Tails of inflation forecasts and tales of monetary policy

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Inflation risk and monetary policy

- Central bankers pay attention to inflation risk measures others than the central tendency of future inflation distribution
- By contrast, literature mostly considers linearized models where “balance of risk” plays no-role for monetary policy
- How to quantify the risks to inflation?
- Does the distribution around point inflation forecasts play a role in the dynamics of inflation and the conduct of monetary policy?

Survey based measures of inflation risk

- We introduce a measure called *inflation-at-risk* (I@R)
  - Tails in the distribution of future inflation
- We rely on survey forecasts to estimate these indicators
  - Individual subjective probabilities for different inflation scenarios
- We estimate upside and downside risks separately
  - A natural measure of the asymmetry of the risks

Changes in inflation risk matter

- Sizeable fluctuations in higher order moments of inflation
- I@Rs contain information about future inflation
  - 1 std-dev increase in asymmetry $\Rightarrow$ 48bps increase in inflation (GDP DEF) 2 years ahead
  - beats RW model out-of-sample
- The Fed reacts to information contained in I@Rs
  - 1 std-dev increase in asymmetry $\Rightarrow$ 26bps increase in the FF rate

Data

- US surveys of professional forecasters
  - since 1969 / Quarterly / $\simeq$ 30 institutions
- End-of-year ahead GDP deflator inflation forecasts
  - Individual mean point forecasts
  - Individual probability: histograms on a set of inflation bins

Individual distributions of inflation

- Smooth individual probability distributions using Engelberg, Manski & Williams (2009) methodology
  - Best fit of a generalized *beta* distribution on individual histograms
  - Estimate of future inflation distribution for each i and t: $\widehat{F}_{it}(\pi_{t+h})$
- Recover individual quantiles from individual distributions:

$$\widehat{q}_{it}(p) = \widehat{F}_{it}^{-1}(p)$$

Aggregate measures of inflation risks

- Inflation-at-risk: average of quantiles across individuals n_t

$$\widehat{\text{I@R}}_t(p) = (1/n_t)\sum_i \widehat{q}_{it}(p)$$

- Interquantile-range (dispersion):

$$\widehat{\text{IQR}}_t(p) = (1/n_t)\sum_i [\widehat{q}_{it}(1-p) - \widehat{q}_{it}(p)] = (1/n_t)\sum_i \widehat{\text{IQR}}_{it}(p)$$

- Asymmetry:

$$\begin{aligned}\widehat{\text{ASY}}_t(p) &= (1/n_t)\sum_i \{[\widehat{q}_{it}(1-p) - \widehat{q}_{it}(.5)] - [\widehat{q}_{it}(.5) - \widehat{q}_{it}(p)]\} \\ &= (1/n_t)\sum_i \widehat{\text{ASY}}_{it}(p)\end{aligned}$$

Aggregate measures of inflation risks

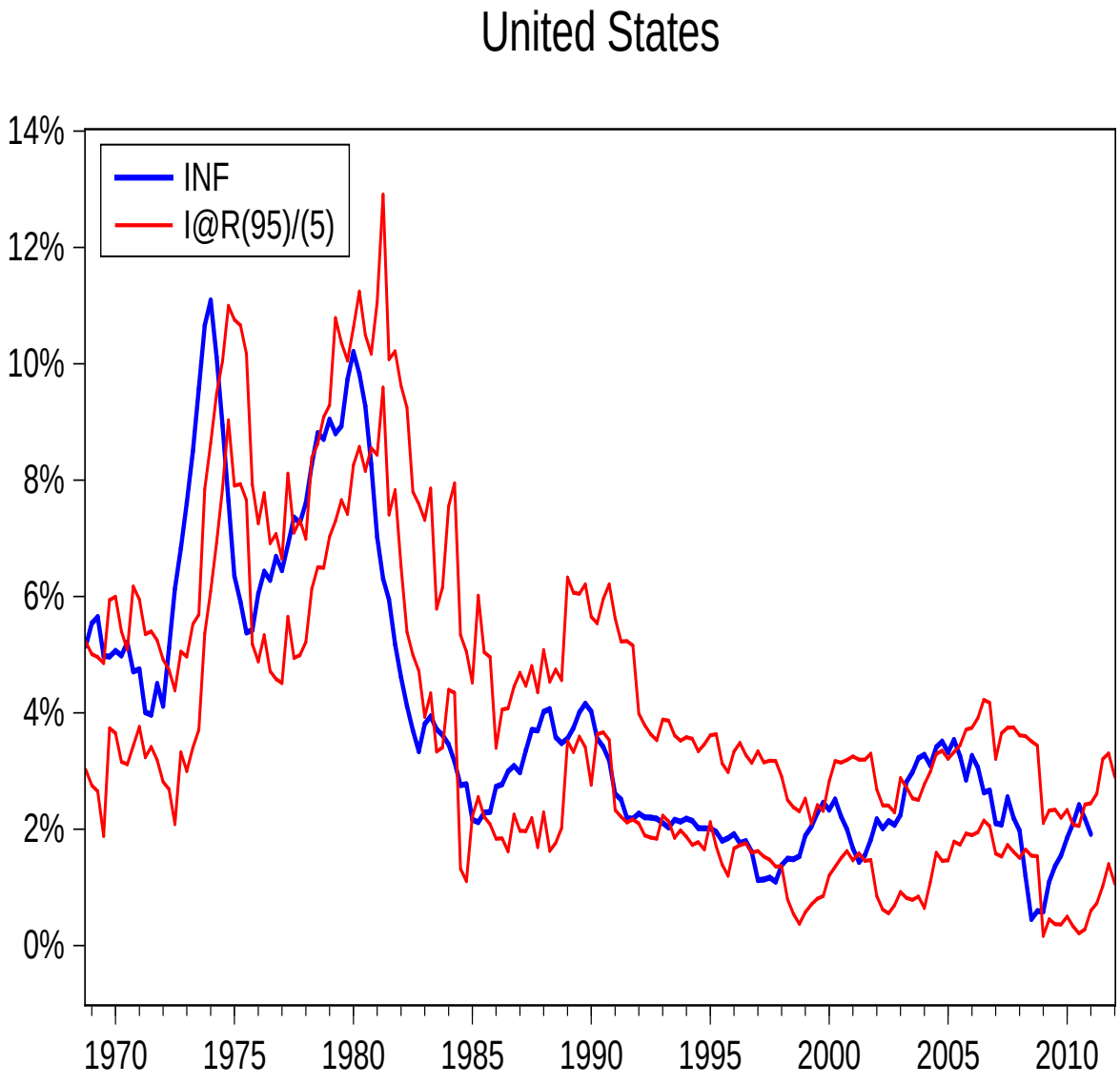
- Measures can be linked to Bowley's (1920) robust coefficient of skewness:

$$\text{RA}_{it}^{h}(p) = \frac{\left(q_{it}^{h}(1-p) - q_{it}^{h}(.50)\right) - \left(q_{it}^{h}(.50) - q_{it}^{h}(p)\right)}{q_{it}^{h}(1-p) - q_{it}^{h}(p)}$$

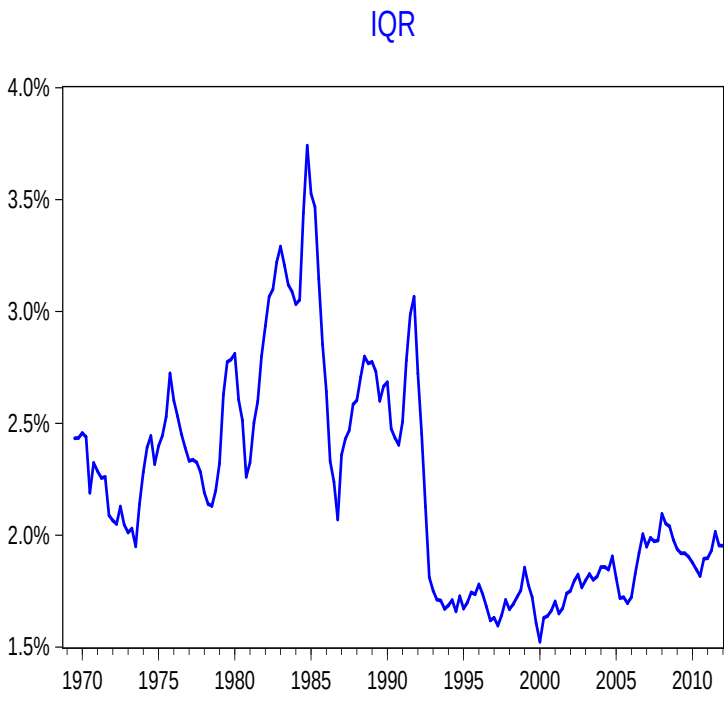
- ASY can be viewed as a signed measure of inflation uncertainty

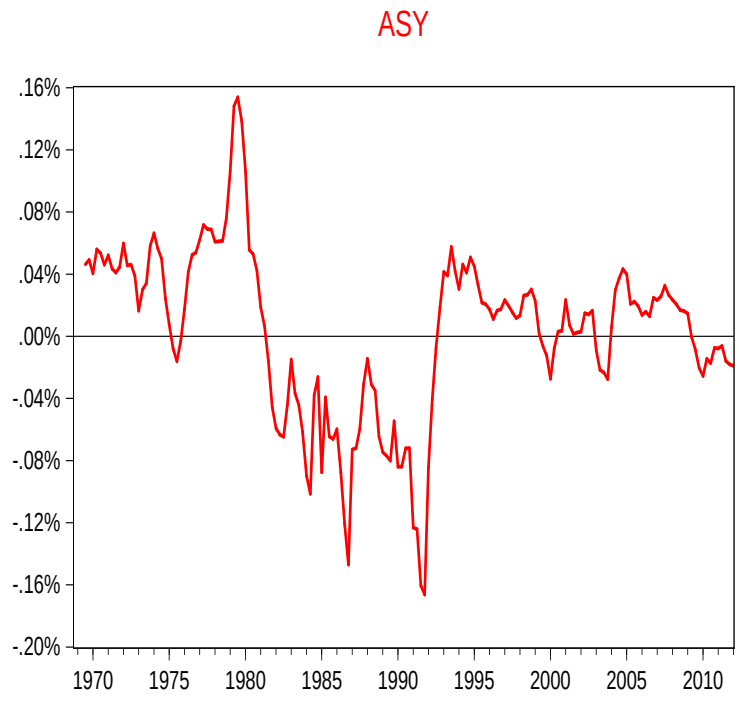
$$\text{ASY}_{t}^{h}(p) = \text{E}_{t}\left[\text{RA}_{it}^{h}(p) \times \text{IQR}_{it}^{h}(p)\right]$$

Inflation realizations and I@R



Range and asymmetry of inflation risks





Comparison with other measures

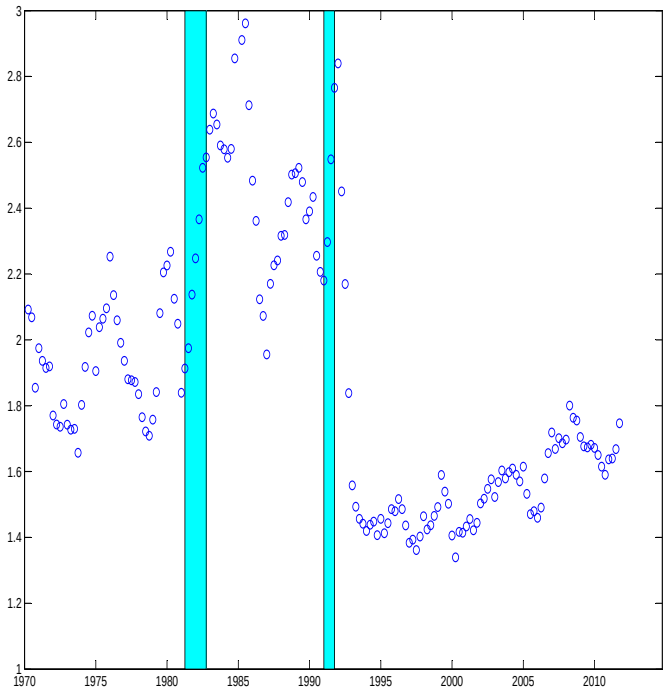
- Disagreement across forecasters (DIS)
- Baker-Bloom-Davis economic policy uncertainty measure (BBD)
- Jurado-Ng-Ludvigson macro uncertainty measure (JNL)
- GARCH model for 2nd moment of inflation
- Realized volatility on stock market (VOLSP500)

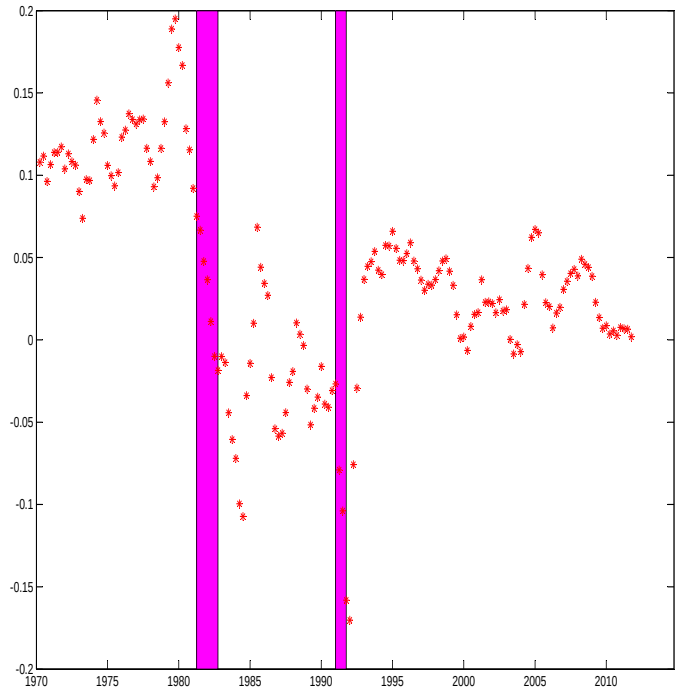
1969-2012 sample

	IQR	ASY	DIS	BBD	JNL	GARCH	VOLSP500
IQR	1.00						
ASY	-0.16**	1.00					
DIS	0.32***	0.08	1.00				
BBD	-0.00	-0.24***	-0.06	1.00			
JNL	0.23***	-0.10	0.31***	0.21***	1.00		
GARCH	-0.01	0.08	0.13*	0.13*	0.53***	1.00	
VOLSP500	-0.04	-0.06	0.03	0.38***	0.30***	0.47***	1.00

Comparison with other measures

- Comparison with structural change in inflation dynamics (Levin & Piger, 2008)





The information content of I@R

In sample

- Regression

$$\pi_{t+k} = a_k + b_k \pi^e_{t+h|t} + c_k \text{IQR}^h_t(p) + d_k \text{ASY}^h_t(p) + \beta_k * Z_t + e_{t+k}$$

- Baseline specification
  - Realized inflation: $\pi_{t+k} = \text{DEF}_{t+k}$
  - Horizon: $k = 1, 2$ years
  - $\pi^e_{t+h|t}$: MPF^h_t from SPF
  - Risk $p = 5\%$ (5% quantiles in distribution of inflation)

- Controls Z_t
  - $\{\text{DEF}_t, \text{Output gap}_t, \pi^{\text{Oil}}_t, \Delta\text{USD}_t\}$

The information content of I@R

In-sample

	No Controls			Controls		
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
$h =$ **1 year ahead**						
MPF	1.009	1.148	0.983	1.086	0.616	0.691
	(11.231)	(11.914)	(13.122)	(12.787)	(3.954)	(4.706)
IQR		−0.855		−0.612		−0.37
		(−3.796)		(−2.314)		(−1.861)
ASY			6.958	6.041		4.337
			(4.483)	(3.835)		(3.662)
R^2	0.647	0.671	0.692	0.703	0.784	0.808
RMSE ratio	0.955	0.921	0.892	0.876	0.764	0.719
# obs	165	165	165	165	151	151
$h = 2$ **years ahead**						
MPF	0.818	0.956	0.785	0.872	0.588	0.631
	(4.4)	(4.188)	(4.943)	(4.218)	(2.328)	(2.405)
IQR		−0.845		−0.52		−0.226
		(−1.793)		(−1.02)		(−0.552)
ASY			8.834	8.055		6.451
			(3.126)	(2.855)		(2.476)
R^2	0.399	0.421	0.47	0.476	0.606	0.654
RMSE ratio	0.932	0.915	0.875	0.87	0.706	0.661
# obs	161	161	161	161	147	147

The information content of I@R

In-sample

- Robustness: result hold for alternate regressors/regressands

$$\pi_{t+k} = a_k + b_k \pi^e_{t+h|t} + c_k \text{UNC}^h_t + d_k \text{ASY}^h_t + \beta_k * Z_t + e_{t+k}$$

- Expected infl., $\pi^e_{t+h|t}$:
  - MED^h_t
  - AR(4) in π_t
- Uncertainty, UNC^h_t:
  - average uncertainty from surveys
  - disagreement from surveys
  - DEF volatility from GARCH
  - SP500 realized volatility
- Others:
  - Risk $p = 25\%$
  - Dependent variable
    - forecast errors
    - 1st difference in inflation rate
  - I@R based on linear extrapolation of individual histograms

The information content of I@R

Out-of-sample

- Compare the forecasting performances (RMSE) of
  - RW
  - AR(1) on inflation gap $(\pi_t - \overline{\pi}_t)$, with $\overline{\pi}_t$ measured using surveys
  - Combinations of MPF, IQR and ASY measured in survey
  - Using real time data

The information content of I@R

Out-of-sample

Estimation Sample: 1974Q4-1984Q4					
Forecasting Sample: 1985Q1-2012Q2					
Horizon	1Q	2Q	3Q	4Q	8Q
Panel A: RW vs. MPF					
MPF	0.8787**	0.8899**	0.9174	0.9209	
+IQR	0.8339**	0.8307***	0.8481*	0.8420*	
+ASY	0.8196***	0.8134***	0.8340**	0.8236*	
+IQR+ASY	0.8450**	0.8641**	0.9154	0.8919	
Panel B: RW vs. AR-GAP					
AR-GAP	0.8889***	0.8674***	0.8651***	0.8747**	0.8567*
+IQR	2.0441***	1.6116***	1.6513***	1.3150***	0.7213***
+ASY	0.8416***	0.8011***	0.8030***	0.7771***	0.7380**
+IQR+ASY	0.8168***	0.8124***	0.7917***	0.7550***	0.7541**

The information content of I@R

Out-of-sample

Estimation Sample: 1974Q4-1984Q4					
Forecasting Sample: 1985Q1-2012Q2					
Horizon	1Q	2Q	3Q	4Q	8Q
Panel A: MPF					
RW	1.1381**	1.1237**	1.0901	1.0859	
MPF+IQR	0.9491**	0.9335*	0.9245	0.9144	
MPF+ASY	0.9327**	0.9140*	0.9092	0.8944	
MPF+IQR+ASY	0.9617	0.9709	0.9979	0.9685	
Panel B: AR-GAP					
RW	1.1249***	1.1528***	1.1559***	1.1433**	1.1673*
AR-GAP+IQR	2.2995***	1.8578***	1.9088***	1.5034***	0.8420*
AR-GAP+ASY	0.9467***	0.9235**	0.9282*	0.8884**	0.8614
AR-GAP+IQR+ASY	0.9188*	0.9366	0.9152*	0.8632*	0.8803

Monetary policy reaction to I@R

Baseline

- Let i_t be the interest rate targeted by the central bank, we investigate

$$\Delta i_t^Q = \beta * X_t + \gamma \text{IQR}_t^h + \delta \text{ASY}_t^h + u_t$$

- Baseline specification
  - $i_t = \text{FF}_t$
  - $X_t = \{\text{MPF}_t^h, \pi_t^{\text{DEF}} \text{ (real time)}, \text{Output growth (real time)}_t, \pi_t^{\text{oil}}, \Delta\text{FF}_{t-1}\}$
  - Risk $p = 5\%$

Monetary policy reaction to I@R

Baseline

	Reference		Regime changes			Other	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Dep. variable	ΔFF	ΔFF	ΔFF	ΔFF	ΔFF	ΔEONIA	ΔFF
Change over	Quarter	2nd-Month	2nd-Month	2nd-Month	2nd-Month	Quarter	Quarter
Sample	US	US	US	US	US	EA	US
	1969-2012	1969-2012	1969-1979	1981-2012	1990-2012	1999-2012	1970-2006
IQR	−0.363	−0.113	−0.664	−0.027	−0.029	−0.214	−0.254
	(−1.944)	(−1.23)	(−1.485)	(−0.261)	(−0.728)	(−1.308)	(−1.059)
ASY	1.936	1.158	0.439	1.202	0.743	2.272	1.830
	(1.737)	(2.139)	(0.23)	(1.791)	(1.63)	(2.028)	(1.875)
R2	0.078	0.133	-0.007	0.249	0.280	.340	0.134
# obs	169	169	44	125	86	54	151
Controls	Real-time	Real-time	Real-time	Real-time	Real-time	Ex-post	Greenbook

Monetary policy reaction to I@R

Controlling for information policy decisions

- Endogenous reaction of survey measures to policy?
- Use timing of the survey (conducted at the beginning of second months of the quarter)
- Estimate regression with Δi_t^M (change observed over the second month)

$$\Delta i_t^M = \beta * X_t + \gamma \text{IQR}_t^h + \delta \text{ASY}_t^h + u_t$$

Monetary policy reaction to I@R

Controlling for information policy decisions

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Monetary policy reaction to I@R

Change in CB reaction function

- Shifts in policy?
  - Pre-Volcker: 1969–1979
  - Post-Volcker: 1981–2011
  - Great-moderation/Great recession: 1990–2011
  - Euro Area: 1999–2011

Monetary policy reaction to I@R

Change in CB reaction function

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Monetary policy reaction to I@R

Information or preference / objective?

- Does the Fed react to ASY as such or because of its predictive power on π_{t+k}?
- Control for Greenbook forecasts of future inflation and output in regression

Monetary policy reaction to I@R

Information or preference / objective?

	Reference		Regime changes			Other	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**
Dep. variable	ΔFF	ΔFF	ΔFF	ΔFF	ΔFF	ΔEONIA	ΔFF
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Conclusion

- We introduced new survey-based measures of inflation risks
- We showed that
  - these measures have explanatory power for future inflation realizations beyond standard linear predictions
  - interest rate target reacts to these measures
- Evidence supportive of models where inflation is non-linear / there is room for risk management approach of monetary policy
- Indicators developed here might help bringing these models to the data

Comparison with other measures

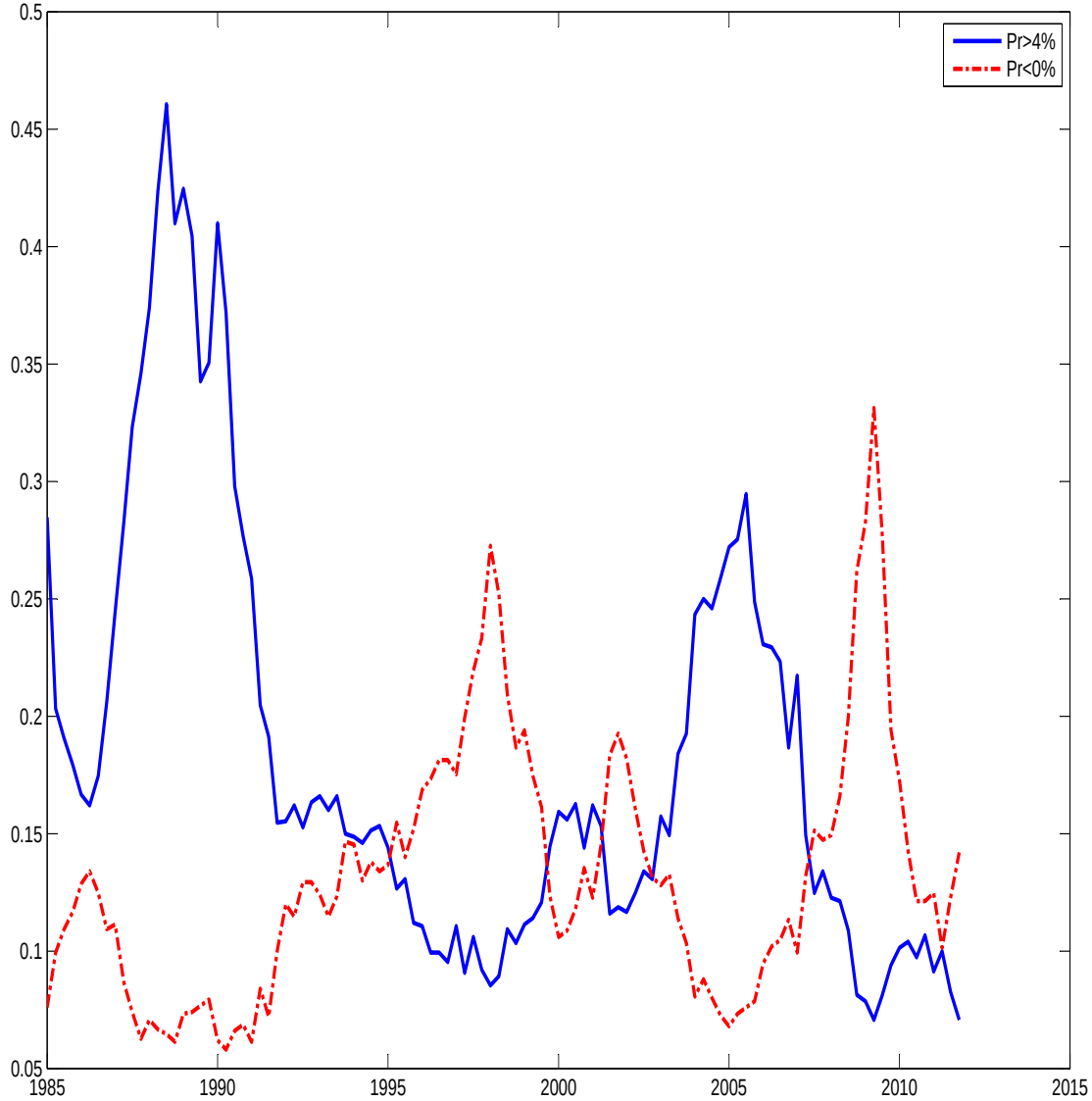
- Disagreement across forecasters (DIS)
- Baker-Bloom-Davis economic policy uncertainty measure (BBD)
- Jurado-Ng-Ludvigson macro uncertainty measure (JNL)
- VIX option implied stock market index
- GARCH model for 2nd moment of inflation
- Realized volatility on stock market (VOLSP500)

1990-2012 sample

	IQR	ASY	DIS	BBD	JNL	VIX	GARCH	VOLSP500
IQR	1.00							
ASY	-0.63***	1.00						
DIS	0.25***	-0.19*	1.00					
BBD	0.23***	-0.30***	0.37***	1.00				
JNL	0.16	-0.15	0.46***	0.32***	1.00			
VIX	0.09	-0.24***	0.34***	0.41***	0.68***	1.00		
GARCH	0.04	-0.02	0.22**	0.24***	0.75***	0.54***	1.00	
VOLSP500	0.02	-0.05	0.23**	0.37***	0.65***	0.79***	0.78***	1.00

Comparison with other measures

Probability of high / low inflation in UCSV



Design of the surveys

Location	**US**						**Euro Area**
Sample period	1968Q4-1973Q1	1973Q2-1974Q3	1974Q4-1981Q2	1981Q3-1985Q1	1985Q2-1991Q4	1992Q1-present	1999Q1-present
Target variable	GNP deflator (yoy inflation)					GDP deflator (yoy inflation)	HICP (yoy inflation)
Target horizon	End of current year						One year ahead
Nb of intervals	15			6		10	
Width of a bin	1%			2%		1%	.5%
Maximum value	12%	14%	18%	16%	14%	10%	5%
Minimum value	-5%	-3%	1%	0%	-2%	-2%	-2%

Measures of inflation risks

Engelberg, Manski & Williams (2009)

- if i uses ≥ 3 intervals
  - fitting a generalized Beta distribution (for $l < x < u$)

$$F(x; a, b, l, u) = \frac{1}{C(a,b)} \int_l^x \frac{(y-l)^{a-1}(u-y)^{b-1}}{(u-l)^{a+b-1}} dy$$

  - 0 if $j \leq l$, and 1 if $j \geq u$
  - restriction $a > 1$, $b > 1$

- if i uses < 3 intervals
  - fitting an isocele triangle