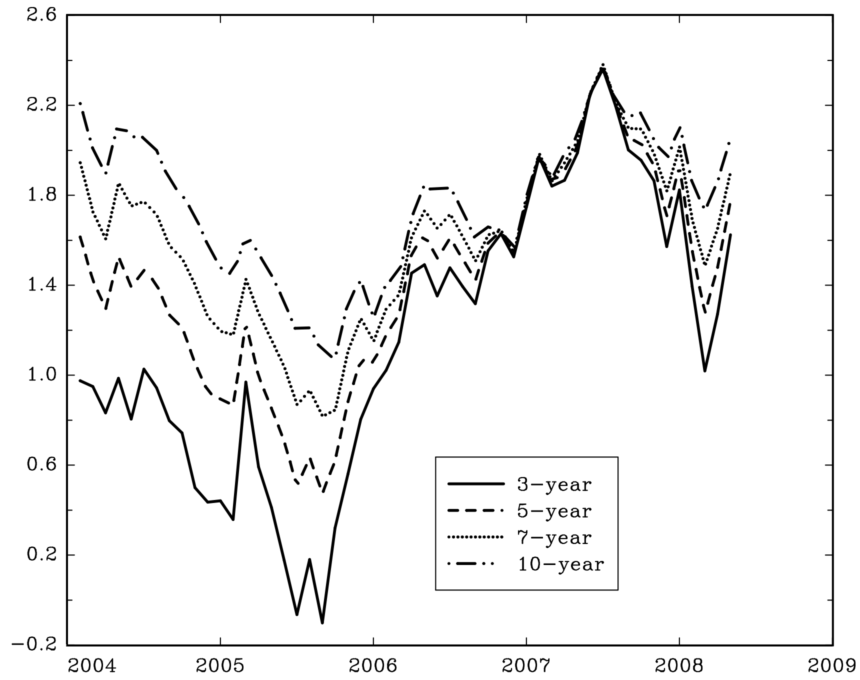


Figure 3a: US zero-coupon break-even inflation rates

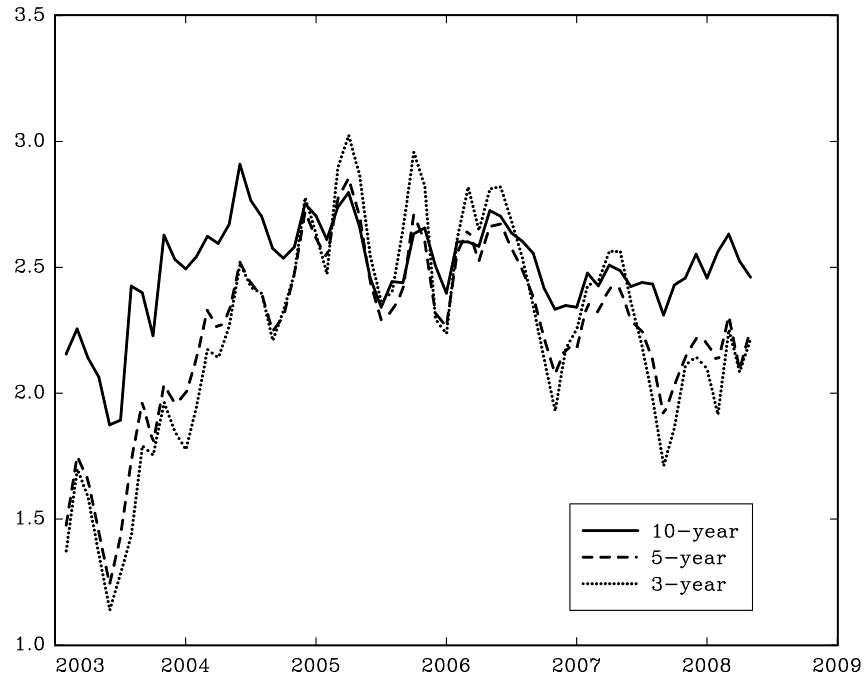


Figure 3b: Euro area zero-coupon break-even inflation rates