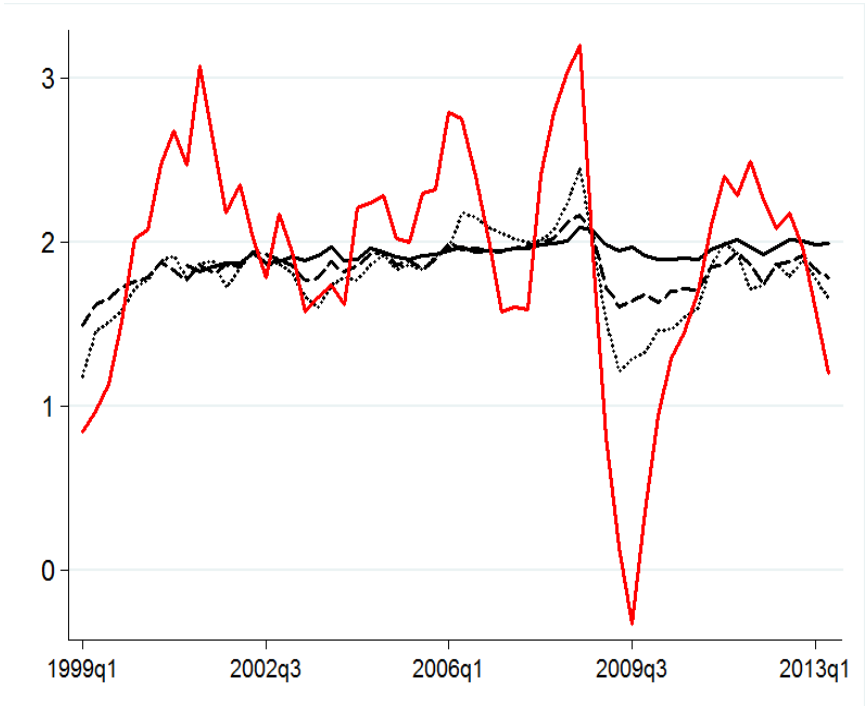
Inflation uncertainty and monetary policy in the Eurozone – Evidence from the ECB Survey of Professional Forecasters

Alexander Glas and Matthias Hartmann

April 7, 2014

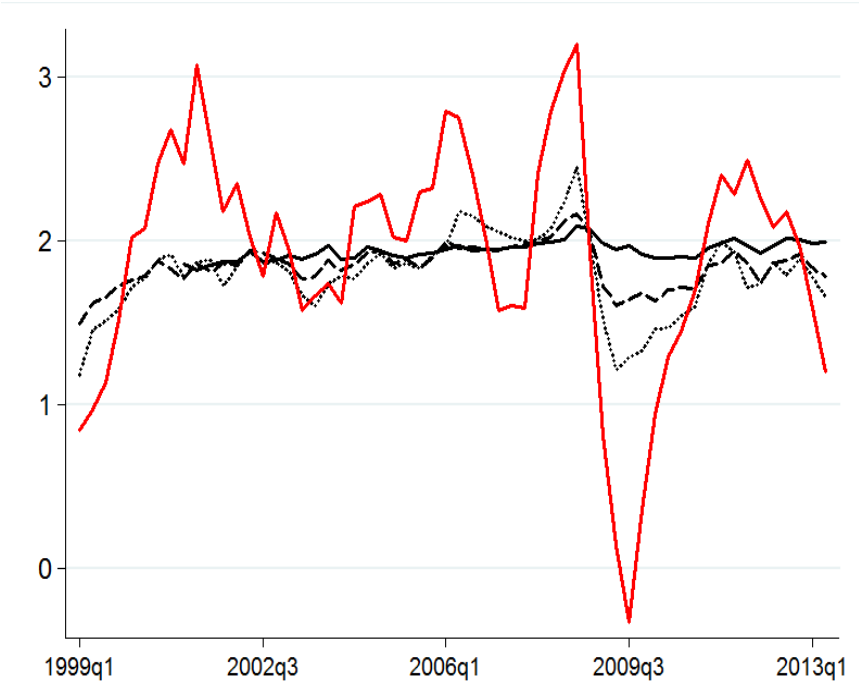
Heidelberg University

ECB: "Eurozone inflation expectations are *WELL ANCHORED*".

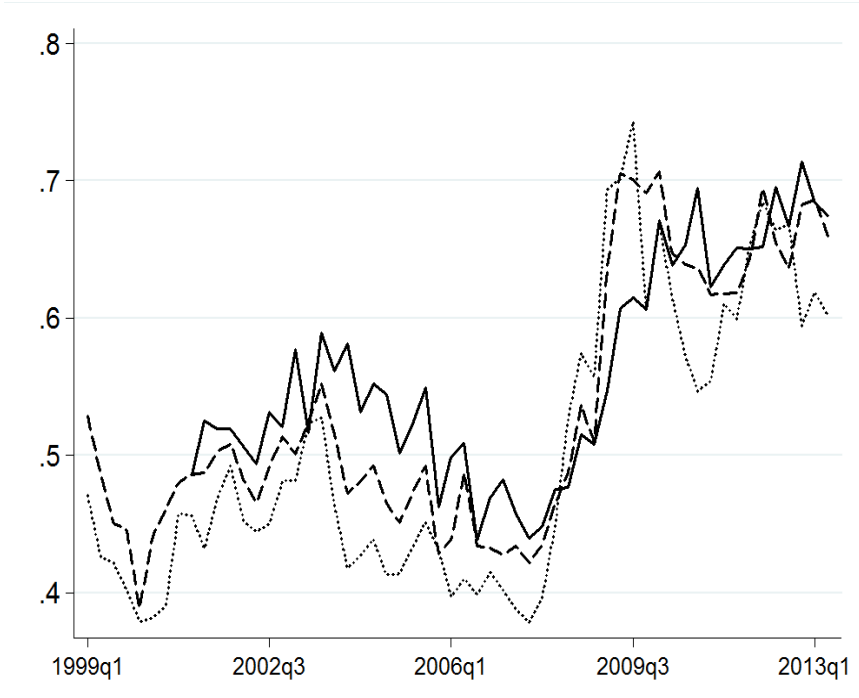


Annual inflation rate (red line) and average SPF forecast
Forecast horizon of 4 quarters ($h = 4$): dotted black line,
Forecast horizon of 8 quarters ($h = 8$): dashed line,
Forecast horizon of 20 quarters ($h = 20$): solid line.

ECB: "Eurozone inflation expectations are *WELL ANCHORED*".
However, increase in std. dev. of aggregate density forecast since ∼2008



Average point forecast



Aggregate inflation uncertainty

Forecast horizon of 4 quarters ($h = 4$): dotted black line,
Forecast horizon of 8 quarters ($h = 8$): dashed line,
Forecast horizon of 20 quarters ($h = 20$): solid line.

This talk

- In contrast to inflation expectations, IU has not returned to its pre-crisis level
- Main questions of interest:
  1. What determines aggregate inflation uncertainty?
  2. How can differences in forecasters' individual IU be explained?
- Discuss ways to measure IU by survey data
- Highlight various potential drivers of individual and aggregate IU:
  1. central bank policy, macroeconomic factors and policy uncertainty
  2. characteristics of survey cross-section: group-specific forecasting success, reversal to aggregate IU

Data

- Forecast data from Survey of Professional Forecasters (SPF)
  - Quarterly data $t = 1, ..., T$ for 1999Q1-2013Q2 $\rightarrow$ $T = 58$
  - Individual forecast data from a panel of 75 active forecasters on HICP inflation
  - Forecast horizons of fixed length: $h = \{4, 8, 20\}$ quarters, $h = 20$ refers to entire year
  - Forecasters assign probabilities to $b = 1, ..., B$ "bins"
  - Lower bound = -0.5 for 1999Q1-2009Q1, = -2.5 for 2009Q2-2009Q4 and = -1.5 for 2010Q1-2013Q2
  - Upper bound = 4.5 for 2000Q4 as well as 2008Q3-2013Q2 and = 4.0 else
  - For $h = 20$, sample is shorter: 2001Q1 to 2013Q2 $\rightarrow$ $T = 50$
  - Missing values are numerous. $\sim$60 responses per survey round

Measuring IU based on SPF data

- Beta distribution is fitted both to individually reported probabilities and their cross-sectional mean

$\rightarrow$ Obtain individual and aggregate inflation uncertainty as standard deviation of respective beta-densities

- Individual inflation uncertainty is denoted $iu_{i,t+h|t}$
- Aggregate inflation uncertainty is denoted $IU^{\bullet}_{t+h|t}$

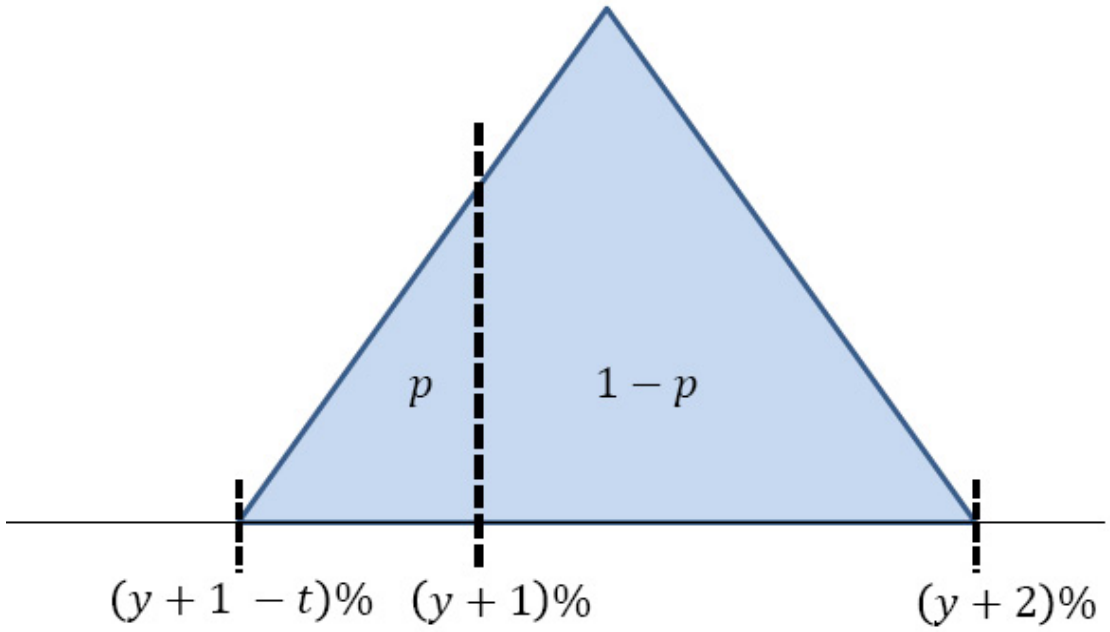
Fitting Methods – Engelberg et al. (2009)

Case 1 : 1 bin is used

- probability density function takes form of isosceles triangle
- base length = bin width
- height $= 2 \times 100 \times$ base length

Case 2 : 2 bins

- Suppose a forecaster assigns probability p and $1 - p$ to the intervals $[y\%, (y+1)\%)$ and $((y+1)\%, (y+2)\%]$. Let $t = \sqrt{p/2}/(1 - \sqrt{p/2})$.
- pdf given by isosceles triangle with endpoints $(y + 1 - t)\%$ and $(y + 2)\%$
- height $= 200/(t + 1)$



Fitting Methods – Engelberg et al. (2009)

Case 3: 3 or more bins are used. Estimate parameters α, β of generalized beta distribution by NLS:

$$\alpha, \beta = arg \min_{\alpha_0, \beta_0} \sum_{b=1}^{B} [Beta(t_b; \alpha_0, \beta_0, lb, ub) - F(t_b)]^2. \qquad (1)$$

where

$$Beta(t; \alpha, \beta, lb, ub) = \begin{cases} 0 & \text{if } t \leq lb \\ \frac{1}{B(\alpha,\beta)} \int_{lb}^{t} \frac{(x-lb)^{\alpha-1}(ub-x)^{beta-1}}{(ub-lb)^{\alpha+\beta-1}} \mathrm{d}x & \text{if } lb \leq t < ub \\ 1 & \text{if } t > ub \end{cases}$$

SPF Data

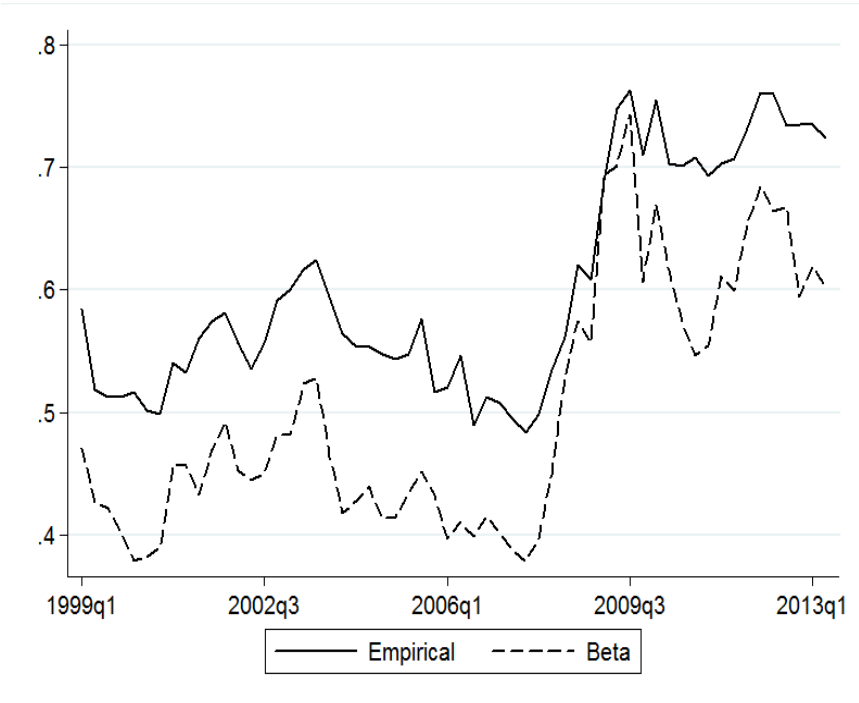
Figure: Individual forecasters panel

Data

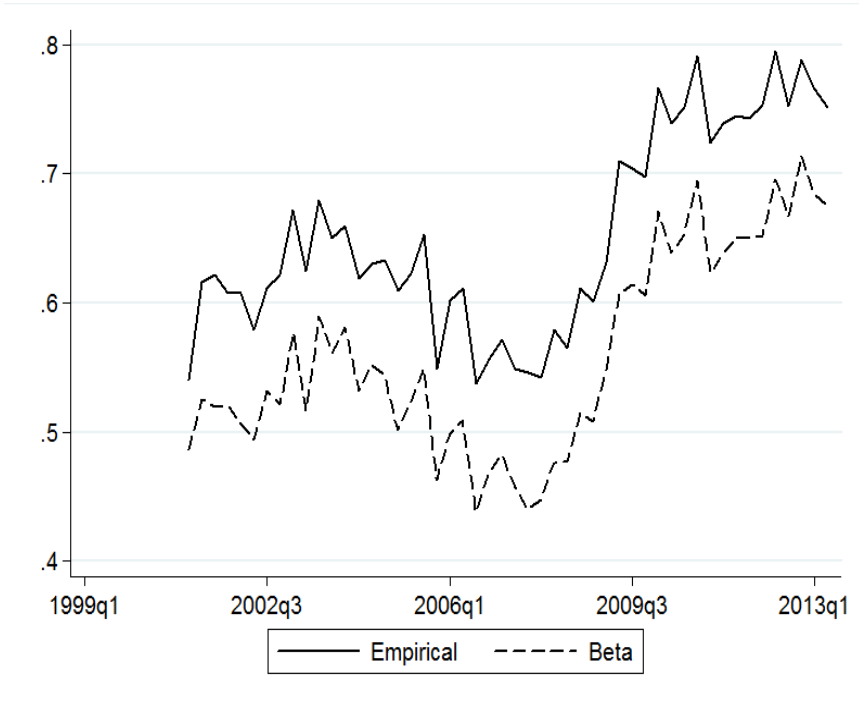
Inflation expectations, $h = 1$

Estimates of $IU^{\bullet}_{t+h|t}$

Histogram-based (Empirical distr.) vs. Engelberg (Beta distr.) approach:



$IU^{\bullet}_{t+4|t}$



$IU^{\bullet}_{t+20|t}$

Aggregate Variance vs Disagreement

A frequently used proxy for IU is the so-called "Disagreement" statistic

$$s_{t+h|t} = \sum_{i=1}^{N} (\hat{\pi}_{i,t+h|t} - \bar{\hat{\pi}}_{t+h|t})^2. \tag{2}$$

where $i = 1, ..., N$ refers to forecasters in the survey

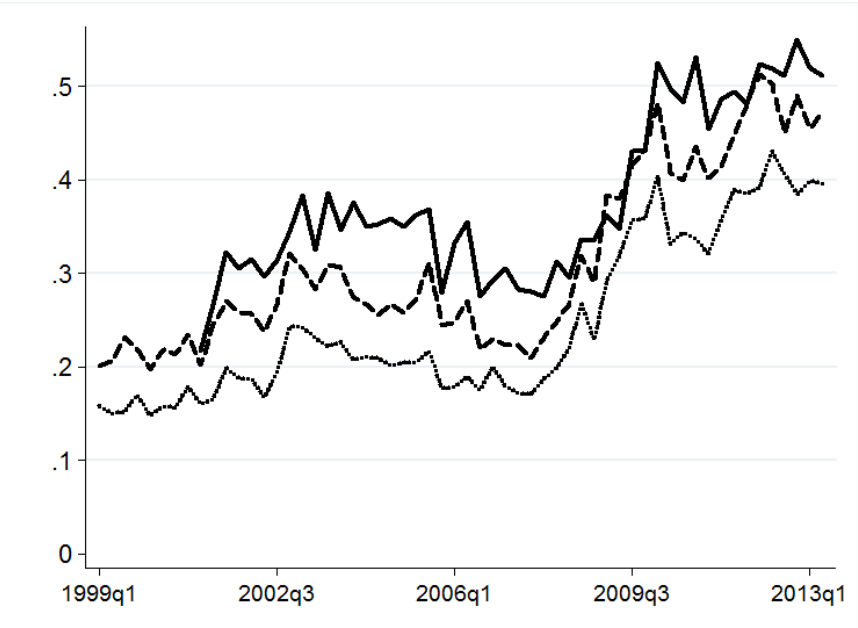
- Aggregate variance can be decomposed as:

$$(IU^{\bullet}_{t+h|t})^2 = (1/N) \sum_{i=1}^{N} iu^2_{i,t+h|t} + s_{t+h|t}. \tag{3}$$

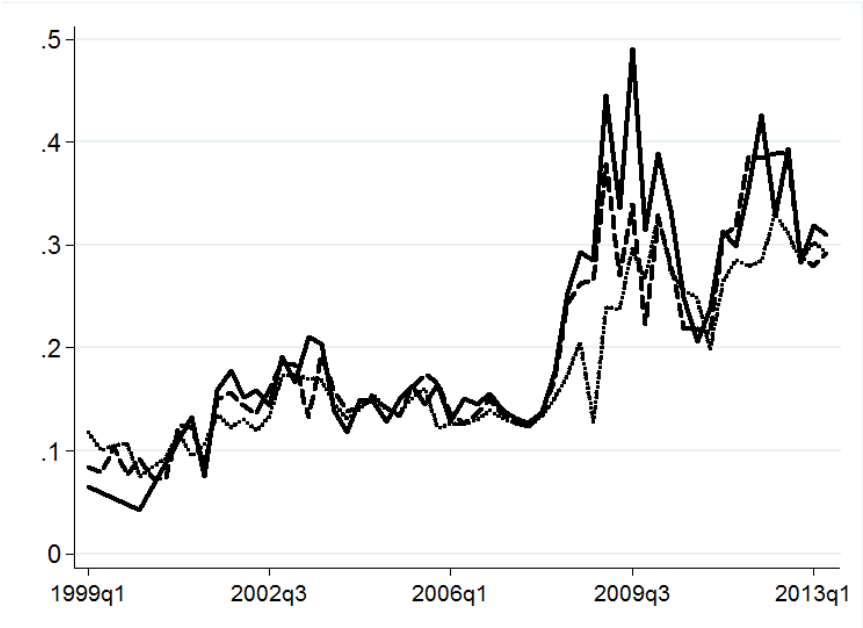
- $s_{t+h|t}$ is one component of aggregate variance

Aggregate Variance vs Disagreement

$$(IU^{\bullet}_{t+h|t})^2 - s_{t+h|t}$$



Empirical (Histogram)



Beta

Forecast horizon of 4 quarters ($h = 4$): dotted line,
Forecast horizon of 8 quarters ($h = 8$): dashed line,
Forecast horizon of 20 quarters ($h = 20$): solid line.

What determines IU?

Do observable quantities help to explain

- $IU^{\bullet}_{t+h|t}$ (aggregate) ?
- $iu_{i,t+h|t}$ (individual-specific) ?

- Potential triggers:
  1. macroeconomic quantities
  2. indicators of central bank policy
  3. indicators of policy uncertainty

Explanatory variables

- $OU^{\bullet}_{t+h|t}$: Output (GDP) growth uncertainty, derived as $IU^{\bullet}_{t+h|t}$
- π: Eurozone inflation rate
  - year-on-year growth rate of HICP: $\pi_t = 100 \times \ln(HICP_t / HICP_{t-4})$
- real, annual GDP growth rate in Eurozone: $y_t = 100 \times \ln(GDP_t / GDP_{t-4})$
- $SD(E)$: World equity price volatility
  - quarterly volatility of the MSCI World Equity Index (captures the evolution of over 6000 stock prices for 23 industrial countries in US dollars)

$$SD_t(E) = 100 \times \sqrt{\sum_{d \in t} r^2_{d,t}}$$

where $r_{d,t} = log(P_{d,t} / P_{d-1,t})$ is the return on day d in quarter t

Explanatory variables – Policy-related

- *Assets*: ECB assets
  - based on total loans for the euro area in trillions of euros (changing composition, unspecified counterpart sector)
- *PolU*: Bloom et al. (2012) Policy Uncertainty index
  - newspaper coverage of policy-related economic uncertainty (weight 0.5)
  - forecaster disagreement about federal government budget balances (weight 0.25)
  - forecaster disagreement about consumer prices (weight 0.25) $\rightarrow$ discarded

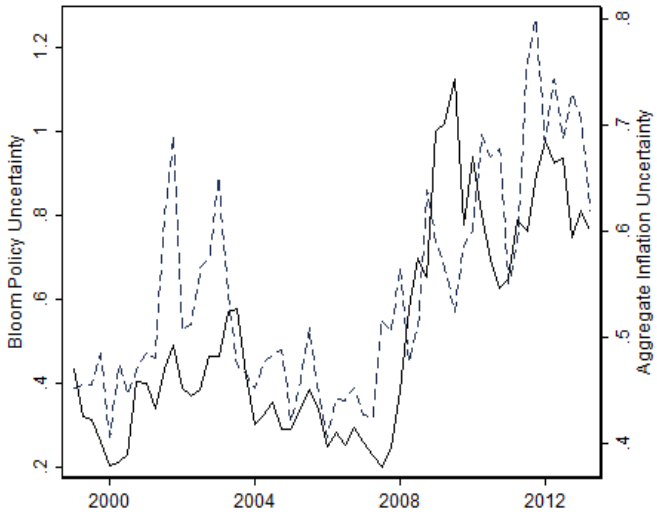
Explanatory variables – Policy-related

- *TD*: Taylor rule deviations

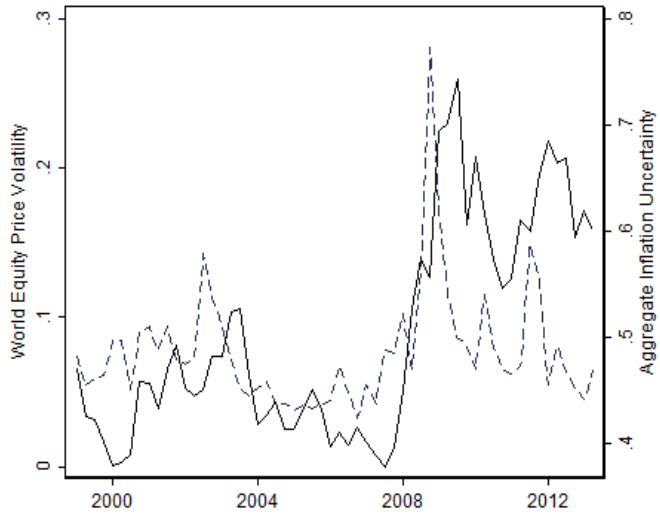
$$TD_t = i_t - i_t^* = i_t - r - 1.5(\pi_t - \pi_t^*) - 0.5\tilde{y},$$

  where i is the actual interest rate, i^* is the Taylor rule interest rate and $\tilde{y}_t = 100 \times (gdp_t - gdp_t^{HP})$ denotes the output gap, where $gdp_t = \ln(GDP_t)$. Moreover, gdp_t^{HP} is HP-filtered trend
  - $TD > 0$ indicates "restrictive" monetary policy
  - $TD < 0$ indicates "expansionary" monetary policy
- *MPC*: KOF Monetary Policy Communicator
  - translates the ECB president's statements on price stability during monthly press conferences into numerical values ($MPC \in [-1, 1]$)
  - higher values depending on how often the term "inflation risk" is mentioned in ECB communication

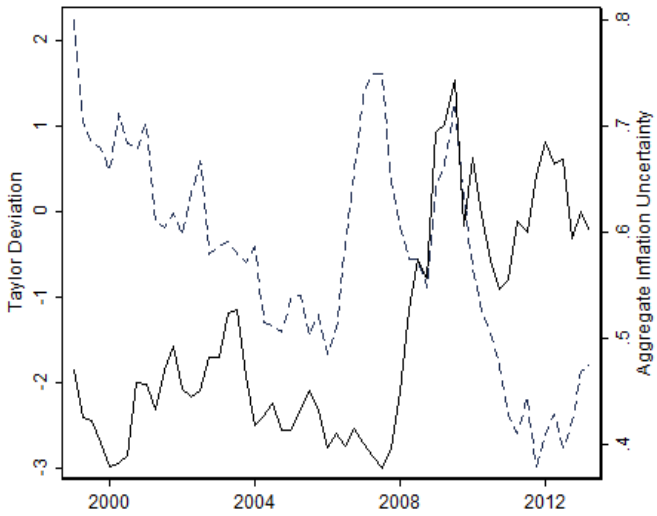
Policy uncertainty ($PolU$)



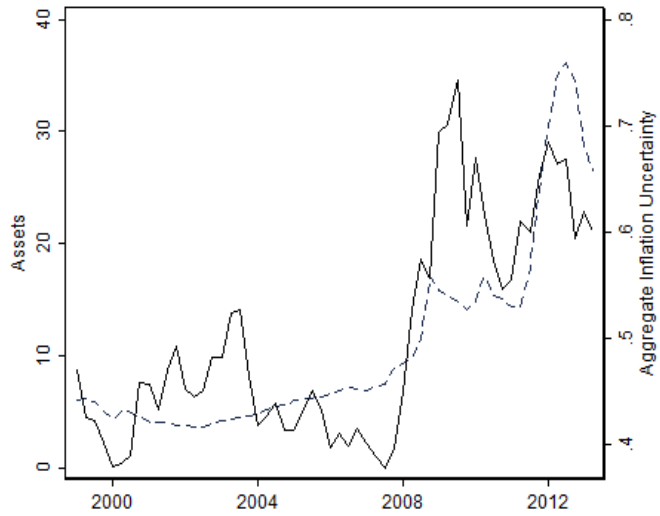
$SD(E)$



TD



$Assets$



Determinants of aggregate $IU^{\bullet}_{t+h|t}$

	$IU^{\bullet}_{t+4\|t}$	$IU^{\bullet}_{t+8\|t}$	$IU^{\bullet}_{t+20\|t}$
$IU^{\bullet}_{t+4-1\|t-1}$	0.29	−0.08	0.024
	(1.62)	(0.54)	(0.14)
$IU^{\bullet}_{t+8-1\|t-1}$	**0.51** *	**0.67** *	0.411
	(1.97)	(3.19)	(1.60)
$IU^{\bullet}_{t+20-1\|t-1}$	**−0.44** *	−0.11	0.132
	(−2.08)	(−0.68)	(0.63)
$OU_{t+h-1\|t-1}$	**0.23** *	−0.07	−0.058
	(2.01)	(−0.72)	(−0.51)
π_{t-1}	0.01	−0.01	−0.015
	(0.43)	(−1.61)	(−1.21)
y_{t-1}	−0.07	−0.38	−0.183
	(−0.16)	(−1.09)	(−0.43)
$SD_{t-1}(E)$	**0.71** *	**0.46** *	−0.011
	(4.76)	(3.87)	(−0.07)
$Assets_{t-1}$	0.01	**0.01** *	0.000
	(1.41)	(2.21)	(0.50)
$PolU_{t-1}$	0.01	0.01	0.028
	(0.17)	(0.26)	(0.81)
TD_{t-1}	−0.01	−0.01	**−0.017** *
	(−1.58)	(−1.46)	(−2.18)
T	49	49	49
BG-LM (4) p-val.	0.41	0.02	0.07
BG-LM (8) p-val.	0.15	0.05	0.28

Determinants of individual-specific $iu_{i,t+4|t}$

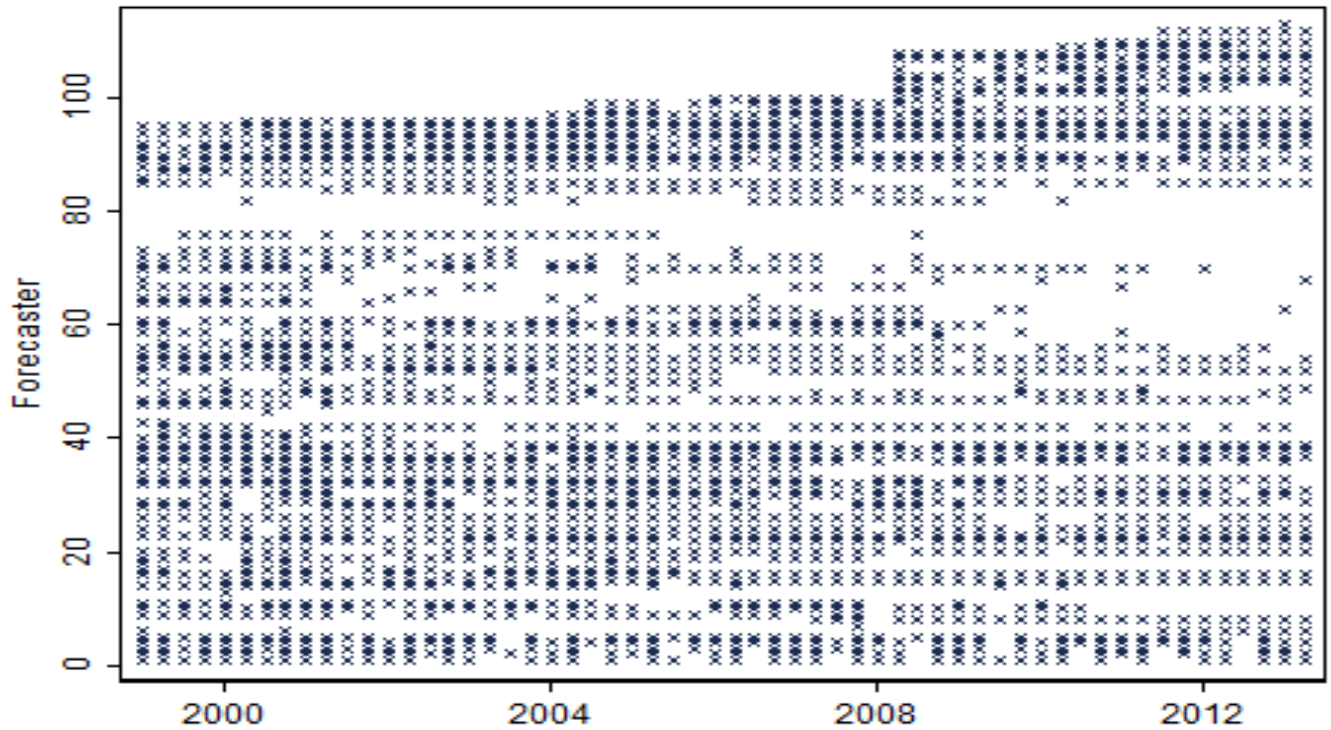


Figure: Individual forecasters panel

Determinants of individual-specific $iu_{i,t+4|t}$

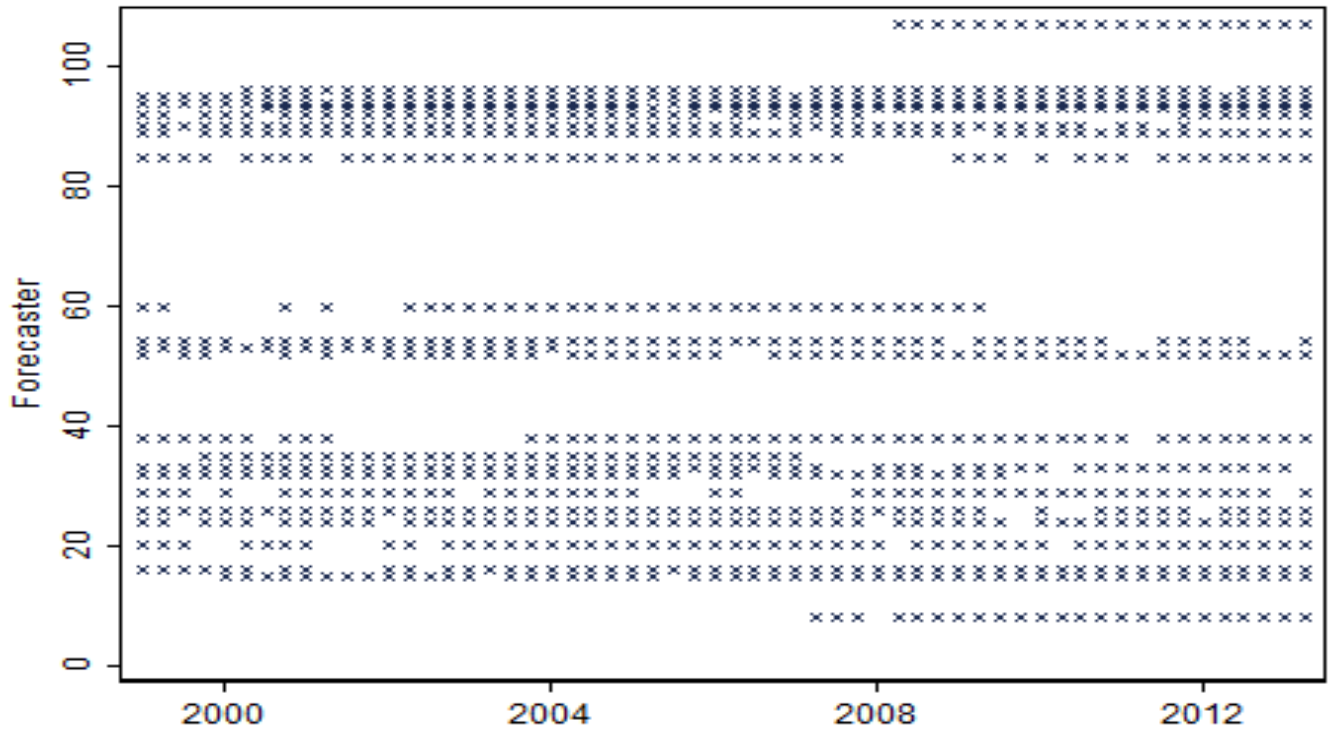


Figure: Individual forecasters panel (only include forecasters with more than 20 consecutive SPF participations)

Determinants of individual-specific $iu_{i,t+4|t}$

Recall: We analyze data from experts. (Survey of *Professional* Forecasters)!

- Exploit cross sectional variation
- Idea: guidance from most successful forecasters among SPF-experts on selection of *IU*-indicators
- Criterion: absolute prediction error

$$a_{i,t+h|t} = |\hat{e}_{i,t+h|t}| = |\pi_{t+h} - \hat{\pi}_{i,t+h|t}|$$

- 2 ways of classifying forecasters:

1. *Unconditional outperformance*, holds for those of $i = 1, ..., N$ forecasters where $a_i = (1/T) \sum_{t=1}^{T} a_{i,t+h|t} <$median$_i(a_i)$
2. *Conditional outperformance*: for each $t = 1, ..., T$, select forecasters satisfying $a_{i,t+h|t} <$median$_i(a_{i,t+h|t})$.

Determinants of $iu_{i,t+4|t}$, FE regression

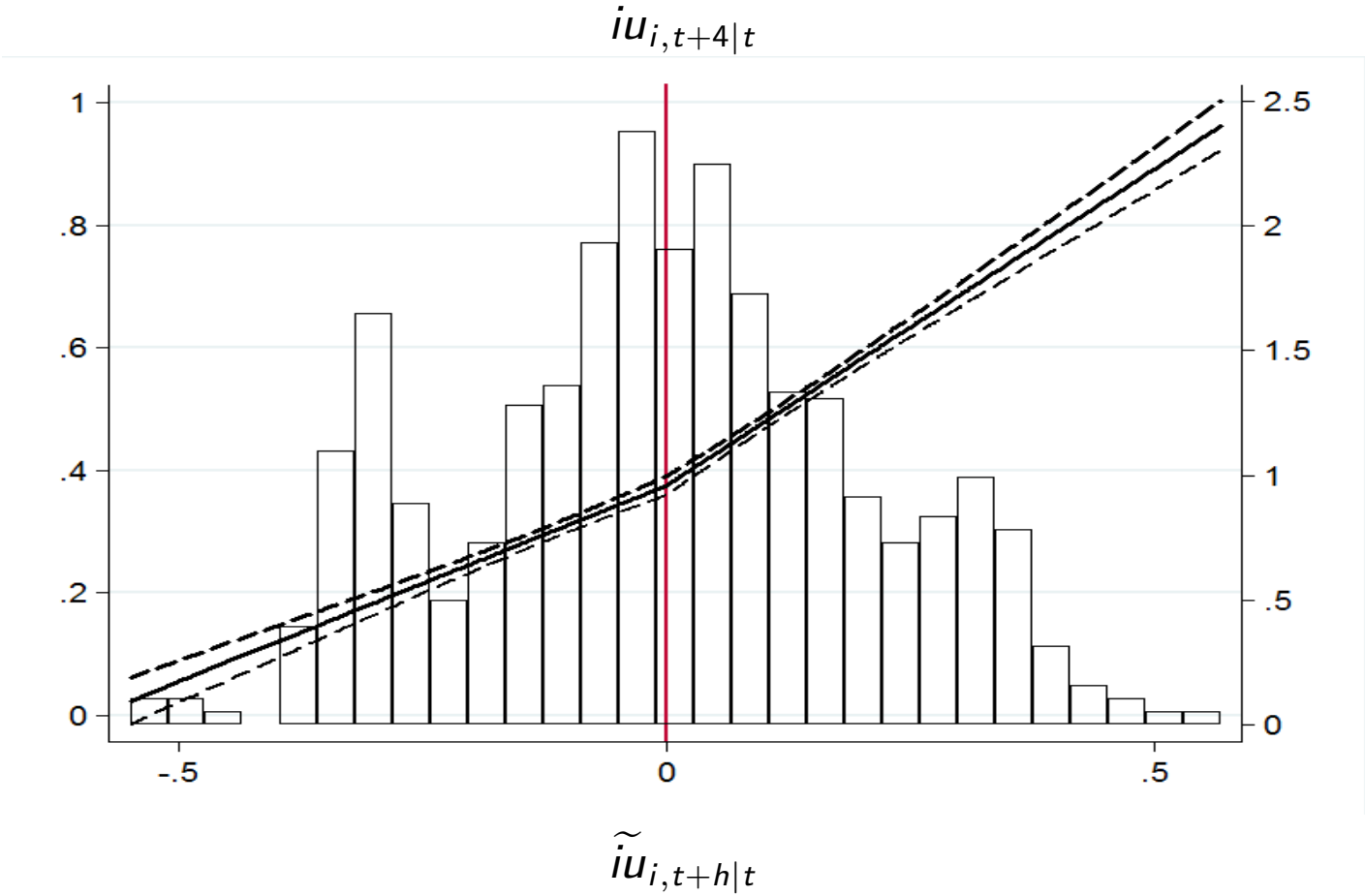
	full sample	Unconditional performance		Conditional performance	
		a <median	a ≥median	a <median	a ≥median
constant	0.73	0.55	1.02	0.63	0.94
	(1.67)	(0.75)	(1.93)	(0.89)	(1.64)
$OU_{t+h-1\|t-1}$	**0.12** *	0.08	**0.14** *	0.07	**0.13** *
	(2.92)	(1.10)	(2.82)	(1.08)	(2.18)
π_{t-1}	**−0.03** *	**−0.05** *	**−0.02** *	**−0.05** *	**−0.04** *
	(−3.86)	(−2.14)	(−2.14)	(−3.16)	(−2.51)
y_{t-1}	−0.42	−0.25	−0.69	−0.28	−0.61
	(−1.00)	(−0.36)	(−1.35)	(−0.41)	(−1.10)
$SD(E)_{t-1}$	0.20	0.25	0.17	0.29	0.04
	(1.68)	(1.23)	(1.14)	(1.58)	(0.26)
$Assets_{t-1}$	**0.02** *	**0.03** *	0.01	0.01	**0.04** *
	(2.86)	(2.25)	(1.47)	(0.86)	(3.48)
$PolU_{t-1}$	0.05	**0.10** *	0.03	**0.10** *	0.04
	(1.77)	(2.05)	(0.73)	(2.01)	(0.80)
TD_{t-1}	**−0.03** *	**−0.02** *	**−0.03** *	**−0.03** *	**−0.02** *
	(−5.21)	(−2.52)	(−4.75)	(−3.49)	(−2.50)
MPC_{t-1}	0.03	**0.15** *	−0.03	0.04	0.02
	(1.12)	(2.58)	(−0.86)	(0.58)	(0.46)
Cross-sections:	24	11	13	11	13
Total no. of obs.:	992	443	549	416	499

Relation between $iu_{i,t+h|t}$ and $IU^{\bullet}_{t+h|t}$

In contrast to forecasts for conditional mean of π, no ex-post comparison of forecast $iu_{i,t+h|t}$ and realized value possible

- Do forecasters consider "consensus" (=aggregate) $IU^{\bullet}_{t+h|t}$ as benchmark?
- If so, is adjustment towards aggregate $IU^{\bullet}_{t+h|t}$ related to observable quantities such as, e.g., (monetary) policy indicators?
- Model joint dynamics of individual uncertainty ($iu_{i,t+h|t}$) and deviations from the aggregate ($IU^{\bullet}_{t+h|t}$), i.e. $\widetilde{iu}_{i,t+h|t} = iu_{i,t+h|t} - IU^{\bullet}_{t+h|t}$

$$\widetilde{iu}_{i,t+h|t} = iu_{i,t+h|t} - IU^{\bullet}_{t+h|t}$$



$$\begin{aligned} iu_{i,t+h|t} &= \beta_1 + \beta_2 \widetilde{iu}_{i,t+h|t} \mathbb{I}(\widetilde{iu}_{i,t+h|t} > 0) + \\ &\quad + \beta_3 \widetilde{iu}_{i,t+h|t} \mathbb{I}(\widetilde{iu}_{i,t+h|t} < 0) + \epsilon_{i,t+h|t} \end{aligned}$$

where $\mathbb{I}(\cdot)$ denotes the indicator function.

Relation between $iu_{i,t+h|t}$ and $IU^{\bullet}_{t+h|t}$

Model joint dynamics of individual uncertainty ($iu_{i,t+h|t}$) and deviations from the aggregate ($IU^{\bullet}_{t+h|t}$), i.e. $\widetilde{iu}_{i,t+h|t} = iu_{i,t+h|t} - IU^{\bullet}_{t+h|t}$

$$\widetilde{iu}_{i,t+h|t} = \beta_{11} + \beta_{12}\widetilde{iu}_{i,t+h-1|t-1} + \beta_{13}iu_{i,t+h-1|t-1} + \varepsilon_{i1,t+h} \quad (4)$$

$$iu_{i,t+h|t} = \beta_{21} + \beta_{22}\widetilde{iu}_{i,t+h-1|t-1} + \beta_{23}iu_{i,t+h-1|t-1} + \varepsilon_{i2,t+h} \quad (5)$$

After estimating (4) and (5), obtain

$$\Delta\widetilde{iu}_{i,t+h|t} = b_{11} + (1 - b_{12})\widetilde{iu}_{i,t+h-1|t-1} + b_{13}iu_{i,t+h-1|t-1} \quad (6)$$

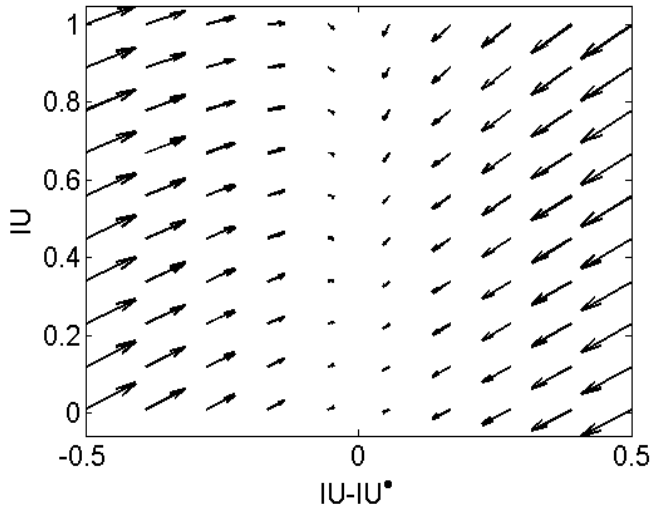
$$\Delta iu_{i,t+h|t} = b_{21} + b_{22}\widetilde{iu}_{i,t+h-1|t-1} + (1 - b_{23})iu_{i,t+h-1|t-1} \quad (7)$$

where, e.g., $\Delta iu_{i,t+h|t} = iu_{i,t+h|t} - iu_{i,t+h-1|t-1}$.

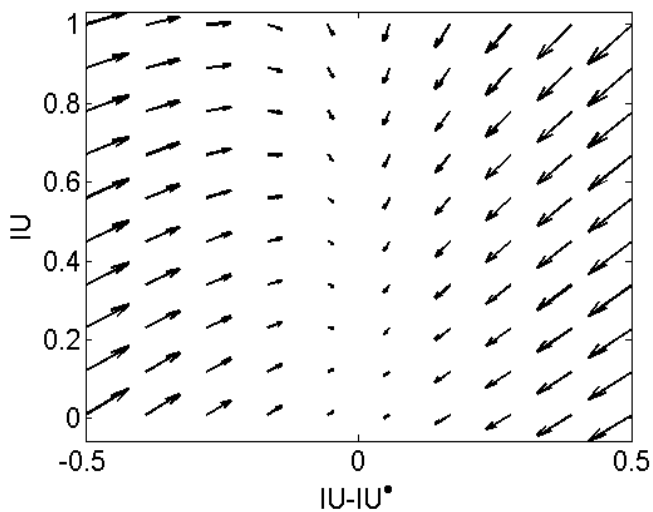
$\rightarrow$ Graphical display of joint dynamics of $iu_{i,t+h|t}$ and $\widetilde{iu}_{i,t+h|t}$ based on (6) and (7)

$iu_{i,t+h|t}$ and $IU^{\bullet}_{t+h|t}$: phase diagrams, $h = 4$

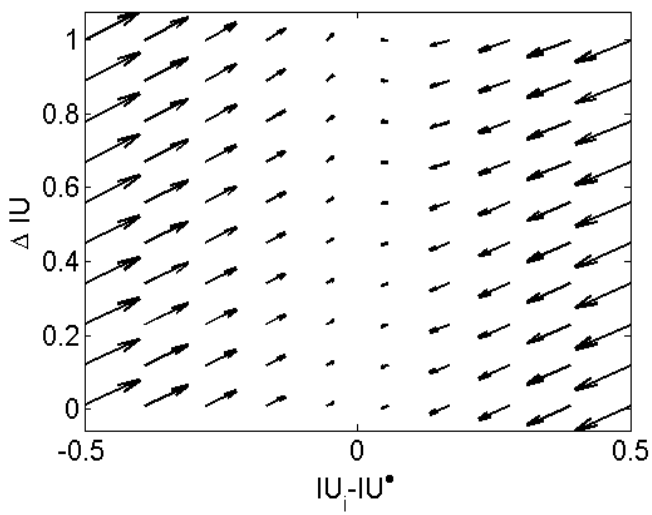
Full sample (992 obs.)



$a <$median (549 obs.)

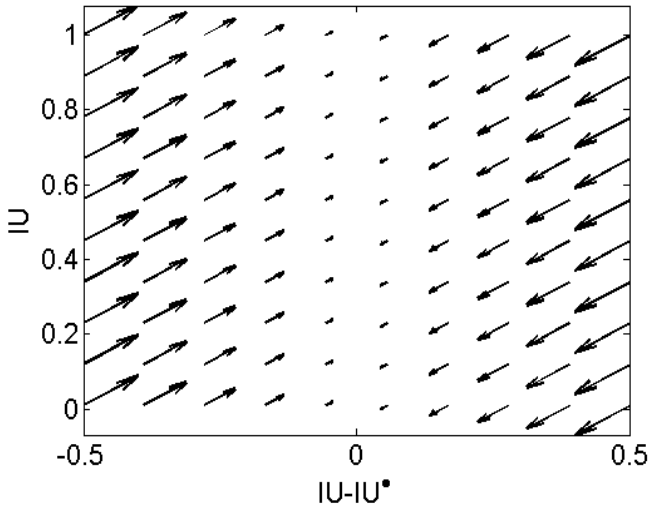


$a \geq$median (443 obs.)

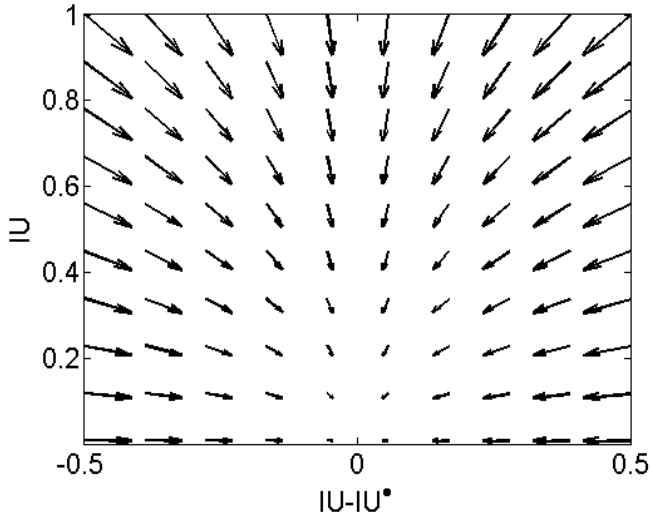


$iu_{i,t+h|t}$ and $IU^{\bullet}_{t+h|t}$: phase diagrams, $h = 4$

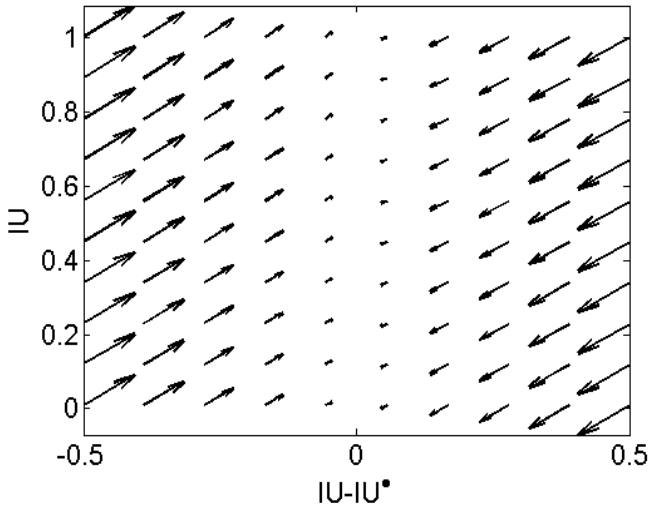
$MPC \nrightarrow IU^{\bullet}_{t+4|t}$ (803 obs.)



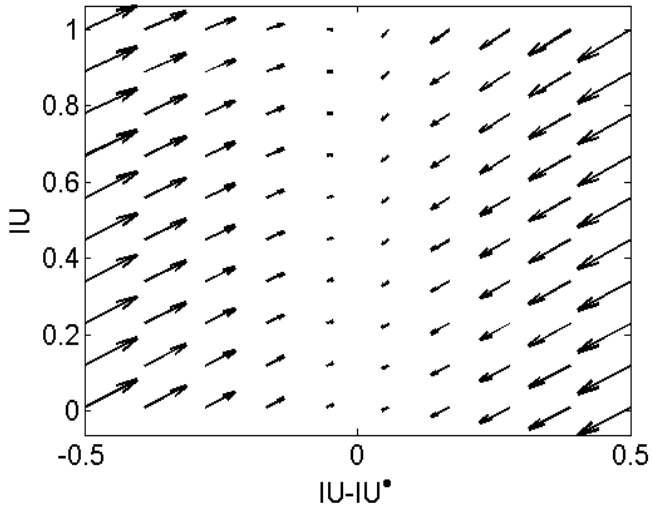
$MPC \rightarrow IU^{\bullet}_{t+4|t}$ (189 obs.)



PolU$\nrightarrow IU^{\bullet}_{t+4|t}$ (741 obs.)

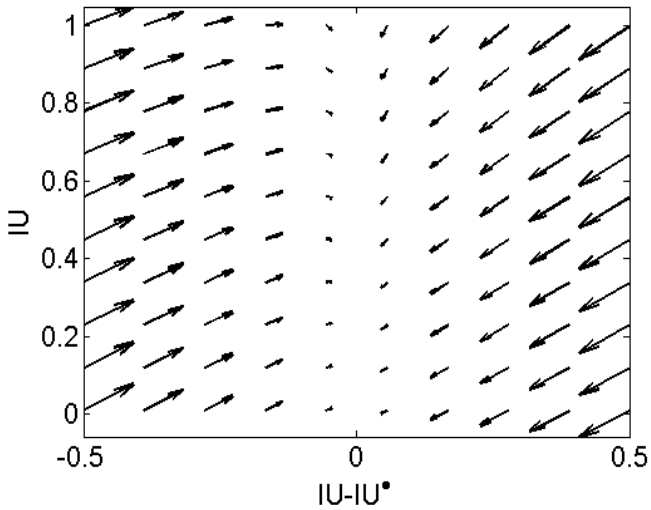


$PolU \rightarrow IU^{\bullet}_{t+4|t}$ (251 obs.)

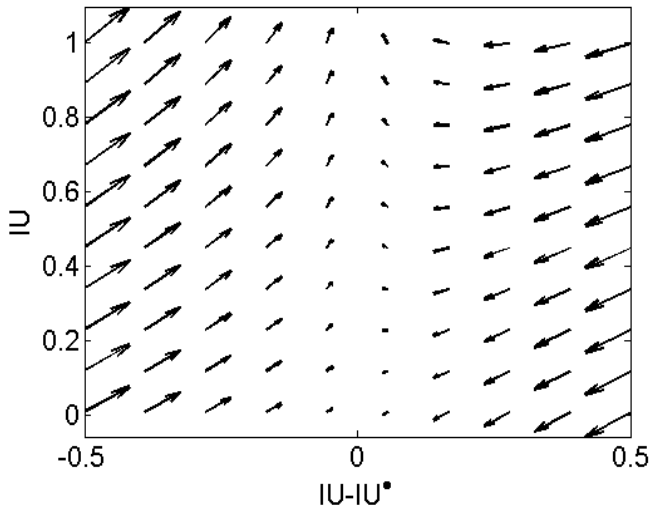


$iu_{i,t+h|t}$ and $IU^{\bullet}_{t+h|t}$: phase diagrams, $h = 4$

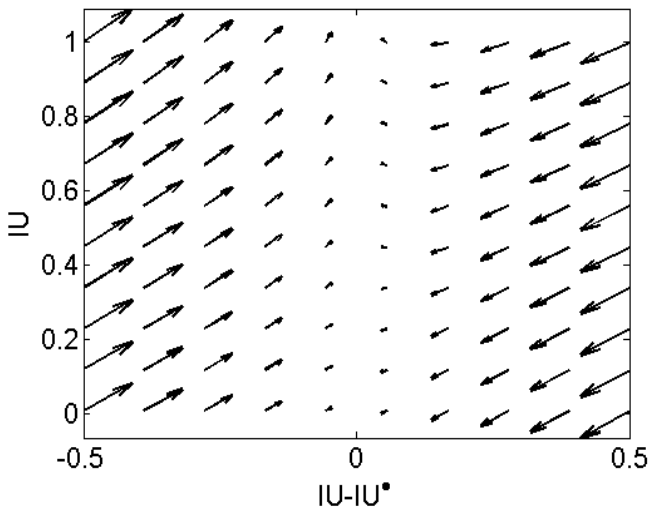
Full sample (992 obs.)



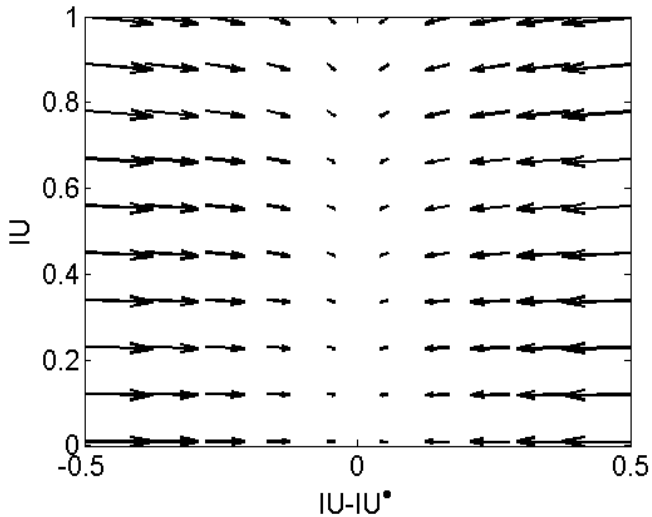
$TD^{France} \rightarrow IU^{\bullet}_{t+4|t}$ (545 obs.)



$TD^{Germany} \rightarrow IU^{\bullet}_{t+4|t}$ (605 obs.)

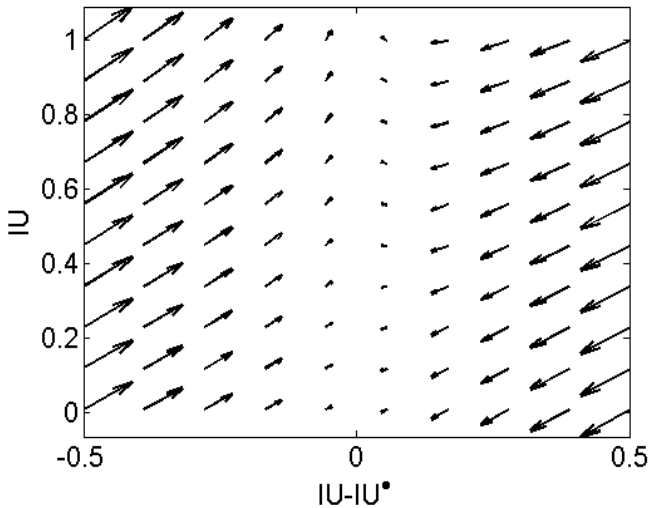


$TD^{Ireland} \rightarrow IU^{\bullet}_{t+4|t}$ (371 obs.)

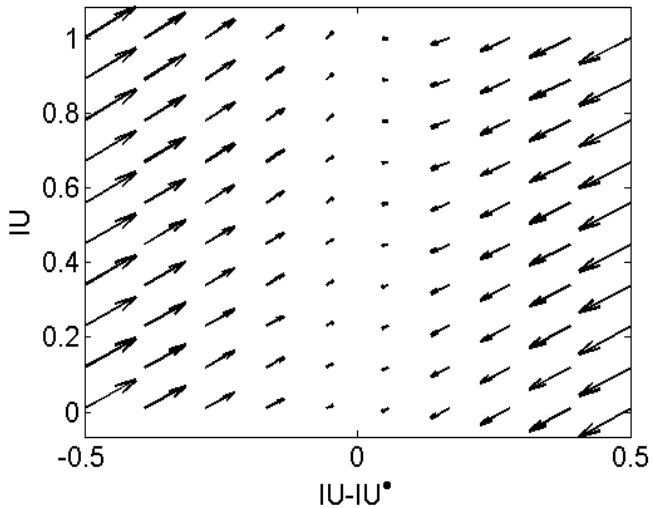


$iu_{i,t+h|t}$ and $IU^{\bullet}_{t+h|t}$: phase diagrams, $h = 4$

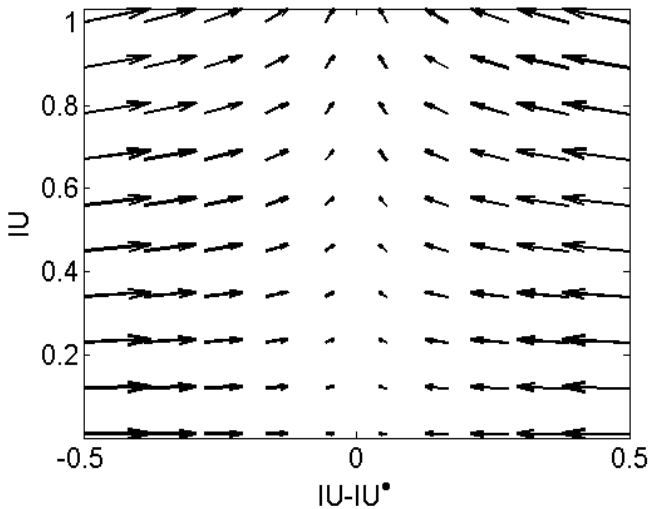
$TD^{Italy} \rightarrow IU^{\bullet}_{t+4|t}$ (638 obs.)



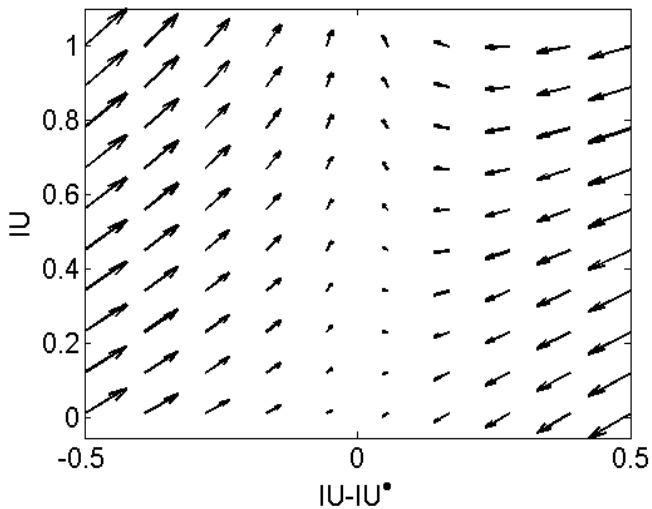
$TD^{Netherlands} \rightarrow IU^{\bullet}_{t+4|t}$ (642 obs.)



$TD^{Portugal} \rightarrow IU^{\bullet}_{t+4|t}$ (301 obs.)



$TD^{Spain} \rightarrow IU^{\bullet}_{t+4|t}$ (458 obs.)



Conclusion

- Analyzing aggregate IU, we find
  - Spillovers from output uncertainty (short horizon)
  - Effect of fluctuations on worldwide equity markets (short horizon)
  - Positive relation to increases in ECB balance sheet (medium horizon)
  - Increases in IU during expansionary monetary policy – Taylor rule (medium horizon)
- Individual *IU*:
  - Distinguish determinants of $iu_{i,t+h|t}$ for more/less successful forecasters
  - $iu_{i,t+h|t}$ of successful forecasters reacts to ECB balance sheet expansions, central bank communication, policy uncertainty
- Relation between aggregate and individual IU:
  - Positive deviations of individual IU from aggregate IU persists if forecasters' IU related to ECB communication
  - Differences in individual IU related to idiosyncratic characteristics of Eurozone member states