Tails of inflation forecasts and tales of monetary policy*

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Abstract

We introduce two new empirical measures pertaining to ex ante unlikely inflation outcomes - as perceived by professional forecasters: (1) a notion of *Inflation-at-Risk* inspired by the widely used Value-at-Risk concept in risk management, and (2) the realized p-value of ex post inflation measured against ex ante forecast distributions. The former pertains to the tails of the ex ante forecast distribution, the latter measures the extend to which realized inflation was a surprise outcome. Using survey expectations from professional in the US and the euro area, the new measures reveal intriguing empirical regularities associated with monetary policy. We also show that these new measures capture important features not covered by either inflation expectations (mean point forecasts) or by other measures of inflation risk that are more widely used in the existing literature.

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1 Introduction

Central bankers consider the anchoring of inflation expectations and the control of inflation risk as crucial objectives in order to achieving price stability. Most of the macroeconomic literature dealing with inflation risk and the conduct of monetary policy does not distinguish between expected inflation and inflation risk. A rise in inflation risk is associated to a rise in expected future inflation. This does not captures situations where inflation risk increases because extreme inflation events are more likely to occur even so expected future inflation rate stays unchanged. Recent references in the macroeconomic literature emphasize the importance of such type of variations in the perception of macroeconomic risks to explain macroeconomic fluctuations (see, among others, Bloom, 2009).

In this paper, we develop new measures of inflation risk that can potentially capture changes in inflation risk that do not translate into changes in the expected inflation rate. We then use them to assess how such variations of inflation risk influence the conduct of monetary policy by central banks and, conversely, how monetary policy shapes perceived inflation risk.

More precisely, we consider two new measures: (1) a notion of *Inflation-at-Risk* inspired by the widely used Value-at-Risk concept in risk management, and (2) the realized p-value of ex post inflation measured against ex ante forecast distributions. The former pertains to the tails of the ex ante forecast distribution, the latter measures the extend to which realized inflation was a surprise outcome.

Our focus is on the subjective perceptions of macroeconomic risk. Consequently, we rely on survey measure of inflation expectations to identify the evolution of inflation risk. More precisely we use the US and European Survey of Professional Forecasters (SPF) which report data on individual expectations as well as on the probability distributions of their inflation expectations. We consider that working with SPF data is a good proxy for the expectations of other private agents. It as indeed be shown that the expectations of professional about macroeconomic variables strongly influence the corresponding expectations of firms and households (see Carroll, 2003).

Using these data over the 1999-2010 sample for the euro-area and the 1970-2010 sample for the US, we find that monetary authorities were able to stabilize perceived inflation risk over the 1990-2010 period. However, extreme events (1970s, 2008-09) were not foreseen. Moreover, there are some differences between the US and the euro area. Subjective inflation risk is on average wider in the US. Downside inflation risk was underrated in the US. By contrast, upside inflation risk was overstated in the euro-area.

Turning to the analysis of how inflation risk interacts with monetary policy our first results show that the ECB reacts to the perception of upward inflation risk but not to the perception of downward inflation risk, on top of the usual predictors of future inflation rates (namely the output gap and the expected inflation rate). By contrast the Fed does not seem to react to such perceived inflation risk measures. Conversely, a monetary policy shock tightening monetary policy transitorily increase the perception of risk by agents. These unforeseen deviations therefore signal variations in future inflation risk.

Importantly, our measures of inflation risk point to features of subjective beliefs about inflation that cannot be seen if one relates to other standard measures of inflation risk. These standard measures are inflation uncertainty, — namely an average of dispersion of individual distributions around the individual expectations (typically individual standard deviations) — and disagreement in inflation forecasts — namely a measure of the dispersion of expectations across individual (typically standard deviation across individuals). By construction, they do not capture the asymmetric reaction of subjective downside and upside inflation risks that we uncover. For instance in the euro-area, these measures mainly capture an increase in the risk of a very low inflation.

The rest of the paper is organized as follows. In section 2, we introduce our new indicator and describe how we estimate them. In section 3 we underlines several empirical regularities that we obtain looking at the behavior of these new indicator in US and European data. In section 4, we conduct simple regression exercises to assess the interaction of perceived inflation risk with monetary policy.

Related literature

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2 New measures of inflation risk

2.1 Inflation-at-Risk (I@R) and realized p-values (RPV)

We let π_t denotes date t year-on-year inflation rate, and $F_{it}^h(x)$ individual's i cumulated distribution of probability at date t for the inflation rate forecasted on $t+h$ namely

$$F_{it}^h(x) = \Pr\left\{\pi_{t+h} < x | i, t\right\}.$$

We also denote $c_{it}^h(p)$ the critical value associated with the probability level p in a particular individual cumulative distribution that is

$$c_{it}^h(p) = \left(F_{it}^h\right)^{-1}(p).$$

Letting $\mathrm{E}_i\left(\cdot\right)$ be the expectation over individuals, we can introduce the following two new measures of inflation risk at date t. On the one hand, *inflation-at-risk* defined by

$$\mathrm{I@R}_t^h(P) = \mathrm{E}_i\left[c_{it}^h(P/100)\right].$$

On the other hand, *realized p-values* associated with the ex-post realization of inflation in the ex-ante inflation forecast distribution of inflation, more precisely

$$\mathrm{RPV}_t^h(\pi_{t+h}) = \mathrm{E}_i\left[F_{it}^h(\pi_{t+h})\right].$$

These two new measures (I@R and RPV) aims at completing the usual analysis of SPF data led with consensus forecast, uncertainty and disagreement measures. The first characteristic of survey expectations is the central tendency indicator given by the so-called *consensus* forecast, *i.e.* the average of individual mean point forecasts:

$$m_t^h = \mathrm{E}_i(m_{it}^h).$$

Letting m_{it}^h be the date t inflation h quarters ahead mean-point forecast of an individual i, the *disagreement* between forecasters is defined as the standard deviation between individual point forecasts

$$\sigma_t^h = \sqrt{\mathrm{V}_i(m_{it}^h)} = \left\{\mathrm{E}_i\left[m_{it}^h - \mathrm{E}_i(m_{it}^h)\right]^2\right\}^{1/2}$$

and the uncertainty (also called the *average risk*) as:

$$\omega_t^h = \mathrm{E}_i\left[\mathrm{V}(m_{it}^h|i,t)\right]$$

where $\mathrm{V}(m_{it}^h|i,t) = \int_{\underline{\pi}_{it}}^{\overline{\pi}_{it}} \left[\pi_{t+h} - \mathrm{E}(\pi_{t+h}|i,t)\right]^2 dF_{it}^h$ and $\mathrm{E}(\pi_{t+h}|i,t) = \int_{\underline{\pi}_{it}}^{\overline{\pi}_{it}} \pi_{t+h} dF_{it}^h$.

Having estimators $\widehat{F}_{it}^h$ and $\widehat{c}_{it}^h$ these new measures can be estimated using empirical averages over the n_t number of individuals answering the survey at date t, namely

$$\widehat{\mathrm{I@R}}_t(p) = \frac{1}{n_t}\sum_i \widehat{c}_{it}^h(p), \quad \widehat{\mathrm{RPV}}_t(\pi_{t+h}) = \frac{1}{n_t}\sum_i \widehat{F}_{it}^h(\pi_{t+h}).$$

The next subsection gives details on how $\widehat{F}_{it}^h$ and $\widehat{c}_{it}^h$ are estimated.

2.2 Estimation method

To estimate I@R and RPV, we consider continuous versions of individual empirical distributions of the SPF, by following Engelberg, Manski and Williams (2006). We distinguish three cases, depending on the number of classes used by respondents:

- if a forecaster uses only one class by responding 100% probability for a given inflation interval from l to u, we assume an isocele triangle being the probability distribution function, such that the peak of the distribution is attained for $\frac{l+u}{2}$.
- if a forecaster uses two adjacents intervals $[l_{1;}u_1]$ and $(l_{2;}u_2]$, we assume a isocele triangle such that
  - if $p_1 > p_2$, i.e. the probability of the first interval is greater than the probability assigned of the second interval, the isocele triangle have a basis $[l_{1,}x]$ where $x \in (l_{2;}u_2]$. The use of Thales theorem is straightforward to determine x.
  - if $p_1 < p_2$, the isocele triangle have a basis $[x, u_2]$ where $x \in [l_{1;}u_1]$.
- if a forecaster uses three intervals, each individual distribution is fitted with a

generalized *Beta* distribution whom cumulative distribution function B is

$$B(j;a,b,l_1,u_{N_t}) = \begin{cases} 0 & if \quad j \leq l \\ \frac{1}{C(a,b)}\int_l^j \frac{(y-l_1)^{a-1}(u_{N_t}-y)^{b-1}}{(u_{N_t}-l_1)^{a+b-1}}dy & if \quad l_1 < j < u_{N_t} \\ 1 & if \quad j \geq u_{N_t} \end{cases} .$$

where a, b are the parameters of the *Beta* distribution, l_1 the lower bound of the support used by the respondent (i.e. the lower bound of the lowest interval), and u_{N_t} the upper bound of the last interval used by the forecaster when she uses N_t classes to respond to the SPF at date t.

To do so, for each date t and forecasters i, we minimize the squared distance between the discretized version of the empirical *cdf* and the continuous *cdf* of a *Beta* distribution as

$$\min_{a>1,b>1}\sum_{j=1}^{N_t}\left[B(j;a,b,l_1,u_{N_t}) - F\left(u_j\right)\right]^2$$

with $F(u_j)$ the probability assigned by the forecaster i to the interval $(l_j;u_j]$ evaluated at the upper bound of each interval. The restriction $a>1, b>1$ restrict the *Beta* distribution to be unimodal. Given that the first and last available class of the questionnaire are unbounded intervals, we assume a width, for this extreme classes, of twice the size of the bounded intermediary intervals.

We denote $\widehat{a}_{i,t}$ and $\widehat{b}_{i,t}$ the estimated parameters of the *Beta* distribution for forecaster i and date t SPF and $\widehat{B}_{i,t}$ the corresponding *Beta* distribution. The individual inflation at risk p is the percentile of the continuous distribution $B_{i,t}$ at the probability threshold p, namely:

$$\widehat{c}_{it}(p) = \widehat{B}_{i,t}^{-1}(p).$$

The inflation-at-risk p for the date t SPF is then

$$\widehat{\mathrm{I@R}}_{p,t} = \frac{1}{n_t}\sum_{i=1}^{n_t}\widehat{c}_{it}(p)$$

where n_t is the number of respondents to the date t SPF.

We also define the realized p-value of the h-quarter-ahead forecast of individual i, for the date t SPF, noted $\text{RPV}^i_{t,t+h}$ as

$$\text{RPV}^i_{t,t+h} = B_{i,t}(\pi_{t+h})$$

where π_{t+h} is the realized inflation at date $t+h$. Then the realized p-value for the date t SPF, noted $\text{RPV}_{t,t+h}$, is

$$\text{RPV}_{t,t+h} = \frac{1}{n_t}\sum_{i=1}^{n_t}\text{RPV}^i_{t,t+h}$$

In this paper, we mainly focus on one-year ahead inflation expectations for the euro area and the US. The structure of the US Survey is different from the euro area one, since there is no constant horizon over the year. Indeed, respondents to the US SPF are asked for the end of the current year forecast of inflation, such that a one-year ahead forecast is only available in the first quarter. As a consequence, to be directly comparable with the euro area SPF, we present quarterly indicator for the euro area but only yearly ones for the US.

3 Inflation risk: some US and European facts

3.1 Beyond average mean point forecasts

As mentioned before, the indicator of inflation forecasts that is mostly surveyed is the average of individual point forecasts (i.e. the consensus forecasts). Figure (1) and Figure (2) reports for the euro area and the US both inflation realizations and mean point forecasts.

In the US, the one-year ahead forecast appears to be highly influenced by the previous observation, with little predictive power, or information contained in the mean of individual point forecasts. The forecasted inflation only appears to be a slight translation of the previous realization. In the euro area, the pattern is different since we obtain that the consensus forecast presents some systematic errors between 1999 and 2006, with a mean point forecast always below the realization. This appears to be persistent over time, even if the realized inflation is above for quite a long period of time (even if one may note a slight trend from 1.2 to 2.2 for MPF over this period). The end of the sample is marked by the high macroeconomic volatility following the 2008 crisis and the difficulties for respondents to anticipate inflation rates over this period.

These systematic errors and the low informative power of mean point forecasts clearly advocates for looking at more precise indicators extracted from SPF data. Given this feature, we may wonder how these inflation realizations were likely to materialize according to forecasters?

This question may be addressed by using our inflation at risk indicator, I@R. Figure (3) shows the time series of realized inflation, together with I@R(5) and I@R(95) for the euro area and Figure (4) for the US.

Both for the US and the euro area, most of the realizations lies within the [5%;95%] interval. The I@R(5) and I@R(95) exhibit roughly the same patterns than the average point forecast. The range between these bounds seems very stable since the beginning of the 90s in the US : the perceived inflation risk did not dramatically evolved over time. In particular, there was no increase in the perception of an extreme inflation risk before the Great Recession, and a surprisingly small hike in that risk over 2009. However, some extreme events did fall outside the 5-95 confidence interval. This includes the beginning of the Great Inflation of the 70s and the Volcker contraction of the early 80s in the US and the up and down of inflation at the beginning of Great Recession of 2008-2009.

Over the sample, these extreme realizations occur both on the lower and upper tails in the US. Concerning the euro area, it mostly happens in the upper tail of inflation, such that forecasters are not able to anticipate higher inflation rates, or could not believe that a realization above some levels is likely to happen. However, these realizations outside the 5-95 interval are more often in the euro area, because the width of this interval is wider in the US by about 1 percentage point. This is one of the reason why the extreme realizations of inflation over 2008-2009 were not out these bands in the US.

In the euro area we can thus understand that there is a very low subjective probability of these events to occur. To see this, we can consider our second new indicator of inflation risk that is the probability associated with the realizations: the realized p-values, RPV. Figure (5) both shows the time series of realized inflation and RPV for the euro-area.

A first striking feature in the euro area, is that the probability for the extreme events of 2008 and 2009 to occur was zero. Indeed, the p-value of the inflation hike of summer 2008 is 100%, meaning that there was, according to forecasters' subjective beliefs, 100% chances that inflation fell below the actual realization. Likewise, the p-value of the deflation episode of early 2009 is 0%, meaning that there was, according to forecasters subjective beliefs again, 0% chances that inflation fell below this actual realization. In addition, the realized p-values also point to realizations that were regularly and for several quarters clearly above 80% over the 1999-2006 period. So, before the Great Recession and at the time of the so-called Great Moderation, not only was the forecast error systematic over the first seven years of the ECB mandate, but most of the time the corresponding realizations of inflation were given a probability of less than 20% and sometimes less than 5%.

Inflation risk was clearly understated in the euro area. 19 periods out of a sample 46, that is 41% of the sample, 41% of the sample, lie above the 80% bound of the subjective perceptions. Even more striking, 11 periods out of 46 lie, that is 24% of the sample, lie above the 90% bound of the subjective perceptions.

Similar observations prevail for the US case, as reported in Figure (6). Some realization of inflation were hardly anticipated by survey respondents, notably during the 70s with the two oil shocks, the Volcker period at the beginning of the 80s and from 2006 to 2010. The RPVindicator points to a tendency for private agents to systematically overrate future inflation rates. 14 periods out of 39, that is 36% of the sample, lie below the 20% bound of the subjective perceptions.

3.2 Beyond forecasters' disagreement and uncertainty

Two other frequently used characteristics of survey forecasts are disagreement and uncertainty. They are both used as indicators of the risk associated with a given consensus forecast. Disagreement is often used as a proxy for uncertainty. However, the two notions differ and they do not evolve systematically together (see Rich and Tracy (2004)), and understanding disagreement between forecasters is still debated in the literature.

Rather than linking and disentangling the two notions of uncertainty and disagreement, we claim that our measures of inflation at risk and realized p-values bring more information.

Figure (7) reports scatter plots of the I@R(5) and I@R(95) against the uncertainty for the euro-area. Figure (7) plots the I@R(5) and I@R(95) against disagreement. High levels of disagreement or uncertainty were associated with relatively lower values of both the I@R(5) and I@R(95). However, the reaction of the I@R was asymmetric: the increase in inflation risk was more on the downside than on the upside.

This can be seen from Figure (9) which shows a scatter plot of I@R(95) against I@R(5). Most of the values are aligned close to a 45 degree line, underlining the stability of the range between the two. However, this is not true for a group of relatively lower values of the I@R(95), which are associated with higher risk. Indeed, for these values, the points of the scatter are clearly below the 45 degree. In the euro-area, periods of high risk are periods where the I@R(95) decreased but the I@R(5) decreased by even more. That asymmetric reaction of the I@R cannot be captured by the standard measures of uncertainty and disagreement.

In the US (Figures are unreported to save space), we observe that disagreement is strong when the 5-95 range move towards higher inflation rates while it is less conclusive concerning uncertainty. The scatter plots of I@R(95) against I@R(5) in Figure (10) shows that the asymmetric effect observed in the euro area does not appear in the US since I@R(95) and I@R(5) are located on the 45 degree line.

Figure (11) reports a scatter plot of our second indicator, the RPV, against disagreement and uncertainty for the euro-area. This indicator allows us to have some information about the forecast accuracy of respondents. A striking feature is that high RPV are associated with low levels of disagreement and uncertainty. Agents were surprisingly confident and in agreement when they faced big surprises that drove inflation up and completely overturn their predictions. On the contrary low levels of RPVs are associated with much more variable levels of disagreement and uncertainty.

3.3 Expected inflation risk

Figure (12) reports a scatter plot of the 1-year ahead forecast I@R(5) and I@R(95) against the current inflation rate observed at the date of the survey for the euro-area.

The perception of inflation risk did not vary much. I@R(5) was always close to 1.1% while I@R(95) was close to 2.6%. The 90 confidence interval is thus asymmetric around 2%, reflecting the asymmetric part of the definition of price-stability"close to but below 2%" in the ECB mandate.

In other words, upside inflation risk was much stable than downside one reflecting the credibility of this mandate. During period of low inflation, respondents tend to increase their risk perception of inflation, notably by decreasing I@R(5), while the reverse is not true: during high inflation periods, I@R(95) does not increase significantly, reflecting that the mandate of the ECB shapes the inflation risk perception of private agents.

The equivalent for the US, given in Figure (13) does not show any clear widening of inflation at risk ranges for some specific levels of inflation. In particular, we do not notice, as it is for the euro area, a higher downward risk for low inflation rates. This can be attributed to the difference in mandates between the ECB and the US monetary authorities. Indeed, if the ECB mandate explicitly and solely focuses on the "close but below 2%" inflation objective, the US objective of growth may guaranty at least some floor for the inflation rate. This in a sense can indirectly control for the range of inflation risks on the downside.

This asymmetry is even more striking if one looks at Figure (14) which reports a scatter plot of the 1-year and 2-year ahead RPV against the realized values of inflation for the euro-area. Almost every inflation realization that was greater than 2.4% was given less than a 10% probability to occur. Downside inflation risk was given a greater probability weight. A few realizations below .6% were given a probability of less than 10%. On the downside, forecasters usually consider higher probability given that inflation is perceived as not sufficiently under control when it reaches some low floors.

Figure (15) reports the same scatter plot for the US economy. The realizations that are above the 90% and 10% thresholds are mostly associated with the Great inflation of the 70s. Like in the euro area, the low inflation of the Great Recession was given a subjective probability of lower than 10%. After the Volcker stabilization episode, upside inflation risk was overweighed compared to realizations. The average RPV is below 50%. In general we have that the perception of inflation risk varied much more than in Europe (even if we should keep in mind that the period under study for the US is much longer and heterogeneous than for the euro area). Indeed, the I@R for example evolved a lot in the US of the 70s. This is partly due to the fact that inflation was much more instable at that time. However the [5%,95%] interval range was much more narrow at that time compared to the 80s, 90s and 2000s. Forecasters were regularly facing extreme events compared to their subjective assessment of risk: the peak in inflation of 1974 was given less than a 5% probability, likewise the fall of 1975 and the the Volcker deflation of 1982-83. Surprisingly, the inflationary consequences of the 1979 oil shocks were much well understood.

To sum up, our measures of inflation risk show that

- Monetary authorities were able to stabilize perceived inflation risk over the 1990-2010 period.

- Extreme events (1970s, 2008-09) were not foreseen.
- Subjective inflation risk is on average wider in the US.
- Downside inflation risk was underrated in the US. By contrast, upside inflation risk was overstated in the euro-area.
- Standard measures of inflation risk (uncertainty/disagreement) do not capture the asymmetric reaction of subjective downside and upside inflation risks. In the euro-area, these measures mainly capture an increase in the risk of a very low inflation.

These facts raise the question of the interaction between monetary policy and inflation risk as evaluated by our new indicators. We investigate this question in the next section.

4 Monetary Policy and inflation risk

In the first subsection we assess whether monetary policy react to variations in inflation risks, in particular as captured by our new indicator of I@R. We then turn to the reverse question of how subjective perceptions of inflation risk are affected by shocks monetary policy shocks.

4.1 Do central banks target inflation risk?

To answer the question, we estimate a version of a simple Taylor rule that includes different measures of inflation risk in addition to the usual factors of inflation expectations and the output gap. We rely on SPF data to measure inflation expectations, using the consensus forecasts, *i.e.* either the mean or the median of individual point forecasts of inflation.

The SPF data also provide potential alternate risk factor measures that affect the interest rate target. The first two measures are the usual uncertainty and disagreement indicators. We compare them to our inflation at risk indicator. Importantly, this indicator allows us to distinguish between the reaction of a central bank to a low inflation or a high inflation risk.

Denoting R_t the short-term interest rate the central bank target, y_t the output gap measure available at date t, and π^e_t the 1-year ahead inflation rate median expectation,[1] we estimate the following version of a Taylor rule

$$R_t = \alpha + \beta_1 \pi^e_t + \beta_2 y_t + \beta_3 \Omega_t + \rho R_{t-1} + e_t \tag{4.1}$$

where e_t is a random term capturing deviations from the rule ("monetary policy shocks"), where the lag in the target interest rate, R_{t-1}, captures the fact that monetary authorities smooth their adjustment to macroeconomic conditions, and where Ω captures inflation risk and is either: disagreement, σ; uncertainty, ω; and aa function of I@R(5) (low inflation risk) or I@R(95) (high inflation risk). The latter I@Rare obviously correlated with the central tendency of inflation expectations, $\pi^e_{q,t}$. So our measure of inflation risk will be the ranges between the expectations for the extreme value of inflation and the central tendency, namely $\left[\text{I@R}(95) - \pi^e_{q,t}\right]$ and $\left[\pi^e_{q,t} - \text{I@R}(5)\right]$.

Table 1 presents the results. Because we work with annual frequency data for the US and quarterly data for the euro area some more notations are needed to detail the estimation. For any variable x in year t, we let $x_{q1,t}$ be x at the end of $t : Q1$, $x_{q2,t}$ be x at the end of $t : Q2$,... At the time of taking their policy decision, the monetary authorities only have available the output gap of the previous quarter older. So we use $y_{q-1,t}$ in the estimation of equation (4.1). Moreover, because of survey data limitations for the US (see section 2), we rely on annual data for the estimation of the US Taylor rule. More precisely we estimate

$$R_{q,t} = \alpha + \beta_1 \pi^e_{q,t} + \beta_2 y_{q-1,t} + \beta_3 \Omega_{q,t} + \rho R_{q-1,t} + e_{q,t}$$

for the euro area and

$$R_{q,t} = \alpha + \beta_1 \pi^e_{q,t} + \beta_2 y_{q-1,t} + \beta_3 \Omega_{q,t} + \rho R_{q,t-1} + e_{q,t}$$

for the US.

The results show that

- The reaction to the output gap are significantly positive in the US and the euro area. The weight put on this variable is comparable in both economies.
- 1 year expected inflation is not significant in the euro area as soon as one introduces

[1] In our sample, the median inflation expectation is very close to the average of individual point forecasts.

complementary measures of inflation risk. Conversely, for the US, the effect does not change much with the introduction of different inflation risk indicators.

- In the US, the Fed does not seem to rely on these complementary inflation risk factors, with the exception of disagreement. However, as discussed previously, disagreement is the measure that relies the less to the notion of inflation risk.
- By contrast, the ECB seems to target more inflation risk as captured by our measure rather than the central tendency of inflation expectations. The median inflation expectation has no significant impact on the short-term interest rate. However, uncertainty, ω, has a clear significant positive impact on the target interest rate of the ECB: monetary policy is tightened when inflation risk rises.
- Interestingly, according to our estimation results, the inflation risk the ECB takes into account is the upward inflation risk. Indeed the target interest rate react positively to I@R(95), but does not react to the I@R(5). This asymmetric reaction to upward and downward inflation risk is not captured by the inflation uncertainty measure, w.

[TO BE COMPLETED]

4.2 Do monetary shocks affect inflation risk?

To answer the question, we look at the reaction to our I@Rindicator to various measures of inflation shocks. As a first step, we loosely identify this using the residual of the Taylor rule estimated in the previous sub-section.

We then look at the effect of past value of these shocks on the perceived inflation risk. In the lines of Sims' causality test approach, we look at the supplementary information these shocks bring to I@R, once one control for lagged values of the I@R. Namely, let p be the risk probability we consider, we estimate

$$\mathrm{I@R}_{q,t}(p) = \mu_p + \sum_{k=1}^{K} \phi_k^p \left[\mathrm{I@R}_{t-k}(p) + \psi_k^p e_{t-k}\right] + u_t^p \tag{4.2}$$

where e_{t-k} is obtained from the first step estimation of equation (4.1) in which we set $\beta_3 = 0$.

We focus on two risk level $p = .95$ and $p = .05$. We limit the lagged values we consider to one year. More precisely, using the notations of the previous section to deal with the issue of different frequency of the data in the euro area and the US we estimate

$$\text{I@R}_{q,t}(p) = \mu_p + \sum_{k=1}^{4} [\phi_k^p \text{I@R}_{q-k,t}(p) + \psi_k^p e_{q-k,t}] + u_{q,t}^p$$

for the euro area and

$$\text{I@R}_{q,t}(p) = \mu_p + \phi_k^p \text{I@R}_{q,t-1}(p) + \psi_k^p e_{q,t-1} + u_{q,t}^p$$

for the US.

Table 2 presents the results. For the euro area, recent lags of monetary policy shocks have a significant positive impact on the perception of inflation risk beyond the information brought by the lagged values of inflation-at-risk measures *per se*. The effect is only transitory. Shocks that are older than 2 quarters have no impact on inflation risk perception. For the US, there is no effect of the monetary policy shock on the perceived risk of inflation. As we only observe the effect of the monetary shock of last year, we cannot discard that there exists a transitory effect of these shocks as for the euro area.

The fact that the transitory effect is positive implies that tightening monetary policy more aggressively than usual regarding economic conditions is interpreted by private agents as a signal of an increasing inflation risk in the upcoming periods. However, that effect is only transitory, meaning that such type of interventions do not impair the credibility that the central bank can limit this inflation risk in the future.

[TO BE COMPLETED]

5 Conclusion

[TO BE COMPLETED]

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A Appendix

A.1 Data sources

The ECB's survey of professional forecasters is conducted every quarter since 1999. A detailed presentation and discussion of the data can be found in Bowles *et al.* (2007). The survey covers around 90 institutions involved in forecasting and operating in the Euro zone. Each institution is asked to report, among other things, forecasts for the (year-on-year) inflation rate for a forecasting fixed horizon of one year and two years. Respondents provide two important types of information. The usual mean point forecasts first but also forecast distributions over a set of (pre-specified) intervals. At the time of the writing this article, the last available survey round is 2010Q1, so that we have 45 time periods available.

US survey: distributions are merely available for so-called calendar forecast, *i.e.* forecasts for a given event (typically the end of current year inflation rate). As a consequence, the uncertainty features a strong seasonal patterns since, as time goes by, the event materializes, and uncertainty shrinks to zero. So we select only the first observation in each year.

The survey data are matched with the corresponding realization of the forecasted variable along with the last value known at the date of the survey.

Figure 1:

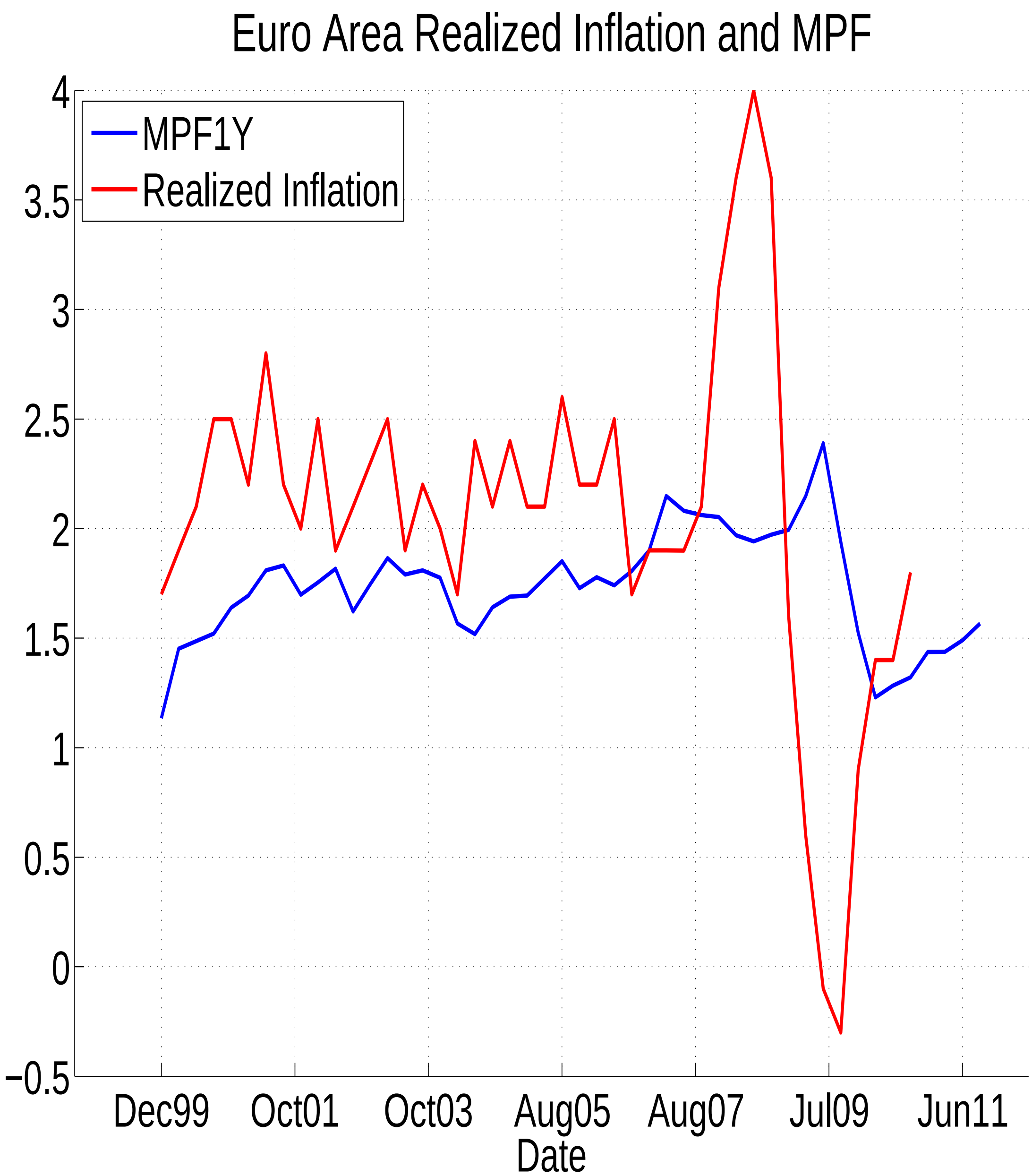

Euro Area Realized Inflation and MPF
MPF1Y
Realized Inflation
4
3.5
3
2.5
2
1.5
1
0.5
0
−0.5
Dec99
Oct01
Oct03
Aug05
Aug07
Jul09
Jun11
Date

Figure 2:

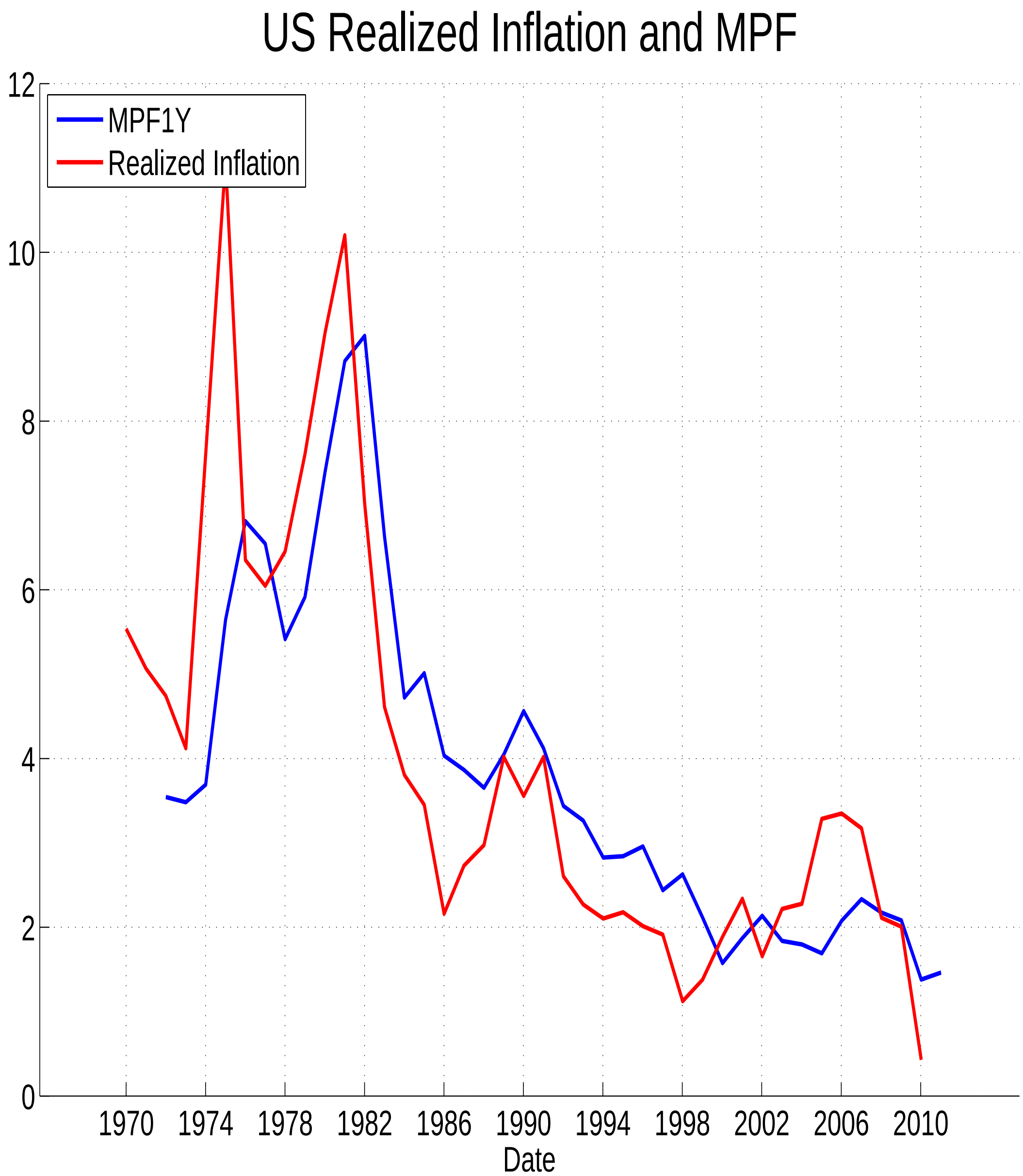

US Realized Inflation and MPF
MPF1Y
Realized Inflation
12
10
8
6
4
2
0
1970
1974
1978
1982
1986
1990
1994
1998
2002
2006
2010
Date

Figure 3:

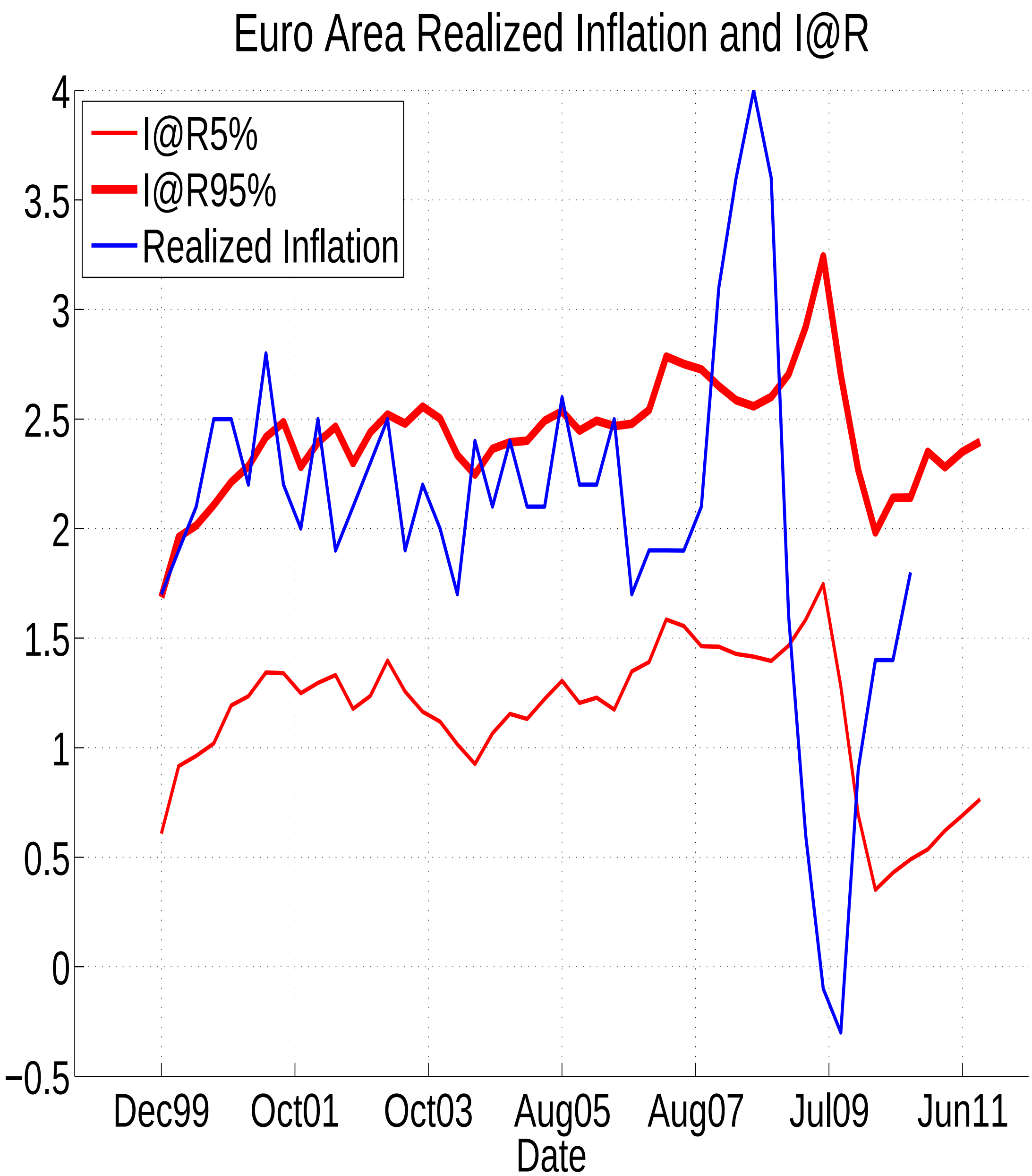
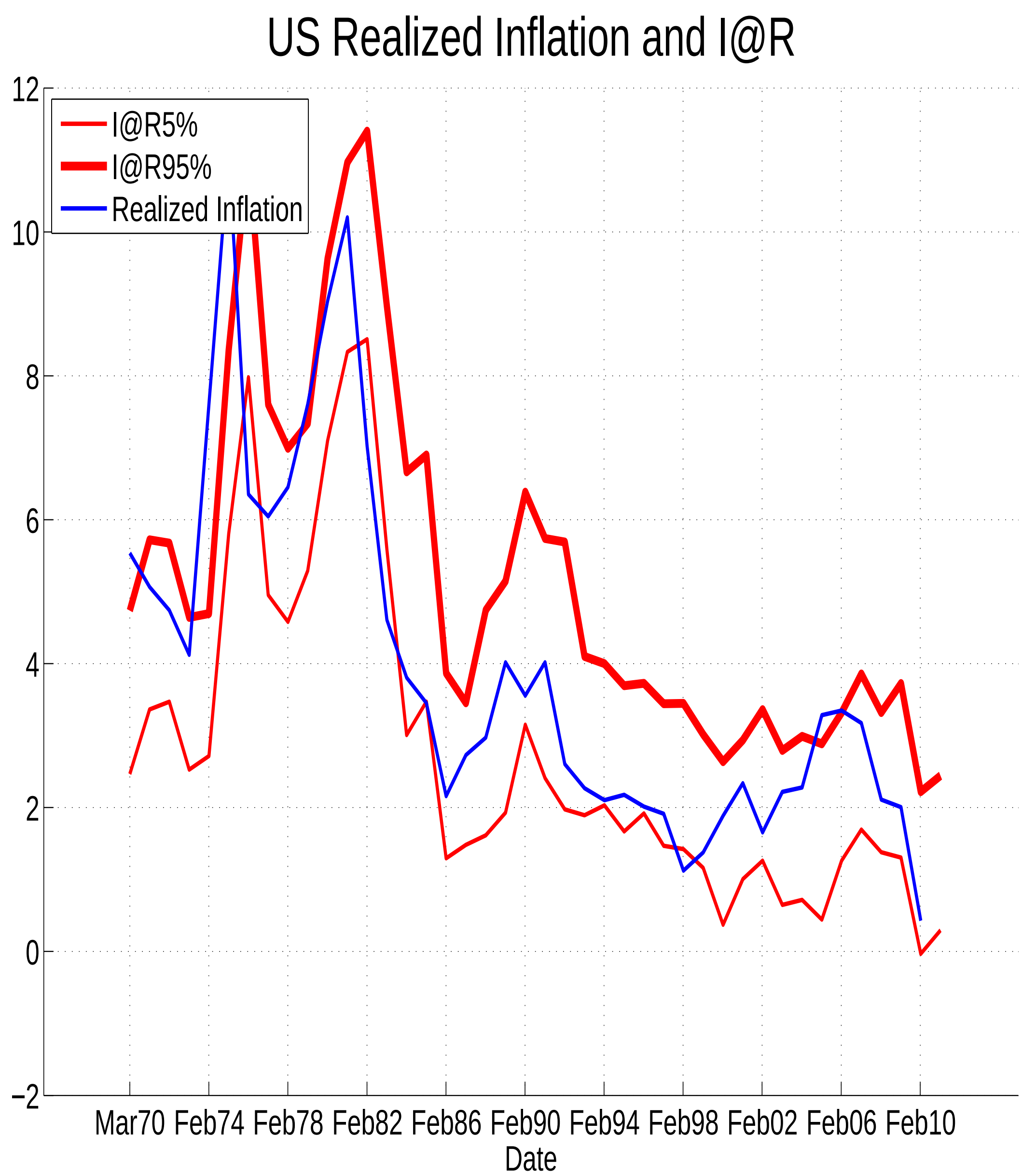
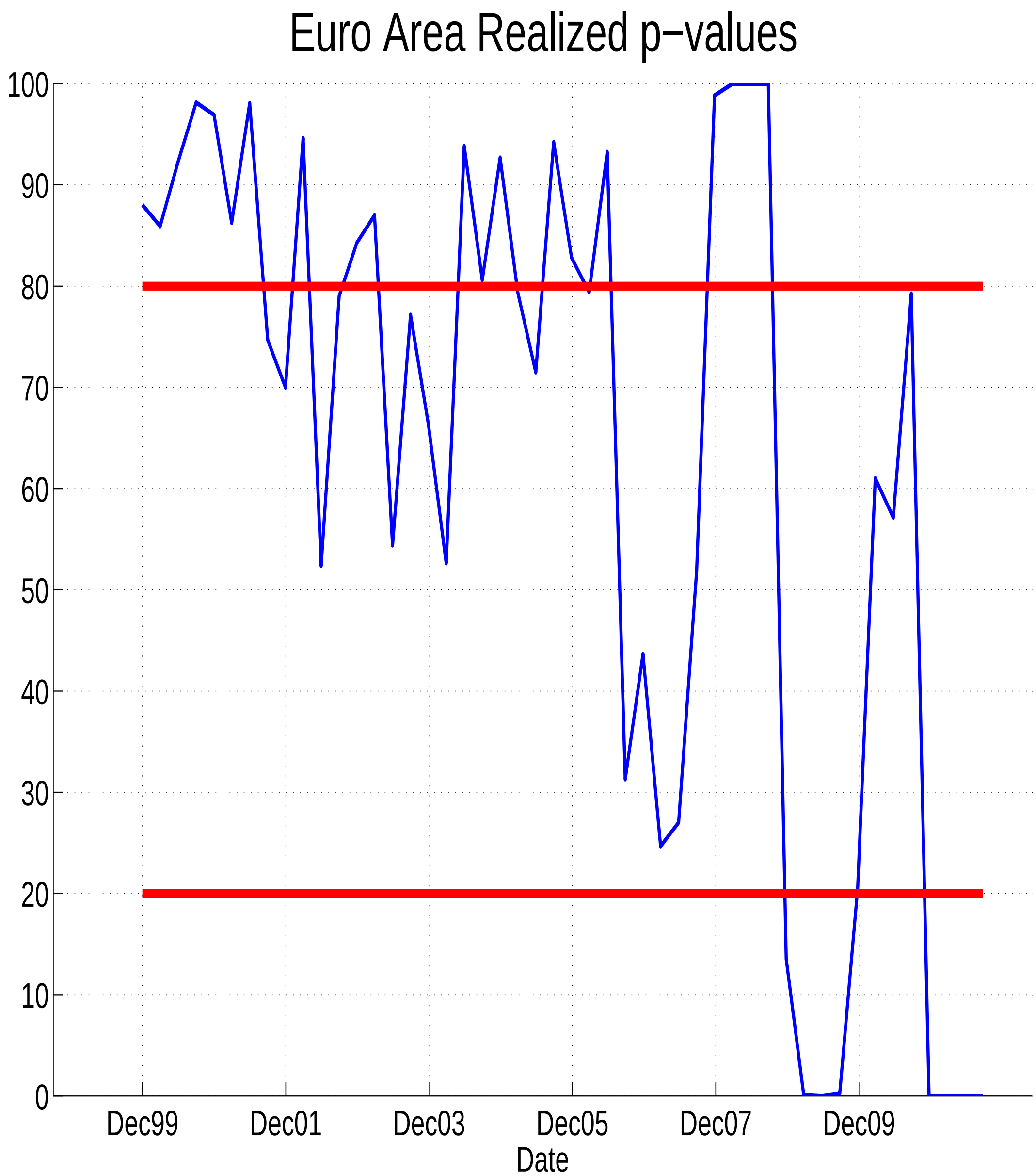

Euro Area Realized Inflation and I@R
I@R5%
I@R95%
Realized Inflation
4
3.5
3
2.5
2
1.5
1
0.5
0
−0.5
Dec99
Oct01
Oct03
Aug05
Aug07
Jul09
Jun11
Date

Figure 4:



US Realized Inflation and I@R
I@R5%
I@R95%
Realized Inflation
12
10
8
6
4
2
0
−2
Mar70 Feb74 Feb78 Feb82 Feb86 Feb90 Feb94 Feb98 Feb02 Feb06 Feb10
Date

Figure 5:



Euro Area Realized p−values
100
90
80
70
60
50
40
30
20
10
0
Dec99
Dec01
Dec03
Dec05
Dec07
Dec09
Date

Figure 6:

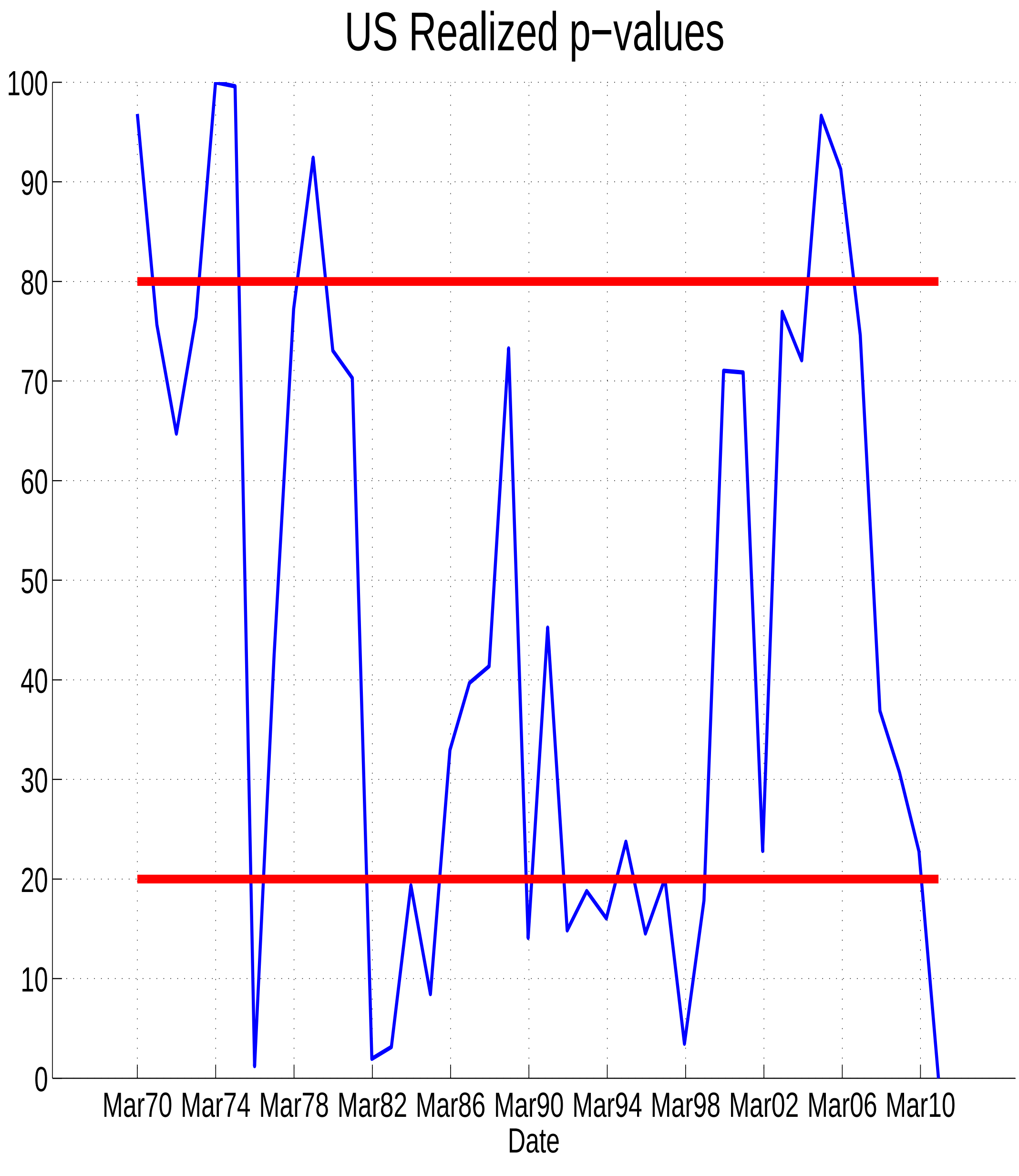

US Realized p−values
100
90
80
70
60
50
40
30
20
10
0
Mar70 Mar74 Mar78 Mar82 Mar86 Mar90 Mar94 Mar98 Mar02 Mar06 Mar10
Date

Figure 7:

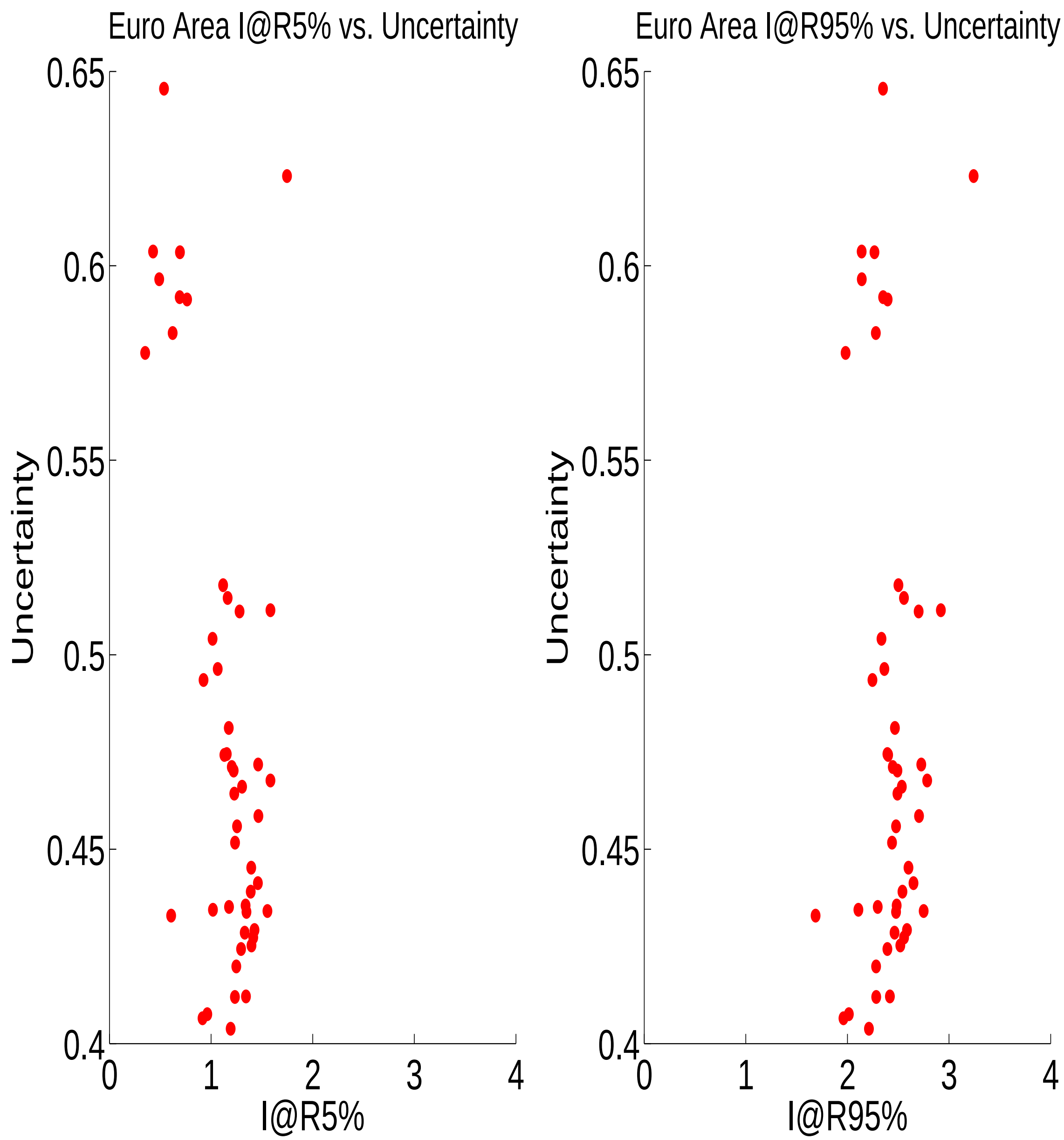

Euro Area I@R5% vs. Uncertainty
Uncertainty
0.65
0.6
0.55
0.5
0.45
0.4
0
1
2
3
4
I@R5%
Euro Area I@R95% vs. Uncertainty
Uncertainty
0.65
0.6
0.55
0.5
0.45
0.4
0
1
2
3
4
I@R95%

Figure 8:

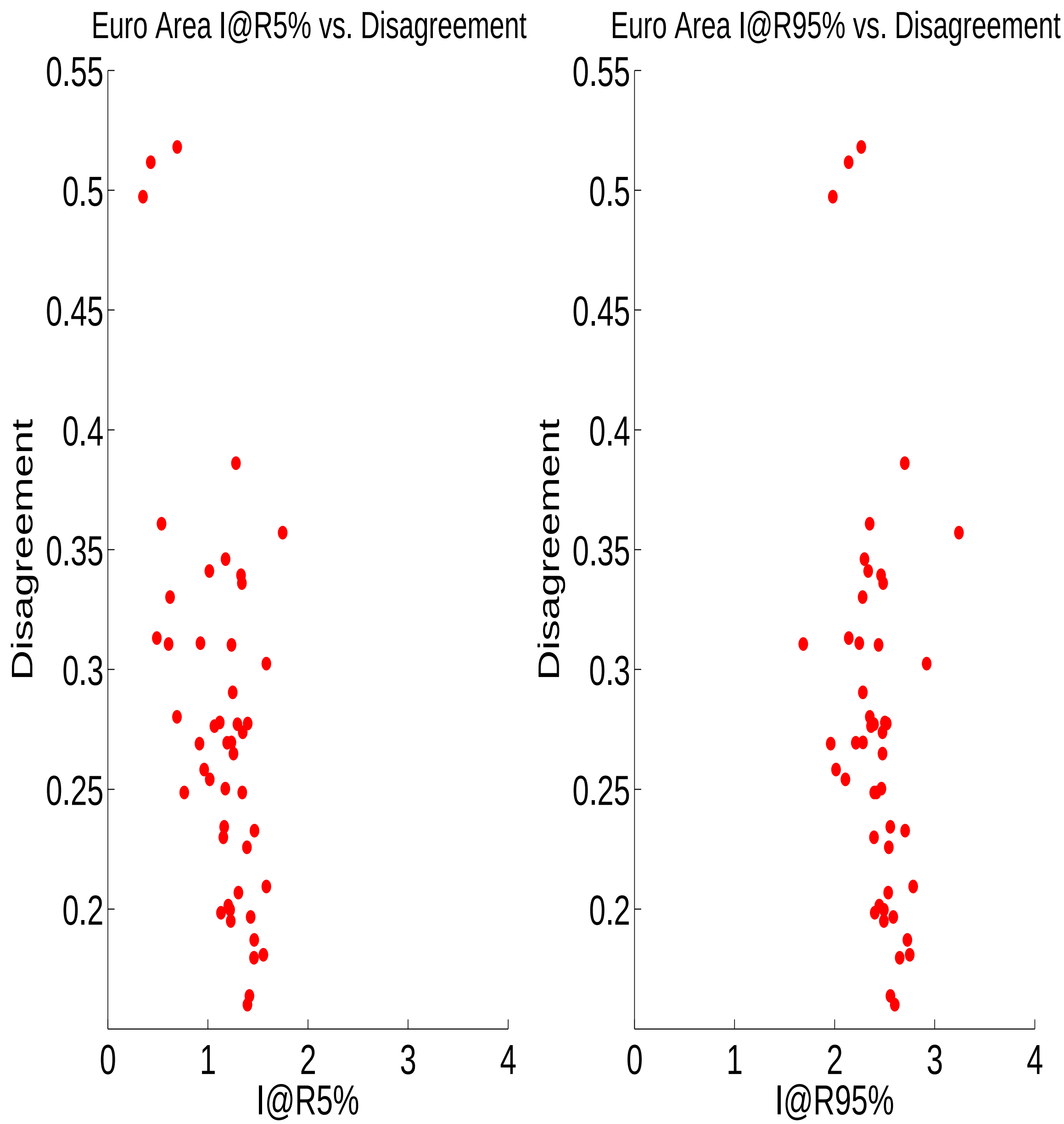

Euro Area I@R5% vs. Disagreement
Disagreement
0.55
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0
1
2
3
4
I@R5%
Euro Area I@R95% vs. Disagreement
Disagreement
0.55
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0
1
2
3
4
I@R95%

Figure 9:

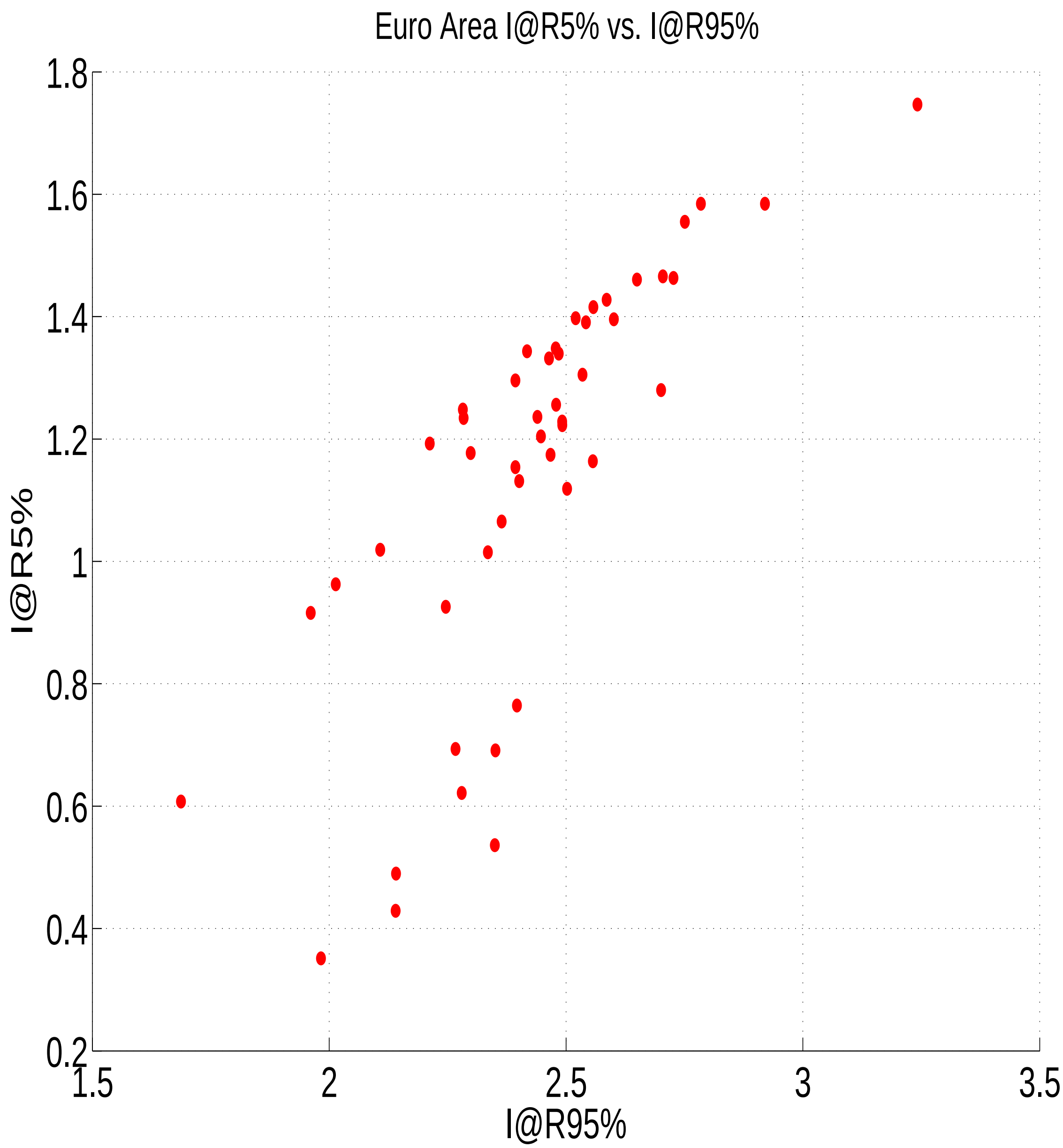


Figure 10:

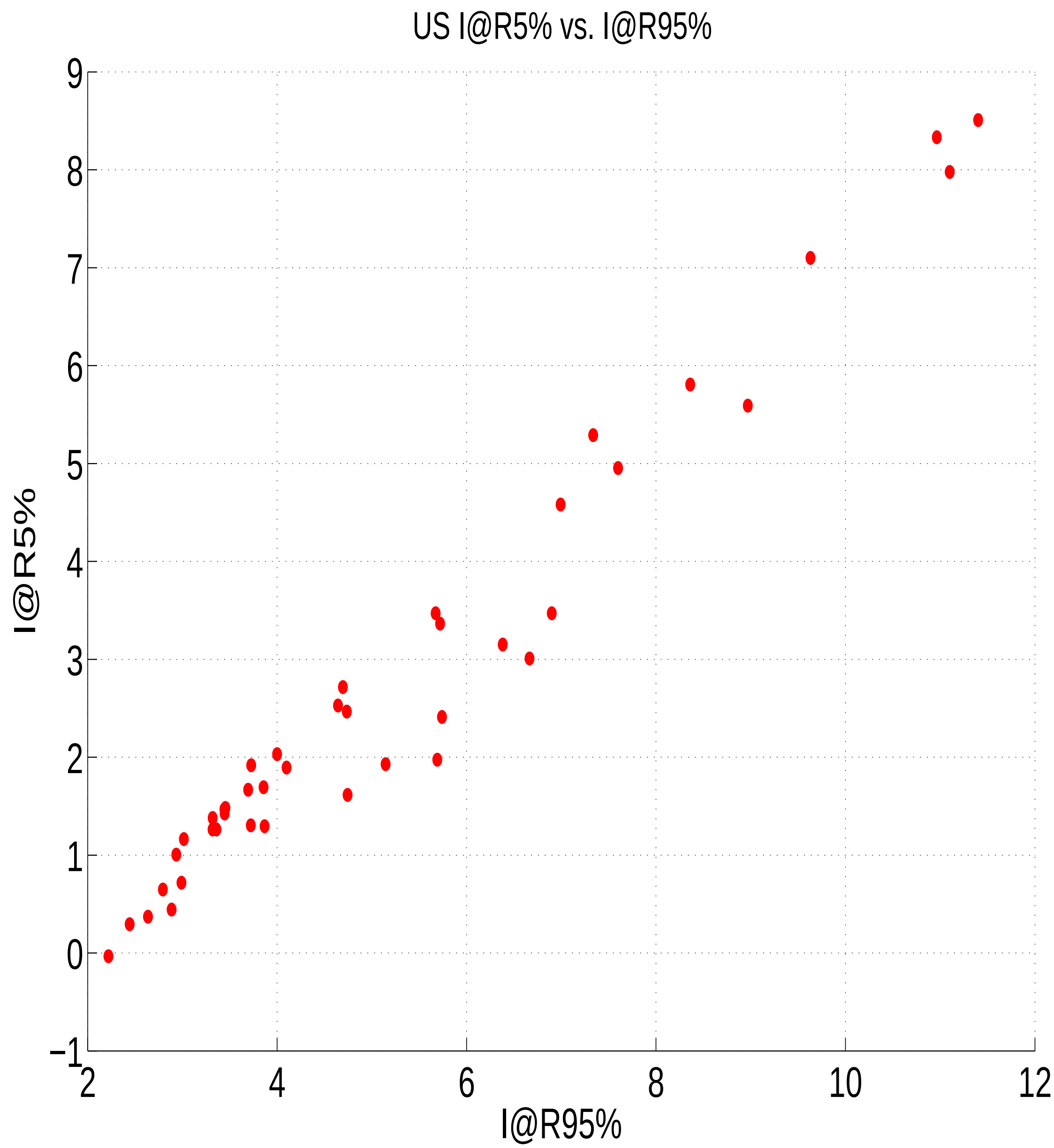
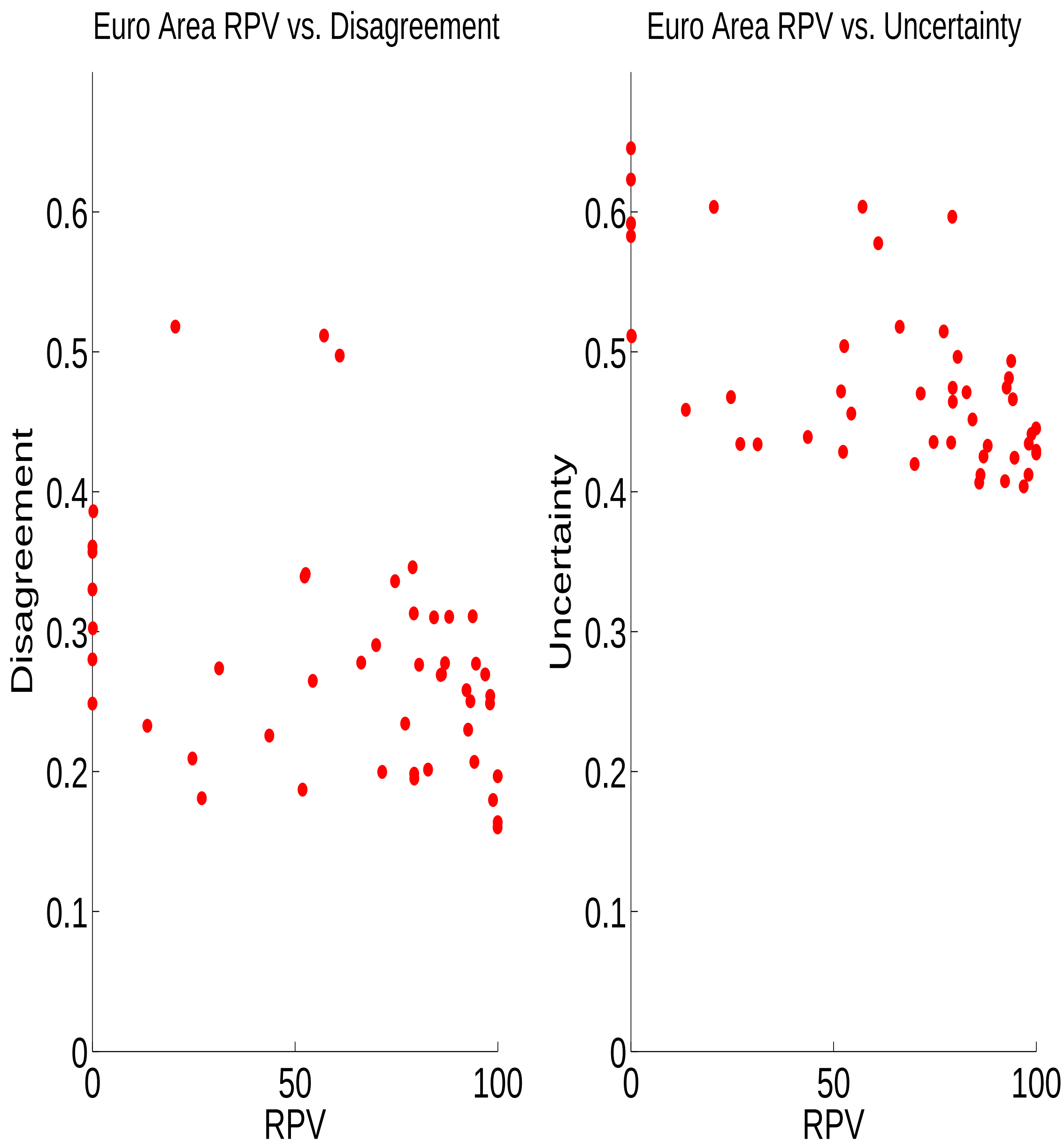
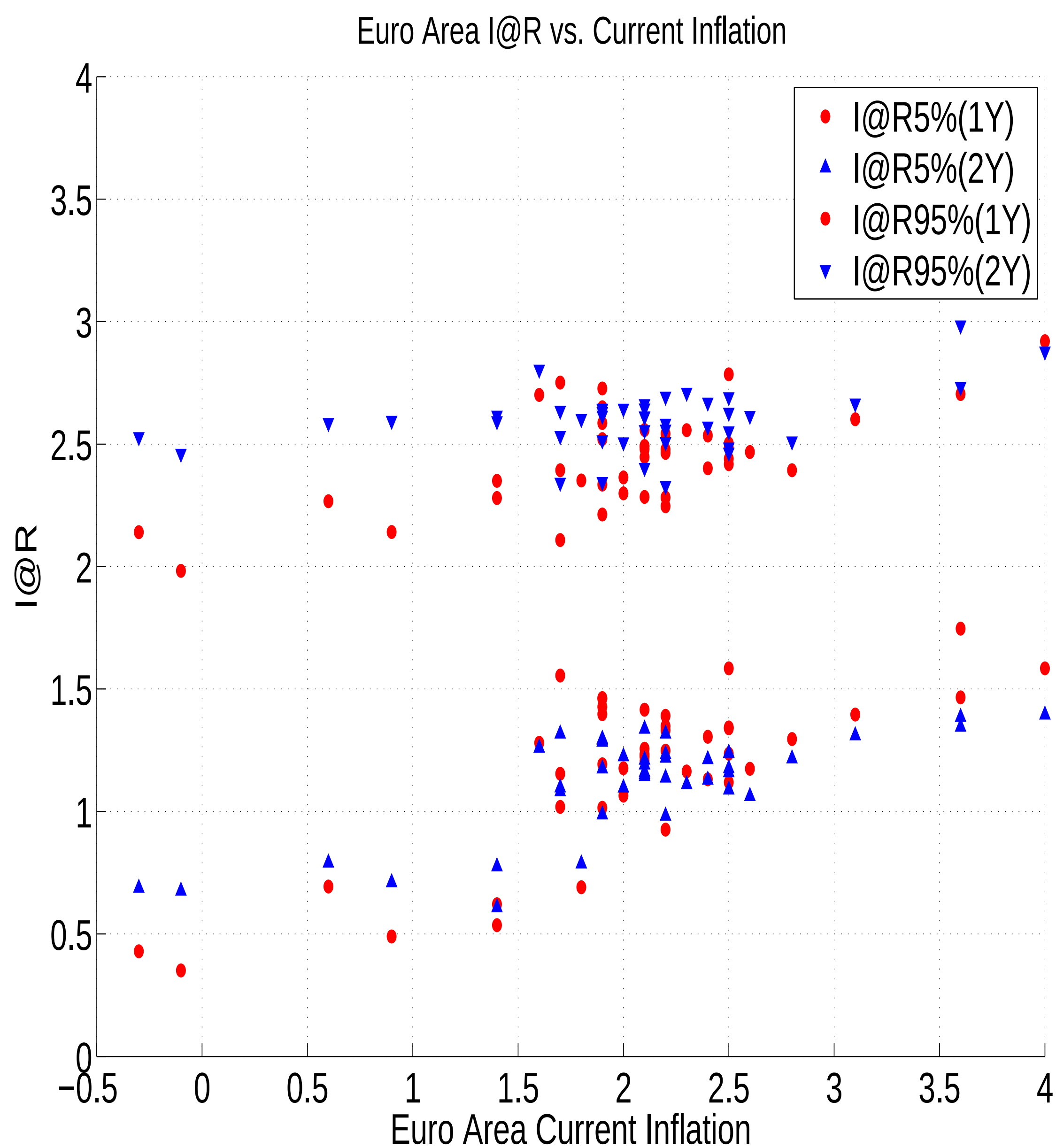


Figure 11:



Euro Area RPV vs. Disagreement
Disagreement
0.6
0.5
0.4
0.3
0.2
0.1
0
0
50
100
RPV
Euro Area RPV vs. Uncertainty
Uncertainty
0.6
0.5
0.4
0.3
0.2
0.1
0
0
50
100
RPV

Figure 12:



Euro Area I@R vs. Current Inflation
I@R5%(1Y)
I@R5%(2Y)
I@R95%(1Y)
I@R95%(2Y)
I@R
Euro Area Current Inflation
0
0.5
1
1.5
2
2.5
3
3.5
4
−0.5

Figure 13:

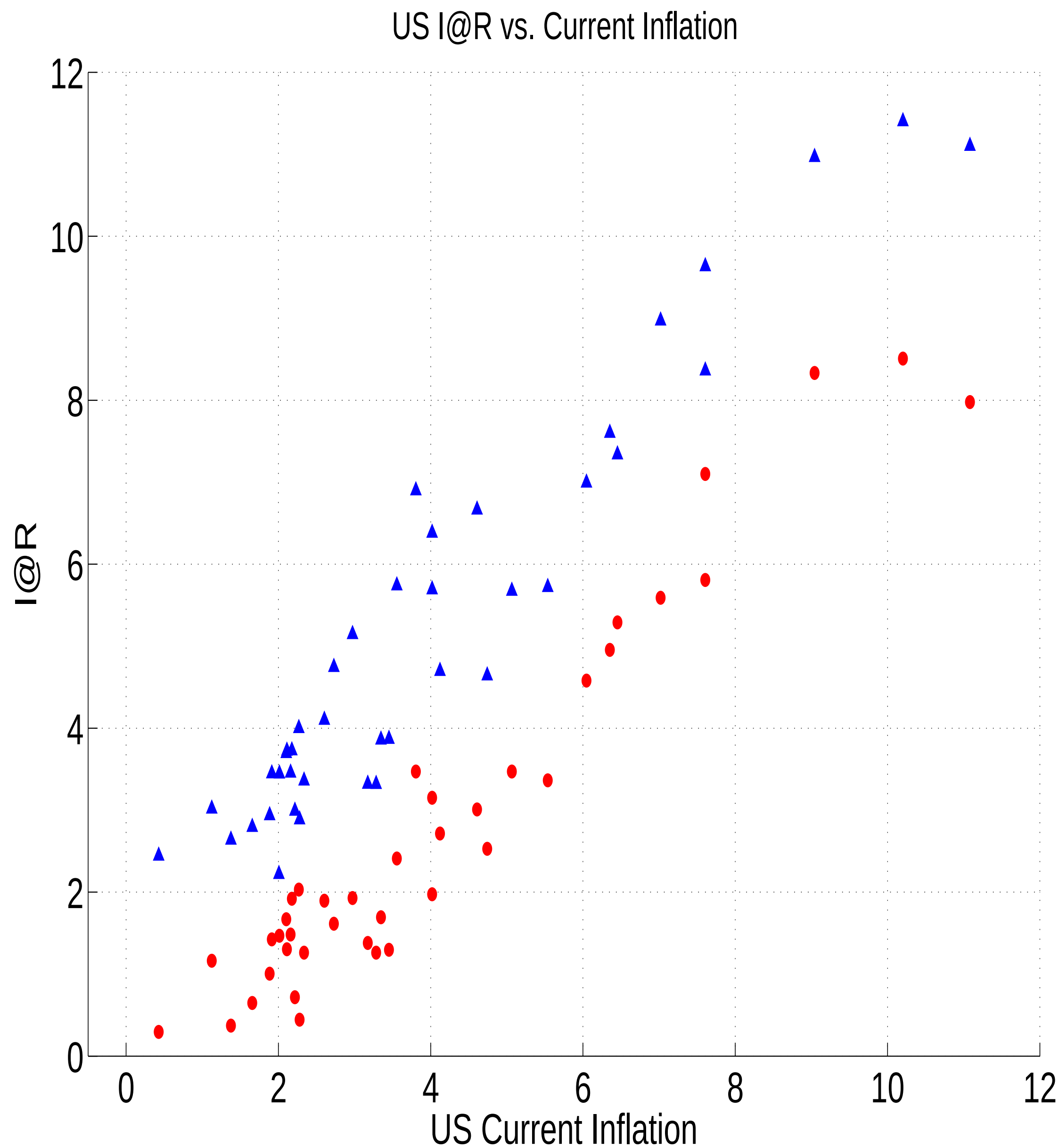

US I@R vs. Current Inflation
I@R
US Current Inflation
0
2
4
6
8
10
12
0
2
4
6
8
10
12

Figure 14:

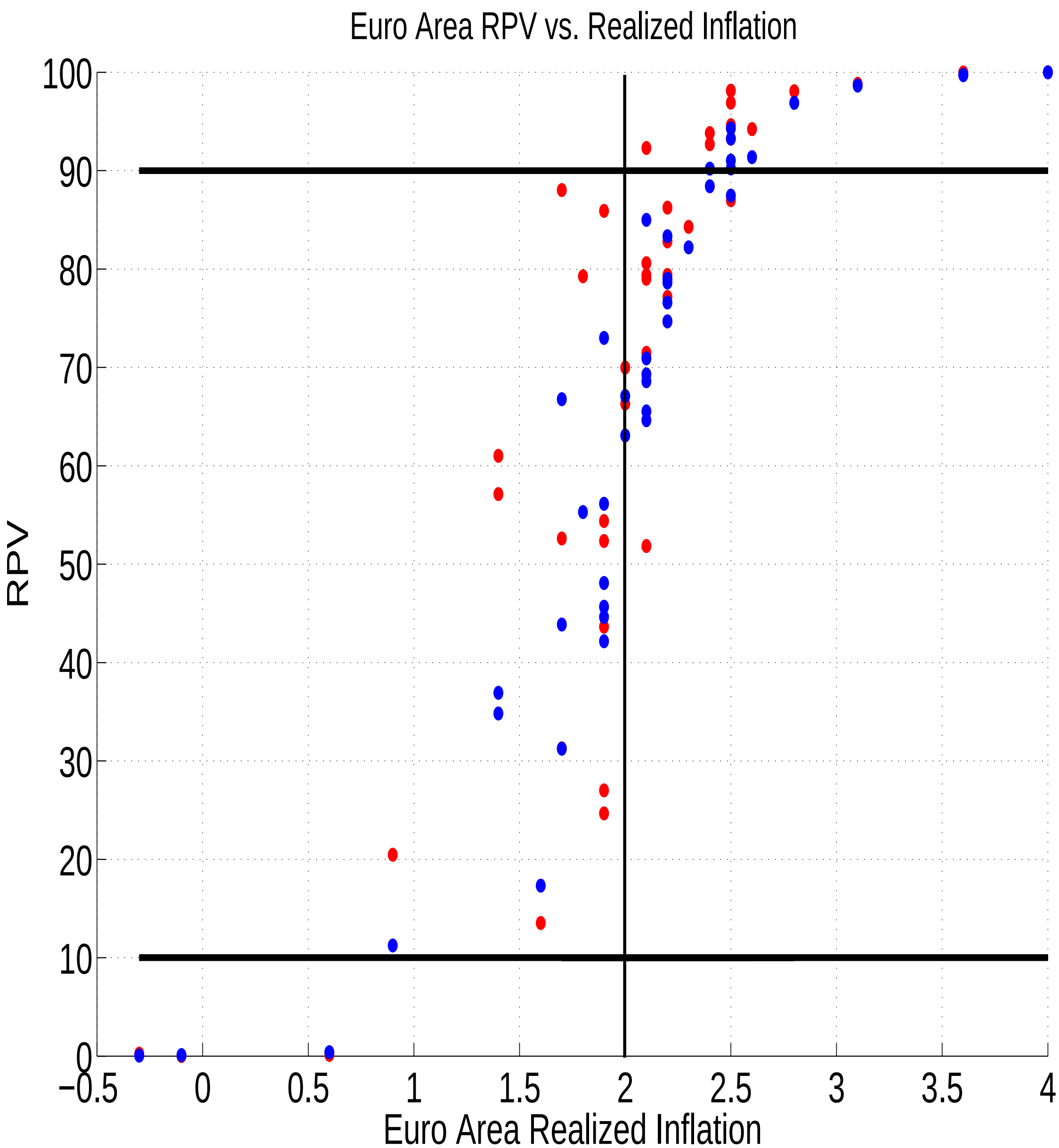

Euro Area RPV vs. Realized Inflation
RPV
100
90
80
70
60
50
40
30
20
10
0
−0.5
0
0.5
1
1.5
2
2.5
3
3.5
4
Euro Area Realized Inflation

Figure 15:

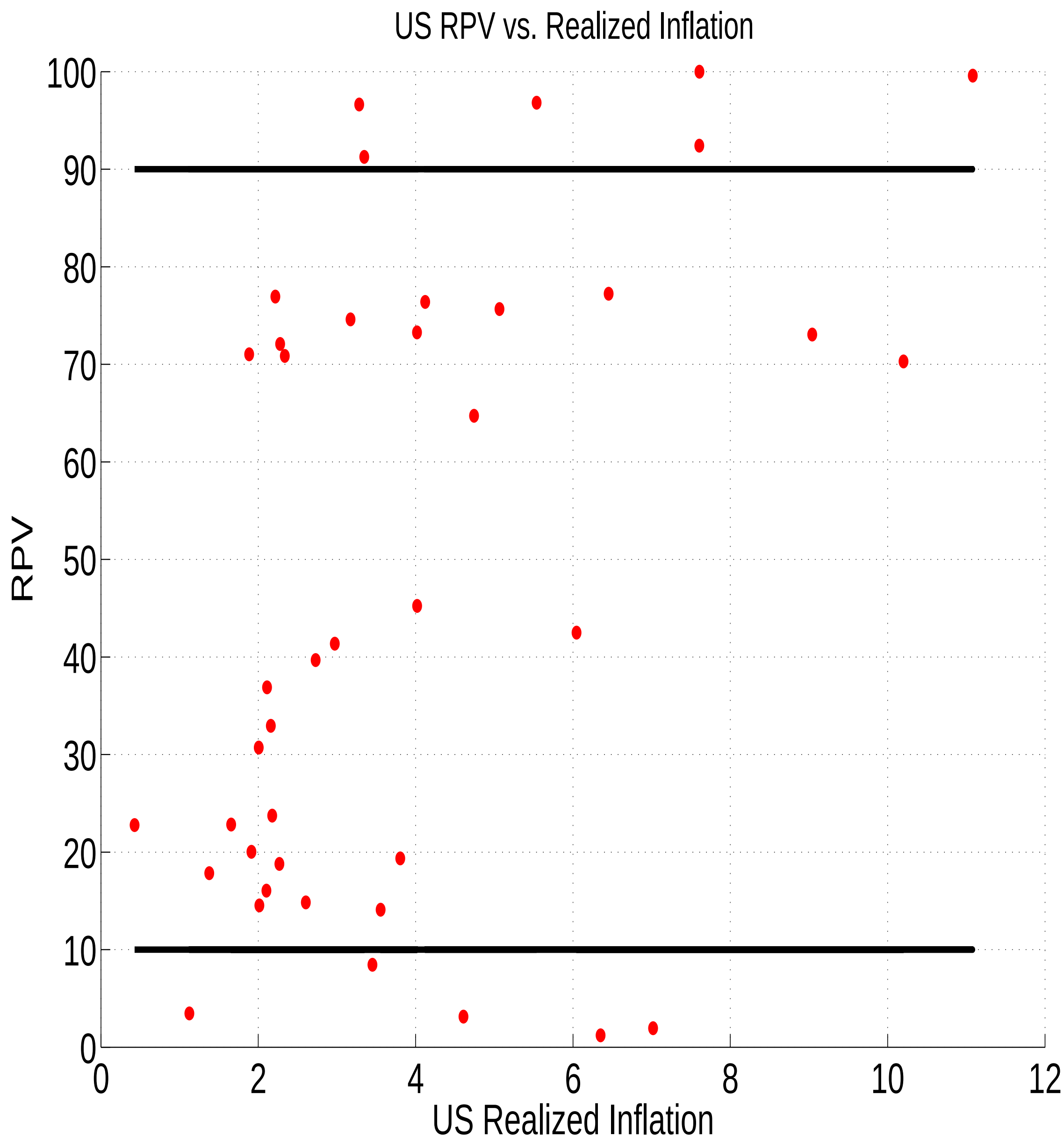

US RPV vs. Realized Inflation
RPV
100
90
80
70
60
50
40
30
20
10
0
0
2
4
6
8
10
12
US Realized Inflation

Table 1: Augmented Taylor rules

	(1)	**(2)**	**(3)**	**(4)**
ECB, $R_{q,t}$				
cst term	1.45	.43	.64	1.40
	(1.03)	(.99)	(1.08)	(1.28)
$R_{q-1,t}$	.79***	.86***	.84***	.80***
	(.10)	(.09)	(.041)	(.10)
$y_{q-1,t}$	.49***	.57***	.55***	.49***
	(.10)	(.11)	(.12)	(.11)
$\pi^e_{q,t}$	.76	.26	.40	.72
	(.49)	(.48)	(.52)	(.49)
$\sigma_{q,t}$	.83			
	(1.10)			
$\omega_{q,t}$		4.35***		
		(1.52)		
$\text{I@R}_{q,t}(95) - \text{I@R}_{q,t}(50)$			2.53*	
			(1.40)	
$\text{I@R}_{q,t}(50) - \text{I@R}_{q,t}(5)$				.53
				(1.53)
FED, $R_{q,t}$				
cst term	2.04	3.14*	4.10**	3.18
	(1.48)	(1.72)	(2.17)	(2.18)
$R_{q-1,t}$	.75***	.75***	.77***	.76***
	(.12)	(.12)	(.12)	(.12)
$y_{q-1,t}$	.58***	.52***	.50***	.53***
	(.15)	(.17)	(.12)	(.16)
$\pi^e_{q,t}$	.87***	.91***	.95***	.90***
	(.22)	(.25)	(.52)	(.26)
$\sigma_{q,t}$	1.03*			
	(.61)			
$\omega_{q,t}$		$-.41$		
		(1.39)		
$\text{I@R}_{q,t}(95) - \text{I@R}_{q,t}(50)$			-1.19	
			(1.60)	
$\text{I@R}_{q,t}(50) - \text{I@R}_{q,t}(5)$				$-.30$
				(1.66)

Table 2: Impact of monetary shocks on perceived inflation risk

	I@R(5)		I@R(95)	
	(1)	**(2)**	**(3)**	**(4)**
ECB				
$I@R_{q-1,t}$	1.40^{***}	1.58^{***}	1.00^{***}	1.21^{***}
	(.15)	(.17)	(.15)	(.17)
$I@R_{q-2,t}$	$-.67^{***}$	$-.86^{***}$	$-.35^{***}$	$-.54^{**}$
	(.24)	(.28)	(.21)	(.25)
$I@R_{q-3,t}$	.11	.16	.01	−.00
	(.15)	(.18)	(.14)	(.16)
$e_{q-1,t}$		$.11^{**}$		$.14^{**}$
		(.06)		(.07)
$e_{q-2,t}$		$.24^{***}$		$.18^{*}$
		(.08)		(.10)
$e_{q-3,t}$		.08		−.05
		(.05)		(.06)
Fed				
$I@R_{t-1}$	$.87^{***}$	$.88^{***}$	$.86^{***}$	$.87^{***}$
	(.08)	(.09)	(.08)	(.10)
e_{t-1}		.12		.13
		(.08)		(.10)