DISCUSSION PAPERS

DP/83/2011

Are Long-term Inflation Expectations Well-anchored? Evidence from the Euro Area and the United States

Tsvetomira Tsenova

BULGARIAN NATIONAL BANK

BULGARIAN
NATIONAL
BANK

DISCUSSION PAPERS

DP/83/2011

Are Long-term Inflation Expectations Well-anchored? Evidence from the Euro Area and the United States

Tsvetomira Tsenova

March 2011

ISBN: 978–954–8579–41–4

Printed in the BNB Printing Centre.

Views expressed in materials are those of the authors and do not necessarily reflect BNB policy.

Elements of the 1999 banknote with a nominal value of 50 levs are used in cover design.

Send your comments and opinions to:
Publications Division
Bulgarian National Bank
1, Knyaz Alexander I Square
1000 Sofia, Bulgaria
Tel.: (+359 2) 9145 1351, 9145 1978
Fax: (+359 2) 980 2425
e-mail: Dimova.L@bnbank.org
Website: www.bnb.bg

Contents

SUMMARY: This paper analyses the anchoring, i.e. stability, of long-term inflation expectations, as well as further moments of the distribution, as perceived by the professional forecasters in the euro area and the US. Evaluation is initially performed on the basis of sensitivity to innovations to observed inflation, short- and medium-term individual forecast news. News are defined in a subjective sense and derived from revisions to shorter-term fixed-target forecasts. The assessment tests for presence of non-linear effects, including regime changes during disinflation in the US in the 90s and the recent financial crisis. Secondly, anchoring is evaluated in terms of level evolution, based on structural non-linear and non-gaussian learning models, used to uncover the presence of common trend, underlying the long-term dynamics of inflation, individual expectations and uncertainty. The findings suggest relatively well-anchored expectations. As regards sensitivity, point expectations in the euro area are perfectly anchored. Although there is presence of non-stationary common process underlying individual expectations and inflation realisations, most forecasters project the ex-ante long-term considerably below trend inflation, a phenomenon documented and named here **collective stabilisation bias**. Long-term uncertainty proved unrelated to both level and changes in the inflation process. In the US there is higher sensitivity to the shorter term, which has diminished significantly after 1999, possibly contributing to stationarity in the underlying inflationary process and absence of collective bias. Both currency areas demonstrate remarkable resilience to shocks during the financial markets crisis.

JEL classification: E52, E31, C52

Keywords: monetary policy; uncertainty and risk; heterogeneity; imperfect knowledge; collective bias; subjective expectations and forecast news; beliefs.

The author would like to thank John Hutton, Dimitar Kostov, Andrew Levin, Athanasios Orphanides, Ricardo Reis, Frank Smets and Gabriel Talmain for their valuable comments.

Dr Tsvetomira Tsenova is Adviser to BNB Deputy Governor Dimitar Kostov, a position she holds since February 2009. Previously she worked as Senior Economist at the Euro Area Economic Developments Division and the Monetary Policy Strategy Division of the European Central Bank, Frankfurt, Senior Expert at the International Relations and EU Integration Directorate, Bulgarian National Bank, External Associate Professor in International Economics at the University of Copenhagen (2003–2004) and Programme Officer at the UNDP (2001–2002). In 2001, she earned her PhD in Economics at the University of York, UK with a doctoral thesis entitled “Macro-theoretic Models of an Economy in Transition”.

Correspondence: Bulgarian National Bank, 1, Knyaz Alexander I Square, Sofia 1000, E-mail: tsenova.ts@bnbank.org

1. Introduction

Long-term inflation expectations are the equilibrium level towards which inflation would converge, after the effects of short-term shocks and initial conditions have disappeared, and monetary policy directed towards the medium-term has become fully effective. Thus, long-term inflation expectations are determined by the *declared* monetary policy inflation objective and its **credibility**. If not declared, they are determined by the **perceived** monetary policy inflation objective and its **attainability**. As such, their anchoring, i.e. stability, is critical for both monetary policy evaluation and modelling of the inflation process.

This paper analyses the anchoring, stability, of long-term inflation expectations, as well as further moments of the distribution, as perceived and reported by the professional forecasters in the euro area and the United States. This way, this investigation examines private sector's subjective beliefs on the state and prospects of the only two reserve currencies in the world. Both are subject to similar monetary policy strategies with strong focus on inflation stabilisation. Communication strategies, however, differ, with a formally announced upper bound of 2 per cent on euro area's inflation objective, and no such for the US. The experience during the financial markets crisis coupled with severe recession has accentuated on the parallels, while at the same time shifting the debate towards the ability of monetary policy to deliver desired results under a disrupted monetary transmission mechanism. Three years into the crisis, professional economists and wider public still seem to differ as to the future long-term implications of monetary accommodation, which has been implemented through non-standard or unconventional measures. Polar views range from monetarists motivated by Friedman (1968) predicting higher long-term inflation spurred by high money growth, as well as a deflationary spiral motivated by Minsky's (1986) liquidity trap.

In order to address the subject of anchoring, the analysis presented in the paper departs from some of the constraints imposed by the rational expectations framework, where the presence of full information presumes **perfectly anchored** inflation expectations at all times, meaning that the inflation objective is perfectly known, fixed, attainable and fully credible. Moreover, there is no judgement and heterogeneity, with all individuals holding the same opinion.

The analysis finds theoretical motivation in the literature on learning under imperfect knowledge, such as Orphanides and Williams (2005). Under imperfect knowledge the inflation objective is imperfectly known or credible, and the private sector would need to learn it from historical and incoming data, or apply judgement as regards the effectiveness of monetary policy actions. Then long-term inflation expectations can be **well-anchored** or alternatively **poorly anchored**. Moreover, the state of long-term expectations can evolve through time.

Orphanides and Williams (2005), define well-anchored expectations in terms of levels, i. e. private sector's shorter-term projections could be time-varying, as the structure of the underlying econometric model, but should not be drifting away from the inflation objective or underlying inflation mean for considerable periods of time. Bernanke (2007) formulates a definition in terms of sensitivity irrespective of the level, i. e. long-term being relatively insensitive to incoming data on inflation.

The paper translates this theoretical guidance into empirical sensitivity tests on anchoring, followed by evaluation of inflation dynamics on the basis of alternative structural non-gaussian learning models. More specifically, the stability of long-term expectations is initially tested with respect to changes in inflation realisations, short- and medium-term individual forecast news. The latter are defined in a subjective sense and derived from revisions to shorter-term fixed target forecasts. Subjective forecast news capture the impact of all individually perceived new information, deemed relevant for expected inflation dynamics at corresponding horizons. The applied non-structural robust panel regression method is chosen due to its minimal reliance on a priori assumptions on the distribution of news and innovations. The assessment also tests for presence of non-linear effects, including seasonality and regime changes during disinflation in the US in the 90s and the recent financial crisis.

Anchoring is further evaluated in terms of structural models of the level of individual long-term inflation expectations and further moments, and their potential role for the dynamics of the inflation process. This is performed by applying a recently extended recursive maximum-likelihood methodology by Chang, Miller and Park (2009) to uncover and evaluate the potential presence of a common unobserved trend between ex-post realisations and ex-ante individual expectations in the long-term. The paper, however, differs from other studies in the inflation dynamics literature, such as Kim and Nelson (1999) and Tetlow (2008), by anchoring the underlying process of inflation dynamics to survey expectations, as well as from empirical literature on imperfect knowledge, e.g. Orphanides and Williams (2005), by incorporating in the model the full set of individual survey forecasts and their evolution.

In addition to analysing point expectations, for the euro area the paper offers comparative assessment based on own estimates of expectations and uncertainty derived from individual probability forecast reports. This is accomplished by non-linear least squares fitting methods developed and applied also in other contexts by Zarnowitz and Lambros (1987), Giordani and

Söderlind (2003) and D'Amico and Orphanides (2006), Boero, Smith and Wallis (2008), Rich and Tracy (2010).

The findings suggest relatively well-anchored expectations. In terms of sensitivity to innovations and news, point expectations in the euro area are perfectly anchored. Although there is presence of non-stationary common process underlying individual ex-ante expectations and ex-post inflation realisations, most forecasters project the ex-ante long-term considerably below trend inflation, a phenomenon documented and named here **collective stabilisation bias**. Long-term uncertainty proved unrelated to both level and changes in the inflation process. No evidence was found for a regime change after the onset of the financial markets crisis. All this provides monetary policy makers in the euro area with a safety margin inspiring less activism during periods of stronger inflationary pressures and high inflation uncertainty in the long-term.

In the US there is higher sensitivity to the shorter term, which has diminished significantly after 1999, and probably led to the observed stationarity in the underlying inflationary process and absence of collective bias. No significant change is found in the structurally modelled inflationary process or sensitivity to short-term transitory shocks during the financial markets crisis, demonstrating remarkable resilience.

Looking forward, there is strong case for further monitoring the state of long-term inflation expectations and further moments, as monetary policy makers start unwinding their non-standard and non-conventional monetary stimulus measures. In the case of the euro area, where some non-stationarity is observed, measures of long-term expectations derived from the probability forecasts can be used to give earlier warning to policy makers, due to their revealed property of showing more sensitivity and alignment with unobserved trend inflation.

2. Moments of the distribution of long-term inflation: identification, estimation, aggregation

I use quarterly reports on individual inflation forecasts form the surveys of professional forecasters in the euro area and the US. The sample period ends at 2009Q4, spanning over the challenging period of the financial markets turmoil. In the case of the euro area, the survey starts with the introduction of the euro 1999Q1. The forecasts target HICP inflation, the harmonized index of consumer prices, which quantifies the upper bound on ECB's inflation objective (close, but below 2 per cent). The panel of respondents consists of 100, more recently 107, individuals and institutions with about 60 participants per round. For the US, only long-term inflation forecast on CPI (Consumer Price Index) cover a comparable period, starting from 1991Q4. The CPI is not that closely linked to monetary policy, because judging by official reports, the Fed's preferred measure on inflation for monetary policy purposes would be the Core PCE (Personal Consumer Expenditure Price Index).

Each forecast *i* for target year *n* produced at time *t* is described by a direct expectation measure – the point estimate $\eta_{i,t}^{n}$, most likely outcome, and a probabilistic forecast – discrete probability distribution, reflecting the respondent's beliefs that the outcome would fall within each of the predetermined intervals. In the case of US, only point expectations data on long-term forecasts of CPI are available.

I derive individual measures of expectations and uncertainty from reported probability distribution. I assume that reported probabilities are distributed uniformly within each interval, and that the distribution underlying the forecast is normal.[1] I estimate the mean $\hat{\mu}_{i,t}^{n}$ and standard deviation $\hat{\sigma}_{i,t}^{n}$ by matching, as close as possible, the empirical probabilities reported in the histogram with the theoretical ones generated from a normal distribution. I implement this by fitting though a least squares procedure the empirical and theoretical normal cumulative probability distributions (CDFs) rather than the probability distributions (PDFs), as motivated by Wallis (2003) and applied by D'Amico and Orphanides (2006) in the case of the US.

Each of the moments of the individual forecasts form cross-sectional probability distributions. Percentiles of the distribution reflect the value below which certain percent of observations fall. The median represents the observation at the 50th percentile of the data, i.e. the value below which 50 per cent of the data falls, while the interquantile range signifies the difference between the observations at the 75th and 25th percentiles.

The central tendency reflects the **consensus** amongst forecasters while their dispersion – the **disagreement**. Here those are represented by correspondingly the median and the interquantile range (level difference between the 75th and 25th percentiles of the distribution) as measures robust to outliers and imperfect knowledge of the shape of the cross-sectional distribution. Consensus measures are denoted as point expectations $\eta_{n,t}$, derived expectations $\hat{\mu}_{n,t}$ and uncertainty $\hat{\sigma}_{n,t}$, while their correspondents in terms ofdisagreement - by $\hat{\varphi}_{n,t}, \hat{\phi}_{n,t}$ and $\hat{\varsigma}_{n,t}$.

[1] To perform robustness checks, I also estimate measures of expectations and uncertainty under two non-parametric alternatives: the *uniform assumption*, according to which reported probability mass is spread uniformly within each interval and between interval borders (as in Zarnowitz and Lambros, 1987), and the *mid-point assumption*, under which the probability mass is concentrated in the center of each interval. Since their use in the statistical analysis produced very similar results, those are not reported.

Figure 1 shows the evolution of the cross-sectional distribution of expected long-term inflation in the euro area. It is relatively fixed, with little and declining dispersion in beliefs amongst forecasters. Up to 2003Q1, there is considerable convergence in the center of the distribution leading to lower dispersion in terms of interquantile range. This must have had an impact on monetary policy communication since in March 2003, i.e. after the 2003Q1 survey round, conducted in mid-January, the ECB redefined its price stability objective from 'below 2 per cent' to 'below 2 per cent, but close'. The observed convergence, however, seems to be due to lower-forecast levels increasing, with 75th percentile remaining fixed throughout the period. While the convergence occurs in the center of the distribution, outer percentiles are more persistently spread out. Consensus expectations are stable, with only small deviations from 1.9 per cent. Those deviations are positive during the last five quarters of the sample period, while zero or negative before, which provides an impression of a slight upward creep. Thus, only after 2007Q3, the survey conducted just a few weeks before the financial markets turmoil in August 2007, consensus expectations approach levels not entirely consistent with the ECB's numerical definition of price stability.

In comparison, the long-term inflation expectations in the US depicted on Figure 2 show considerable convergence up to 1998, followed by a period of relative stability both in terms of consensus and disagreement. There is a slight rise in disagreement during the financial markets turmoil. The heterogeneity in the center of the distribution is relatively large compared to the euro area.

From this preliminary look at the data, it seems that long-term inflation expectations are heterogeneous both in terms level and dynamics, which evolve through time. It would be useful to identify the main shared tendency driving the cross sectional developments. Methods should incorporate the possibility of a common trend, which might be particularly important for the euro area and possibly the US in the 90s.

Figure 1

LONG-TERM INFLATION EXPECTATIONS IN THE EURO AREA: QUANTILE PLOT OF THE CROSS-SECTIONAL DISTRIBUTION OF POINT ESTIMATES, 1999Q1–2009Q4

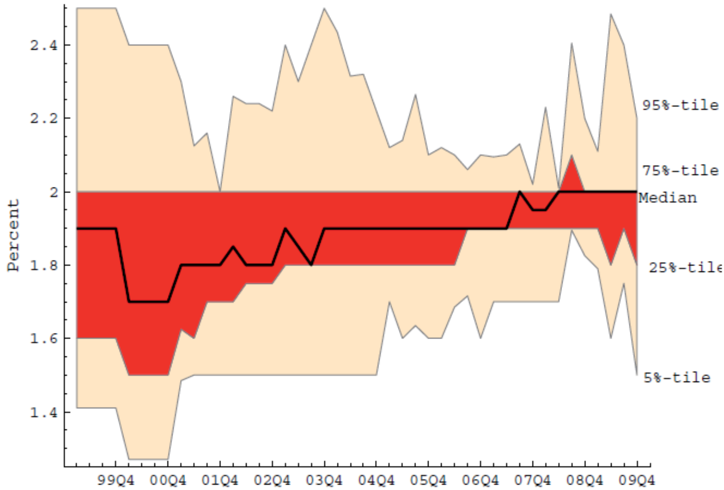
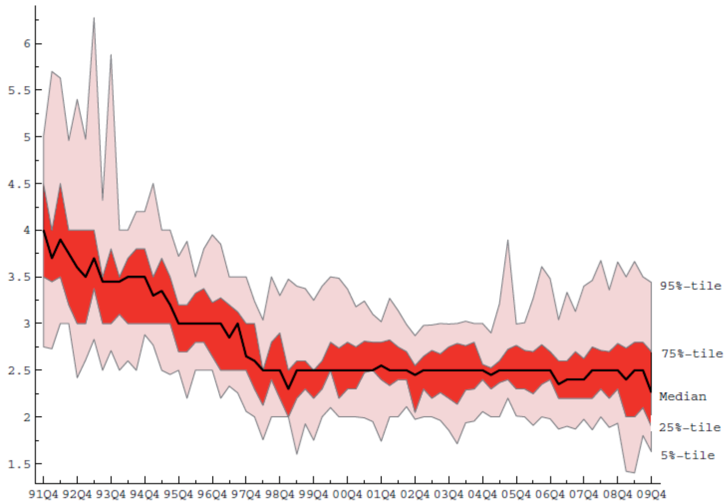


Figure 2

LONG-TERM INFLATION EXPECTATIONS IN THE US, 1991Q1–1999Q4: QUANTILE PLOT OF THE CROSS-SECTIONAL DISTRIBUTION OF POINT ESTIMATES



3. Methodology

The anchoring (stability) of long-term inflation expectations is evaluated in terms of sensitivity – responsiveness to shocks, and in terms of level evolution. To address the first issue I employ non-structural tests based on robust panel estimations, while for the second I employ structural non-linear identification of unobserved common trend dynamics.

3.1. Sensitivity tests

The key to testing the anchoring of long-term inflation expectations is their sensitivity to current information. Since the paper analyses subjective beliefs and imperfect knowledge, I use for identification non-structural panel regressions, which impose minimum a priori assumptions on the distributions of innovations and news.

Revisions to the fixed target forecast show the impact of the arrival of new information on expected inflation developments. For example, revisions to the moments of long-term forecasts $\Delta\pi_{i,t}^{e\ long}$ reveal changes in beliefs on the equilibrium state of inflation, after initial conditions and short-term shocks have disappeared. It is possible that those changes are linked to observed shocks to the inflation process. Under imperfect knowledge, those can be partly due to permanent shocks to the sample mean and transitory shocks. For example, at time *t* the inflation rate π_{t-1} becomes available, changes in the current inflation rate would contain permanent, $\Delta\pi_{t}^{e\ long}$, and transitory innovations $\Delta\nu_{t-1}$

$$\Delta\pi_{t-1} = \Delta\pi_{t}^{e\ long} + \Delta\nu_{t-1}.$$

I utilise the fixed target shorter-term forecasts to compose consistent proxies for forecast news, subjective to the information, model and judgement of each individual forecaster. The current and next year forecasts I use to derive proxies for the moments of short-term news $\Delta\pi_{i,t}^{e\ News\ S}$, forecast innovations 4 to 1 quarters forward, which capture currently observed shocks and one-step-ahead revision to the path of all other predictable variables considered by the individual forecaster. The next and year after forecasts I use to derive medium-term news $\Delta\pi_{i,t}^{e\ News\ M}$, innovations 8 to 5 quarters forward, which contain the impact of expected monetary policy actions, as well as one-step-ahead revisions to the path of all other predictable variables, which might be considered by the individual forecaster.

I estimate separately the sensitivity of long-term inflation expectations and further moments of the distribution $\pi_{i,t}^{e\ long}$, to the corresponding moments of these three proxies for incoming data, which leads to the following sets of regressions:

$$\Delta\pi_{i,t}^{e\ long} = \beta^{\Delta\pi}\Delta\pi_t + \Delta\varepsilon_{\iota,t}^{\Delta\pi} \quad (1)$$
$$\Delta\pi_{i,t}^{e\ long} = \beta^{\pi e\ News\ S}\ \pi_{i,t}^{e\ News\ S} + \Delta\varepsilon_{\iota,t}^{\pi e\ News\ S} \quad (2)$$
$$\Delta\pi_{i,t}^{e\ long} = \beta^{\pi e\ News\ M}\ \pi_{i,t}^{e\ News\ M} + \Delta\varepsilon_{\iota,t}^{\pi e\ News\ M} \quad (3)$$

When perfectly anchored, the moments of long-term expectations should be insensitive to all proxies of incoming data and the slope coefficients of Equations 1, 2 and 3 should be insignificant. If well-anchored, they should be insensitive to shorter-term incoming data with slope coefficients of Equations 1 and 2 being insignificant. Alternatively, they would be poorly anchored. Significance of slope coefficients on Equation 3 would provide evidence of learning by the forecasters from monetary policy actions, since those target medium-term developments. In interpreting the evidence on expectations, priority is given to point estimates relative to derived expectations from the probability distributions, since the latter are subject to inevitable measurement error.

The main analysis is modified in order to check the robustness of the results in the presence of non-linearities due the seasonal dependence of the coefficients, as well as regime changes.

3.2. Non-linear modelling

I model the non-linear process underlying the evolution of individual long-term inflation expectations, uncertainty and inflation, allowing for the possibility of a common unobserved trend. I use a novel approach developed by Chang, Miller and Park (2009) which extends the Kalman filtering and smoothing maximum likelihood methodology to provide structural modelling and estimation with co-integrated time-series. That is particularly suitable in the case of long-term inflation expectations, where the common tendency is very important to uncover, and which could be non-stationary. At the same time, the reclusive nature of the estimation involves real-time prediction and updating of the parameter estimates. It is based on direct maximum likelihood estimation and therefore associated with less estimation uncertainty in comparison with other techniques, such as the Bayesian methods. As shown by Chang, Miller and Park (2009), this method is more successful in identifying underlying unit root trends compared to non-structural co-integration models.

The estimated non-linear models have the following structure:

$$y_{i,t} = \beta_{0,i}x_t + u_{i,t}$$
$$x_t = x_{t-1} + \nu_t$$

where $y_{i,t} \in \{\pi_{i,t}^{e\ long}\}'$ for Model 1 or $y_{i,t} \in \{\pi_{t-1}\ \pi_{i,t}^{e\ long}\}'$ for Model 2

$y_{i,t}$ is a vector of observable time-series consisting of the moments of the distribution of long-term inflation – $\pi_{i,t}^{e\ long}$ and inflation; $\pi_{i,t}^{e\ long}$ consists of η – point expectations, μ – means of the probability forecast distributions, σ^2 – standard deviation of the probability forecast distribution; π_{t-1} observed inflation rate at time *t*; $\beta_{0,i}$ is a vector of estimated individual level parameters; x_t estimated unobserved stochastic unit root trend; $u_{i,t}$ assumed to be identically normally distributed (iid) errors; ν_t – normally distributed iid errors with variance 1.

I assess the anchoring of long-term inflation moments by evaluating the stationarity of the uncovered dynamics, heterogeneity and bias with respect of underlying inflation dynamics.

4. Sensitivity of long-term inflation expectations and further moments of the distribution to corresponding measures of news

I test the sensitivity of long-term expectations and uncertainty to inflation observations, short and medium-term news. The main focus of the analysis is the period 1999Q1 – 2009Q4, in order to compare the Euro area with the US. Earlier data is also used when analysing regime change in the US. While forecasts of inflation for the Euro area are reported both in terms of point and probability forecasts, due to data availability, the analysis of the US concerns only point estimates.

I test the sensitivity of the moments of long-term inflation, as assessed by the professional forecasters at each point of time, to new inflation realisations and corresponding moments of individual forecast news. I use first difference estimation since it is a powerful and robust method in evaluating the sensitivity of the relationships, measured by the slope coefficients. The estimation results of a series of unbalanced panel regressions over the whole sample period, 1999Q1 − 2009Q4, are reported in Table 1.

In the euro area long-term expectations from point estimates, η, prove to be very well-anchored. They are insensitive to all three considered proxies of individual forecast news (columns 2–4). However, derived measures of long-term expectations, i. e. mean of probability forecasts μ, show responsiveness to changes in observed inflation, short-term news at 1 per cent significance level and medium-term news at 5 per cent significance. The magnitude of the relationship seems rather small, with slope coefficients at 0.1 and below (columns 5–7). Estimates based on long-term inflation uncertainty send some mixed signals. Uncertainty in the long-term does not respond to observed inflation, indicating that shocks to the inflation process are not linked to uncertainty innovations in the long term. However, they are sensitive to both short and medium-term uncertainty innovations (columns 8–10). The magnitude of the link is higher, with slope coefficients at 0.3 and 0.5 per cent correspondingly.

In the US long-term point expectations are anchored to a lesser extent. There is evidence of sensitivity with respect to inflation and short-term news at 1 per cent significance level, and with respect to medium term forecast news at 5 per cent significance (columns 11 to 13). Even though the size of the response reflected in the coefficients is comparable to that of the euro area, there is little dispersion in the relationship resulting in small standard errors of the coefficients, individually clustered for robustness. This indicates that the private sector in the US is vigilantly observing shocks to the inflation process, including possible shocks to its mean, and adjusting their views on its long-term convergence. Large current shocks could potentially induce substantial revisions to the long-term.

Table 1

CHANGES IN INDIVIDUAL LONG-TERM EXPECTATIONS AND UNCERTAINTY AND THEIR RESPONSE TO CHANGES IN CURRENT INFLATION, CORRESPONDING MEASURES OF INDIVIDUAL SHORT- AND MEDIUM-TERM NEWS, 1999Q1 – 2009Q4

Estimated panel regressions:

$$\Delta\pi_{i,t}^{e\ long} = \beta^X X_{i,t} + \Delta\varepsilon^{Xi,t}$$

$\pi^e \in$	Euro	Points	η	Euro	Means	μ	Euro	Uncert.	σ^2	US	Points	η
$X_{i,t} \in$	$\Delta\pi_t$	$\pi_{i,t}^{e\ New\ S}$	$\pi_{i,t}^{e\ New\ M}$	$\Delta\pi_t$	$\pi_{i,t}^{e\ New\ S}$	$\pi_{i,t}^{e\ New\ M}$	$\Delta\pi_t$	$\pi_{i,t}^{e\ New\ S}$	$\pi_{i,t}^{e\ New\ M}$	$\Delta\pi_t$	$\pi_{i,t}^{e\ New\ S}$	$\pi_{i,t}^{e\ New\ M}$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
β^X	**0.02**	**0.03**	**0.06**	**0.04*** **	**0.07*** **	**0.10** **	**-0.01**	**0.28*** **	**0.51*** **	**0.03*** **	**0.05*** **	**0.06** **
	(0.02)	(0.02)	(0.05)	(0.01)	(0.02)	(0.04)	(0.01)	(0.07)	(0.09)	(0.01)	(0.01)	(0.02)
N	1205	1205	1196	1071	1071	1067	1071	1071	1067	1181	1105	780
i	72	72	72	69	69	69	69	69	69	69	69	69
	0.14	0.14	0.14	0.16	0.16	0.16	0.11	0.10	0.09	0.25	0.25	0.26
$F_{(1,i\text{-}1)}$	2.27	1.87	1.59	26.81****	12.62***	6.02**	1.29	17.18***	33.91***	10.22***	10.89***	5.70**

Note: $\pi_{i,t}^{e\ long}$ denotes moments of the distribution of long-term inflation; *X* consists of proxies for individually perceived new information: changes in latest observations of inflation $\Delta\pi$, moments of the distribution of short-term forecast news $\pi^{News\ S}$ and medium-term forecast news $\pi^{News\ M}$; considered moments of the distribution: expectations, η – point estimates and $\hat{\mu}$ – estimated mean of probability forecasts, and standard deviation of probability forecasts $\hat{\sigma}$. Standard errors, reported in parenthesis, are clustered by forecaster ID to correct for possible heteroscedasticity. *** denotes 1 per cent or less significance level, ** 5 per cent or less significance, * 10 per cent or less significance level. Panel consists of all forecasters providing point and probability forecasts in the sample period. *N* – number of observations in each panel; *i* number of individual in each panel; *F* – *F* test statistics.

I further test for the presence of non-linearity in the panels, due to possible seasonal variation in the coefficients. Revisions to the fixed target forecasts reflect current and future innovations to the inflation process, but possibly in a recursive fashion. As the end of the forecast target period nears, there is more information on the event, and innovations should be surrounded by less uncertainty. Therefore I assess the possibility of quarterly time variation, which is reported in Table 2.

The results on anchoring continue to hold. For both the euro area and the US, there is no evidence of non-linearities due to seasonal variation in the relationship between long-term inflation expectations and short-term news (columns 2, 4 and 8). There is also no evidence of seasonal variations in the sensitivity of long-term inflation uncertainty to both short and medium term uncertainty news (columns 6 and 7).

In the US, some evidence is found in support of non-linearities due to seasonal variation with respect to medium-term news at 5 per cent level (column 9). Quarters incorporating information about monetary policy actions in the first quarter of the year, show higher response.

In the euro area point expectations are still altogether insensitive to point medium-term developments, but the first and second quarter coefficients start being significant (column 3). Derived expectations show evidence of seasonality with respect to medium term news at 5 per cent level (column 5). However, the response pattern is not as predicted, since the the first and forth quarters matter most, instead of smoothly declining coefficients from first to fourth quarter.

Table 2

NON-LINEARITIES DUE TO SEASONAL VARIATION: SENSITIVITY OF LONG-TERM INFLATION EXPECTATIONS AND UNCERTAINTY TO FORECAST NEWS, 1999Q1 – 2009Q4

Estimated equations:

$$\Delta\pi_{i,t}^{e\ long} = \beta_X^{q1} Z_{1,i,t} + \beta_X^{q2} Z_{2,i,t} + \beta_X^{q3} Z_{3,i,t} + \beta_X^{q4} Z_{4,i,t} + \Delta\varepsilon_{i,t}^{X}$$

where $Z_{1,i,t} = X_{i,t}$ for t = 1999Q1..2009Q1, and 0 otherwise;

$Z_{2,i,t} = X_{i,t}$ for t = 1999Q2..2009Q2, and 0 otherwise;

$Z_{3,i,t} = X_{i,t}$ for t = 1999Q3..2009Q3, and 0 otherwise.

$Z_{4,i,t} = X_{i,t}$ for t = 1999Q4..2009Q4, and 0 otherwise.

$\pi^e \in$	Euro	η	Euro	μ	Euro	σ	US	η
$X_i \in$	$\pi_t^{e\ New\ S}$	$\pi_{i,t}^{e\ New\ M}$	$\pi_t^{e\ New\ S}$	$\pi_t^{e\ New\ M}$	$\pi_t^{e\ New\ S}$	$\pi_t^{e\ New\ M}$	$\pi_t^{e\ New\ S}$	$\pi_t^{e\ New\ M}$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
β_X^{q1}	**0.06**	**0.22****	**0.08*****	**0.26*****	**0.31*****	**0.45*****	**0.11*****	**0.24*****
	(0.03)	(0.10)	(0.03)	(0.06)	(0.09)	(0.10)	(0.03)	(0.07)
β_X^{q2}	**0.01**	**0.12***	**0.01**	**0.03**	**0.39*****	**0.44*****	**0.03**	**0.07***
	(0.03)	(0.07)	(0.03)	(0.04)	(0.11)	(0.12)	(0.02)	(0.04)
β_X^{q3}	**0.00**	**-0.05**	**0.12*****	**0.02**	**0.18*****	**0.46*****	**0.03**	**0.07****
	(0.03)	(0.06)	(0.04)	(0.08)	(0.07)	(0.10)	(0.02)	(0.03)
β_X^{q4}	**0.01**	**0.03**	**0.12***	**0.11****	**0.25****	**0.66*****	**0.03**	**0.00**
	(0.05)	(0.04)	(0.07)	(0.04)	(0.13)	(0.19)	(0.02)	(0.03)
N	1205	1196	1071	1067	1071	1067	1105	780
i	72	72	69	69	69	69	82	74
	0.14	0.14	0.16	0.16	0.10	0.09	0.25	0.26
$F_{(4,i-1)}$	0.90	1.52	4.06***	6.07***	7.19***	11.04***	3.51***	4.80***
H0 : q1 = q2 =								
=q3 = q4								
$F_{(3,i-1)}$	0.98	1.73	1.23	3.72**	0.77	0.45	1.74	3.81**

Note: $\pi^{e\ long}$ denotes moments of the distribution of long-term inflation; *X* consists of proxies for individually perceived new information: changes in latest observations of inflation $\Delta\pi$, moments of the distribution of short-term forecast news $\pi^{News\ S}$ and medium-term forecast news $\pi^{News\ M}$; considered moments of the distribution: expectations, η – point estimates $\hat{\mu}$ and – estimated mean of probability forecasts, and standard deviation of probability forecasts $\hat{\sigma}$. Standard errors, reported in parenthesis, are clustered by forecaster ID to correct for possible heteroscedasticity. *** denotes 1 per cent or less significance level, ** 5 per cent or less significance, * 10 per cent or less significance level. Panel consists of all forecasters providing point and probability forecasts in the sample period. *N* – number of observations in each panel; *i* – number of individual in each panel; *F* – *F* test statistics.

Table 3

NON-LINEARITIES DUE TO REGIME CHANGES: SENSITIVITY OF LONG-TERM INFLATION EXPECTATIONS AND UNCERTAINTY TO FORECAST NEWS

Estimated panel regressions:

$$\Delta\pi_{i,t}^{e\,long} = \beta_1^X Z_{1,i,t} + \beta_2^X Z_{2,i,t} + \beta_3^X Z_{3,i,t} + \Delta\varepsilon^X_{i,t}$$

where $Z_{1,i,t} = X_{i,t}$ for t = 1991Q1..1998Q4, and 0 otherwise;

$Z_{2,i,t} = X_{i,t}$ for t = 1999Q1..2007Q2, and 0 otherwise;

$Z_{3,i,t}$ = Xi,t for t = 2007Q3..2009Q4, and 0 otherwise.

$\pi^e \in$	Euro	Points	η	Euro	Means	μ	Euro	Uncert.		US	Points	η
$X_{i,t} \in$	$\Delta\pi_t$	$\pi_{i,t}^{e\,New\,S}$	$\pi_{i,t}^{e\,New\,M}$	$\Delta\pi_t$	$\pi_{i,t}^{e\,New\,S}$	$\pi_{i,t}^{e\,New\,M}$	$\Delta\pi_t$	$\pi_{i,t}^{e\,New\,S}$	$\pi_{i,t}^{e\,New\,M}$	$\Delta\pi_t$	$\pi_{i,t}^{e\,New\,S}$	$\pi_{i,t}^{e\,New\,M}$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
β_1^x										**0.04*****	**0.32*****	**0.21*****
										(0.05)	(0.06)	(0.05)
β_2^x	**0.00**	**-0.01**	**0.09****	**0.05*****	**0.10**	**0.20*****	**0.00**	**0.20*****	**0.47*****	**0.03****	**0.06*****	**0.10*****
	(0.02)	(0.03)	(0.04)	(0.02)	(0.06)	(0.06)	(0.01)	(0.06)	(0.09)	(0.01)	(0.02)	(0.02)
β_3^x	**0.03**[1]	**0.05**[1]	**0.05**	**0.04*****	**0.06*****	**0.05**	**-0.01**[1]	**0.43*****	**0.56*****	**0.04*****	**0.04***	**0.03**
	(0.02)	(0.03)	(0.07)	(0.01)	(0.02)	(0.05)	(0.01)	(0.15)	(0.15)	(0.01)	(0.02)	(0.04)
N	1205	1205	1196	1071	1071	1067	1071	1071	1067	1926	1802	1242
i	72	72	72	69	69	69	69	69	69	126	124	116
	0.14	0.14	0.14	0.16	0.16	0.16	0.11	0.10	0.09	0.30	0.30	0.30
$F_{(1/2,i-1)}$	1.31	1.32	2.63	13.73***	8.24***	5.80***	1.32	10.03***	19.88***	5.92***	12.14***	10.93***
H0 : $\beta_2^x = \beta_3^x$ $F_{(1,i-1)}$	1.56	1.88	0.29	0.48	0.31	3.10*	0.15	2.22	0.29	0.12	0.39	2.29
H0 : $\beta_1^x = \beta_2^x$ $F_{(1,i-1)}$										4.66**	21.59***	4.16**
H0 : $\beta_1^x = \beta_3^x$ $F_{(1,i-1)}$										3.78**	22.54***	9.55***

Note: $\pi^{e\,long}$ denotes moments of the distribution of long-term inflation; *X* consists of proxies for individually perceived new information: changes in latest observations of inflation $\Delta\pi$, moments of the distribution of short-term forecast news $\pi^{News\,S}$ and medium-term forecast news $\pi^{News\,M}$; considered moments of the distribution: expectations, η – point estimates and $\hat{\mu}$ – estimated mean of probability forecasts, and standard deviation of probability forecasts $\hat{\sigma}$. Standard errors, reported in parenthesis, are clustered by forecaster ID to correct for possible heteroscedasticity. *** denotes 1 per cent or less significance level, ** 5 per cent or less significance, * 10 per cent or less significance level, [1] significance at 11 per cent. Panel consists of all forecasters providing point and probability forecasts in the sample period. *N* – number of observations in each panel; *i* – number of individual in each panel; *F* – *F* test statistics.

Further, I test for the presence of panel non-linearities due to regime changes. The anchoring (stability) of long-term inflation expectations is a matter of degree which can change over time (Bernanke, 2007). Monetary policy and confidence in its ability to control inflation could impact the beliefs of the private sector as to which of the observed innovations to the inflation process are transitory and which of them are likely to carry over into the future. Periods characterised with relatively large external shocks, such as the recent financial markets turmoil, might undermine the confidence in the transmission mechanism and the abilities of monetary policy. Therefore, I test the anchoring of long-term expectations allowing for non-linearities in the relationship.

The periods considered are: before 1998 for the US, a relatively calm period of moderate shocks and confidence in the monetary transmission from 1999Q1 to 2007Q2, and the financial markets turmoil period after 2007Q3. Table 3 reports on the results.

Point expectations in the euro area remain well-anchored with respect to observed shocks to inflation and short-term forecast news. This is evident from the joint insignificance of the panel response coefficients before and during the financial markets turmoil. During the latter period, there is slightly higher sensitivity to the short-term, but only at 11 per cent significance level. The non-linear panel uncovers some sensitivity to medium-term forecast news at 10 per cent significance. This shows learning on the side of the private sector from monetary policy actions and other forecastable transmission factors. The learning is significant at 5 per cent level only before the financial turmoil, while it becomes insignificant afterwards. The $F-test$ statistics shows no evidence for significant difference between the anchoring in the two regimes (columns 3–4).

Derived measures of long-term expectations in the euro area continue to show sensitivity with respect to all proxies of news (columns 5–7). However, during the financial markets turmoil the response declines. While before the turmoil the long-term was significantly affected by medium-term forecast news, i.e. revisions to expected monetary transmission, during the turmoil that response becomes insignificant. In this case, the hypothesis of equal response before and after the turmoil can be rejected at 10 per cent confidence level.

Long-term inflation uncertainty remains insensitive to observed inflation but influenced by forecast news on uncertainty at shorter horizons (columns 8–10). The financial markets turmoil increases the magnitude of that sensitivity, but not significantly. There is slight negative response to observed inflation during the turmoil, significant at only 11 per cent level. This might be due to mostly negative innovations to observed inflation during the turmoil, lack of deflationary episodes in the history of the euro area before, and general increase in uncertainty at all horizons.

In the case of the US, there is a longer-track record during which to follow the stability of long-term expectations (columns 11 to 13). During the 90s, a significantly high proportion of shocks to the current-, short- and medium-term were carried over to the long-term. Judging by the response coefficients, forecast revisions to the short-term mattered most. This was followed by a moderate period, during which long-term inflation expectations were sensitive to the three measures of news, but at significantly lower rate. The financial markets turmoil marked a slight reduction in response coefficients to short- and medium-term news, with the long-term almost being unaffected by the latter. This could be caused by disagreement about the likely future transmission of large shocks observed during the turmoil, as well as undermined confidence in the ability of monetary policy to offset them. The degrees of anchoring during the turmoil and the preceding period significantly differ from that in the 90s, but not from each other.[2]

5. Non-linearities in the common evolution of individual long-term inflation expectations, uncertainty and inflation

In the estimation I utilise information from the most regular respondents, who have supplied reports on their long-term inflation forecasts in more that 80 per cent of the survey rounds during the period 1999Q1 – 2009Q4. This is necessary in order to minimise the noise from including missing observations. This results in a panel of 15 individuals for euro area's point expectations, 12 for euro areas's probability forecasts and 12 for the US.

The estimation results on the underlying trends at individual level are reported in Table 4. I estimate two types of models: one which identifies common non-linear trend dynamics underlying the individual long-term moments of the distribution, and one which additionally includes currently observed inflation.

In the case of euro area expectations, both points and means of the probability forecasts, I manage to identify common trend, shared not only amongst individual forecasts, but also by actual inflation observations (columns 2–9). All parameters are significant, and rather close by, under both types of models.

[2]The results in this section are robust to other possible periodic divisions as well as the inclusion of additional variables, such as output growth gaps.

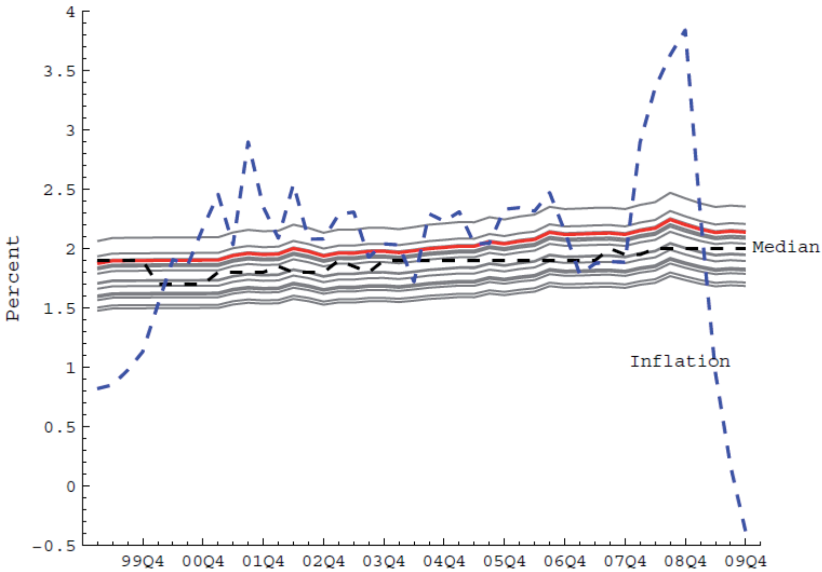
There is marked heterogeneity in the level of trend dynamics, which is comparable to the outer bounds of the cross-sectional distribution, from 5th to 95th percentiles, rather than its inner center, mostly monitored by policy makers. Figure 3 illustrates the case of point expectations.

Most forecasters' beliefs in the euro area possess stabilisation bias, in the sense that their individual trend levels lie below that of inflation. This means that at each point of time, large proportion of forecasters believe that inflation is bound to converge to lower level than its time-varying sample mean indicates, which points towards high confidence in monetary policy.

Figure 3

UNDERLYING TRENDS IN INDIVIDUAL LONG-TERM INFLATION EXPECTATIONS, MEDIAN EXPECTATIONS AND INFLATION IN THE EURO AREA

(Trend inflation represented by red line. Illustrates the case of point expectations.)



Within the model, level heterogeneity is quantified by the individual parameters $\beta_{0,i}$. In the case of point expectations, only one of the 15 regular forecasters exceeds the level of trend inflation and only 3 coincide with it. The stabilisation bias is time-variant and increases with the trend level. Similarly, for expectations estimated as means of the probability forecast distribution, with 13 regular forecasters only 2 exceed the trend inflation level and only one coincides with it. Each individual bias is also time-varying and increases with the inflation trend.

Table 4

PARAMETER ESTIMATES OF MODELS OF UNOBSERVED STOCHASTIC TREND UNDERLYING THE COMMON DYNAMICS OF INFLATION, AND INDIVIDUAL LONG-TERM EXPECTATIONS AND UNCERTAINTY IN THE EURO AREA AND THE US, 1999Q1 – 2009Q4

Estimated structural model:

$$y_{i,t} = \beta_{0,i} x_t + u_{i,t}$$

$$x_t = x_{t-1} + \nu_t$$

$y_{i,t} \in \{\pi_{i,t}^{long}\}'$ for Model 1 (columns 2–3, 6–7 10–11 and 12–13)

or $y_{i,t} \in \{\pi_{t-1} \pi_{i,t}^{long}\}'$ for Model 2 (columns 4–5 and 8–9)

π^e	∈Euro	η			Euro	μ			Euro	σ^2	US	η
i	$\beta_{0,i}$		$\beta_{0,i}$		$\beta_{0,i}$		$\beta_{0,i}$		$\beta_{0,i}$			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1	**0.128**	(0.010)	**0.127**	(0.010)	**0.141**	(0.012)	**0.140**	(0.012)	**0.109**	(0.011)	**0.234**	(0.019)
2	**0.135**	(0.011)	**0.135**	(0.011)	**0.161**	(0.013)	**0.160**	(0.013)	**0.230**	(0.023)	**0.277**	(0.022)
3	**0.163**	(0.014)	**0.162**	(0.014)	**0.168**	(0.014)	**0.168**	(0.014)	**0.112**	(0.012)	**0.182**	(0.015)
4	**0.158**	(0.013)	**0.157**	(0.013)	**0.152**	(0.013)	**0.152**	(0.013)	**0.135**	(0.014)	**0.199**	(0.016)
5	**0.147**	(0.012)	**0.147**	(0.012)	**0.185**	(0.016)	**0.184**	(0.016)	**0.087**	(0.009)	**0.189**	(0.015)
6	**0.178**	(0.015)	**0.178**	(0.015)	**0.173**	(0.014)	**0.172**	(0.014)	**0.072**	(0.008)	**0.192**	(0.015)
7	**0.167**	(0.014)	**0.167**	(0.014)	**0.139**	(0.011)	**0.138**	(0.011)	**0.065**	(0.007)	**0.196**	(0.016)
8	**0.144**	(0.012)	**0.143**	(0.012)	**0.143**	(0.012)	**0.143**	(0.012)	**0.103**	(0.011)	**0.211**	(0.017)
9	**0.130**	(0.010)	**0.130**	(0.010)	**0.169**	(0.014)	**0.169**	(0.014)	**0.134**	(0.014)	**0.143**	(0.012)
10	**0.139**	(0.011)	**0.138**	(0.011)	**0.169**	(0.014)	**0.169**	(0.014)	**0.074**	(0.009)	**0.210**	(0.017)
11	**0.148**	(0.012)	**0.147**	(0.012)	**0.172**	(0.014)	**0.171**	(0.014)	**0.082**	(0.010)	**0.197**	(0.016)
12	**0.155**	(0.013)	**0.154**	(0.013)	**0.165**	(0.014)	**0.165**	(0.014)	**0.131**	(0.014)	**0.223**	(0.018)
13	**0.159**	(0.013)	**0.159**	(0.013)	**0.142**	(0.012)	**0.142**	(0.012)	**0.167**	(0.017)		
14	**0.162**	(0.014)	**0.162**	(0.014)								
15	**0.137**	(0.011)	**0.137**	(0.011)								
π			**0.162**	(0.016)			**0.171**	(0.017)				
ι	$\gamma_{\iota,\iota}$		$\gamma_{\iota,\iota}$		$\gamma_{\iota,\iota}$		$\gamma_{\iota,\iota}$		$\gamma_{\iota,\iota}$			
1	0.085	(0.010)	0.084	(0.010)	0.107	(0.013)	0.106	(0.013)	0.185	(0.022)	0.317	(0.035)
2	0.129	(0.015)	0.130	(0.015)	0.159	(0.019)	0.158	(0.019)	0.394	(0.049)	0.356	(0.039)
3	0.303	(0.033)	0.304	(0.033)	0.261	(0.029)	0.263	(0.029)	0.290	(0.033)	0.052	(0.016)
4	0.289	(0.032)	0.290	(0.032)	0.126	(0.015)	0.124	(0.015)	0.453	(0.050)	0.173	(0.020)
5	0.113	(0.014)	0.114	(0.014)	0.292	(0.032)	0.293	(0.032)	0.342	(0.037)	0.244	(0.028)
6	0.329	(0.036)	0.330	(0.036)	0.125	(0.016)	0.128	(0.017)	0.233	(0.026)	0.191	(0.023)
7	0.206	(0.023)	0.207	(0.023)	0.104	(0.013)	0.105	(0.013)	0.077	(0.011)	0.229	(0.027)
8	0.205	(0.022)	0.205	(0.022)	0.145	(0.017)	0.145	(0.017)	0.231	(0.026)	0.206	(0.024)
9	0.071	(0.009)	0.070	(0.009)	0.148	(0.018)	0.146	(0.018)	0.219	(0.027)	0.174	(0.020)
10	0.103	(0.012)	0.103	(0.012)	0.233	(0.026)	0.233	(0.026)	0.414	(0.045)	0.191	(0.023)
11	0.067	(0.010)	0.066	(0.010)	0.204	(0.023)	0.204	(0.023)	0.507	(0.055)	0.231	(0.026)
12	0.196	(0.022)	0.197	(0.022)	0.339	(0.037)	0.338	(0.037)	0.342	(0.039)	0.307	(0.035)
13	0.217	(0.024)	0.217	(0.024)	0.103	(0.013)	0.103	(0.013)	0.370	(0.043)		
14	0.327	(0.036)	0.327	(0.036)								
15	0.077	(0.010)	0.076	(0.010)								
π			0.755	(0.081)			0.752	(0.081)				
LL	**19.106**		**18.886**		**15.718**		**15.5**		**9.2709**		**11.803**	

Note: $y_{i,t}$ is a vector of observable timeseries consisting of the moments of the distribution of long-term inflation – $\pi_{i,t}^{long}$ and inflation; η stands for point expectations, μ – for means of the probability forecast distributions, σ^2 – for standard deviation of the probability forecast distribution; π_{t-1} observed inflation rate at time *t;* $\beta_{0,i}$ is a vector of estimated parameters; *x* estimated unobserved stochastic unit root trend; $u_{i,t}$ assumed to be identically normally distributed (iid) errors; ν_t – normally distributed iid errors with variance 1; γ_{ii} estimates of the variances of the shocks to the observed series; LL – model log-likelihood; parameters are estimated through a Kalman Filter maximin likelihood procedure by the inverse of the computed Hessian. Standard errors are reported in parenthesis. Time-series dimension – 44 observations.

Table 5

PARAMETER ESTIMATES OF MODELS OF UNOBSERVED STOCHASTIC TREND UNDERLYING THE COMMON DYNAMICS OF INFLATION, AND MEDIAN LONG-TERM EXPECTATIONS AND UNCERTAINTY IN THE EURO AREA AND THE US, 1999Q1 – 2009Q4

Estimated structural model:

$$y_t = \beta_{0,i} x_t + u_t$$
$$x_t = x_{t-1} + \nu_t$$
$$y_t \in \{\pi_{i,t}^{long} \pi_{t-1}\}'$$

$\pi_{i,t}^{long} \in$	Euro	η	Euro	μ	Euro	σ	US	η
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
β_π	0.239	(0.025)	0.164	(0.015)	0.168	(0.016)	0.206	(0.022)
β_π^{long}	0.218	(0.021)	0.151	(0.012)	0.127	(0.010)	0.201	(0.015)
$\gamma_{\pi,\pi}$	0.115	(0.053)	0.025	(0.036)	0.104	(0.031)	0.000	(0.048)
$\gamma_{\pi long, \pi}$	-0.659	(0.090)	-0.717	(0.086)	-0.672	(0.081)	-1.266	(0.157)
$\gamma_{\pi long, \pi long}$	0.000	(0.300)	0.000	(0.426)	0.000	(0.322)	0.023	(2.981)
LL	**0.931**		**1.496**		**1.400**		**0.687**	

Note: $y_{i,t}$ is a vector of observable time-series consisting of the moments of the aggregate distribution of long-term inflation – $\pi_{i,t}^{long}$ and inflation; η stands for point expectations, μ – for means of the probability forecast distributions, σ^2 – for standard deviation of the probability forecast distribution; π_{t-1} observed inflation rate at time *t;* β_0 is a vector of estimated parameters; *x* estimated unobserved stochastic unit root process; γ variances and covariances of the shocks to the observed series; *LL* – model log-likelihood; parameters are estimated through a Kalman Filter maximin likelihood procedure by the inverse of the computed Hessian. Standard errors are reported in parenthesis.

The median of the non-parametric cross-sectional distribution of long-term expectations is quite rigid in following underlying developments. On one hand, this confirms the good anchoring results from the sensitivity analysis, but at the same time warrants caution in its usefulness for monitoring purposes. The means of the distribution show more flexibility and alignment with underlying trends.

The results at individual level are further confirmed at aggregate level. I estimate the trend, underlying the joint dynamics of inflation and median expectations, often used by researchers to represent aggregate expectations (see Table 5, columns 2–5). The estimated trend expectations follow the dynamics of median expectations but more flexibly. There is almost a half percentage point stabilisation bias in long-term trend expectations compared to trend inflation (see Figure 4). The bias is time-variant, but at times almost nears half a percentage point.

For the euro area I also uncover the joint non-linear model underlying individual uncertainty, the second moment of long-term inflation distribution (see columns 10–11 of Table). The individual dynamics is more heterogeneous in terms of level, compared to that of the first moments. It is also rather closely matched with the percentiles of the non-parametric cross-sectional distribution, which prove to be relatively good in indicating underlying developments. There is a pronounced increase in trend uncertainty ever since the first signs of the start of the financial markets turmoil in 2007Q2. The model failed to uncover a common trend between individual long-term uncertainty and inflation, which confirms results from sensitivity analysis in the previous section.

During the same period, the US individual long-term inflation expectations are characterised by a non-linear dynamics underlined by only a barely noticeable trend, which is not shared by observed inflation (see Table 4, columns 12–13). The dispersion in the level of the trend is more substantial than in the euro area, more than one percent (see Figure 5). That could be due to a higher range of inflation realisations in the US during the period, or monetary policy communication. The latter could be due to unwillingness of the Fed to quantify and communicate its inflation objective, or a mistrust in the accuracy of this particular measure of inflation, the CPI, as opposed to the PCE. Similarly to euro area's expectations, here too, the outer percentiles of the distribution most correctly indicate the level heterogeneity in individual trends.

Figure 4

COMMON UNDERLYING TRENDS IN INFLATION AND MEDIAN LONG-TERM EXPECTATIONS OF INFLATION IN THE EURO AREA

(Illustrates the case of point expectations.)

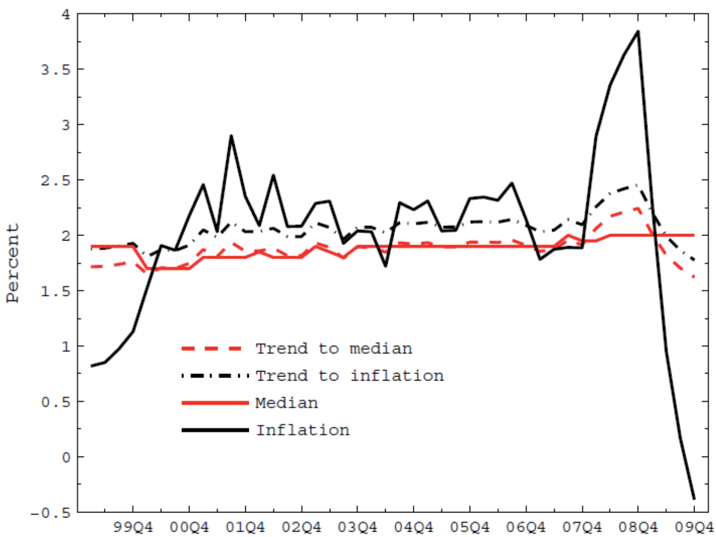
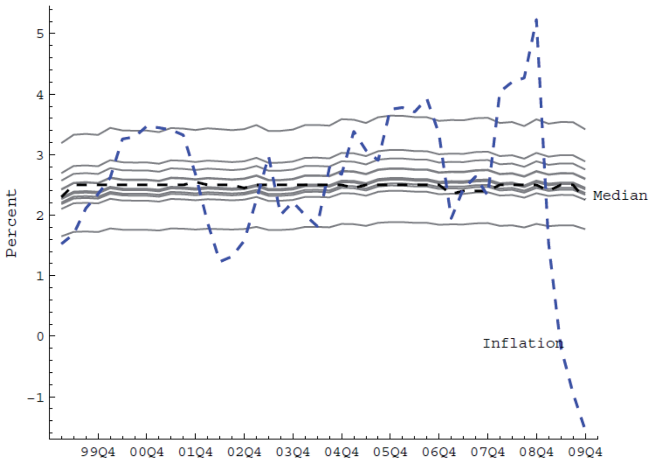


Figure 5

UNDERLYING TRENDS IN INFLATION AND MEDIAN LONG-TERM EXPECTATIONS OF INFLATION IN THE US, 1999Q1 – 2009Q4



At aggregate level, estimations again fail to find common underlying trend between inflation and median long-term inflation expectations. It seems that in the studied period, the mean of inflation process is stationary, it almost perfectly coincides with median long-term inflation expectations and there is no stabilisation bias. Apparently due to previous convergence and active learning on the side of the private sector, long-term expectations are fully aligned with shocks to the inflation process. The underlying process is stationary. Although there might be persistent individual biases with respect to the mean of the inflation process, on aggregate they balance each other.

6. Conclusion

This paper analyses direct evidence on long-term inflation beliefs from the professional forecasters in the euro area and the US, with a view to assessing the anchoring of long-term inflation expectations, as well as further moments of the distribution.

The findings suggest relatively well-anchored expectations. In terms of sensitivity to innovations and news, point expectations in the Euro area are perfectly anchored. Although there is presence of non-stationary common process underlying individual ex-ante expectations and ex-post inflation realisations, most forecasters project the ex-ante long-term considerably below trend inflation, a phenomenon documented and named here as collective stabilisation bias. Long-term uncertainty proved unrelated to both level and changes in the inflation process. No evidence was found for a regime change after the onset of the financial markets crisis. All this provides monetary policy makers in the euro area with a safety margin inspiring less activism during periods of stronger inflationary pressures and high inflation uncertainty in the long-term.

In the US there is higher sensitivity to the shorter term, which has diminished significantly after 1999, and probably lead to the observed stationarity in the underlying inflationary process and absence of collective bias. No significant change is found in the structurally modelled inflationary process or sensitivity to short-term transitory shocks during the financial markets crisis, demonstrating remarkable resilience.

Looking forward, there is a strong case for further monitoring the state of long-term expectations and further moments, as monetary policy makers start unwinding their non-standard and non-conventional monetary stimulus measures. In the case of the euro area, where some non-stationarity is observed, measures of long-term expectations derived from the probability forecasts can and should be used to give earlier warning to policy makers, due to their revealed property of showing more sensitivity and alignment with unobserved trend inflation.

References

Bernanke, Ben (2007) "Inflation Expectations and Inflation Forecasting", speech delivered at the Monetary Economics Workshop of the National Bureau of Economic Research Summer Institute, Cambridge, Massachusetts, 10 July 2007.

Boero, Gianna, Jeremy Smith and Kenneth Wallis (2008) "Here is the News: Forecast Revisions in the Bank of England Survey of External Forecasters", National Institute Economic Review, No. 203, pp. 68–77.

Chang, Yoosoon, J. Isaac Miller and Joon Y. Park (2009) "Extracting a Common Stochastic Trend: Theory with Some Applications", Journal of Econometrics 150 (2009), pp. 231–247

D'Amico, Stefania and Athanasios Orphanides, (2006) " Uncertainty and Disagreement in Economic Forecasting", mimeo, Board of Governors of the Federal Reserve System, March 2006.

Friedman, Milton (1968) "The Role of Monetary Policy", Americal Economic Association Papers and Proceedings, 58(1), March, pp. 1–17.

Giordani, Paolo, and Paul Söderlind (2003) "Inflation Forecast Uncertainty", European Economic Review, 47, pp. 1037–1059.

Orphanides, Athanasios and John Williams (2005) "Inflation Scares and Forecast-based Monetary Policy", Review of Economic Dynamics, 2005, 2 April, pp. 498–527.

Orphanides, Athanasios and John Williams (2007) "Robust Monetary Policy with Imperfect Knowledge", Journal of Monetary Economics, 2007, 54(5) July, pp. 1406–1435.

Kim, C. J. and C. R. Nelson (1999) "State-space Models with Regime Switching", MIT Press.

Mankiw, N. Gregory, Ricardo Reis and Justin Wolfers (2003) "Disagreement about Inflation Expectations", NBER Working Paper No. 9796, June.

Mynsky, Hyman (1986) "Stabilizing an Unstable Economy", New Haven, Yale Univerity Press.

Rich, Robert and Joseph Tracy (2010) "The Relationships among Expected Inflation, Disagreement, and Uncertainty: Evidence from Matched Point and Density Forecasts", Review of Economics and Statistics, February, 92(1): pp. 200–207.

Tetlow, Robert J. (2008) "Inflation Targeting and Target Instability", International Journal of Central Banking, December 2008.

Wallis, Kenneth (2003) "Chi-squared tests of interval and density forecasts, and the Bank of England's fan charts", International Journal of Forecasting, 19, 165–175

Zarnowitz, Victor and Louis A. Lambros (1987) Consensus and Uncertainty in Economic Prediction", Journal of Political Economy, 95, pp. 591–621.

DISCUSSION PAPERS

DP/1/1998 The First Year of the Currency Board in Bulgaria
Victor Yotzov, Nikolay Nenovsky, Kalin Hristov, Iva Petrova, Boris Petrov

DP/2/1998 Financial Repression and Credit Rationing under Currency Board Arrangement for Bulgaria
Nikolay Nenovsky, Kalin Hristov

DP/3/1999 Investment Incentives in Bulgaria: Assessment of the Net Tax Effect on the State Budget
Dobrislav Dobrev, Boyko Tzenov, Peter Dobrev, John Ayerst

DP/4/1999 Two Approaches to Fixed Exchange Rate Crises
Nikolay Nenovsky, Kalin Hristov, Boris Petrov

DP/5/1999 Monetary Sector Modeling in Bulgaria, 1913–1945
Nikolay Nenovsky, Boris Petrov

DP/6/1999 The Role of a Currency Board in Financial Crises: The Case of Bulgaria
Roumen Avramov

DP/7/1999 The Bulgarian Financial Crisis of 1996–1997
Zdravko Balyozov

DP/8/1999 The Economic Philosophy of Friedrich Hayek (The Centenary of his Birth)
Nikolay Nenovsky

DP/9/1999 The Currency Board in Bulgaria: Design, Peculiarities and Management of Foreign Exchange Cover
Dobrislav Dobrev

DP/10/1999 Monetary Regimes and the Real Economy (Empirical Tests before and after the Introduction of the Currency Board in Bulgaria)
Nikolay Nenovsky, Kalin Hristov

DP/11/1999 The Currency Board in Bulgaria: The First Two Years
Jeffrey B. Miller

DP/12/2000 Fundamentals in Bulgarian Brady Bonds: Price Dynamics
Nina Budina, Tzvetan Manchev

DP/13/2000 Currency Circulation after Currency Board Introduction in Bulgaria (Transactions Demand, Hoarding, Shadow Economy)
Nikolay Nenovsky, Kalin Hristov

DP/14/2000 Macroeconomic Models of the International Monetary Fund and the World Bank (Analysis of Theoretical Approaches and Evaluation of Their Effective Implementation in Bulgaria)
Victor Yotzov

DP/15/2000 Bank Reserve Dynamics under Currency Board Arrangement for Bulgaria
Boris Petrov

DP/16/2000	A Possible Approach to Simulate Macroeconomic Development of Bulgaria Victor Yotzov
DP/17/2001	Banking Supervision on Consolidated Basis *(in Bulgarian only)* Margarita Prandzheva
DP/18/2001	Real Wage Rigidity and the Monetary Regime Choice Nikolay Nenovsky, Darina Koleva
DP/19/2001	The Financial System in the Bulgarian Economy Jeffrey Miller, Stefan Petranov
DP/20/2002	Forecasting Inflation via Electronic Markets Results from a Prototype Experiment Michael Berlemann
DP/21/2002	Corporate Image of Commercial Banks (1996–1997) *(in Bulgarian only)* Miroslav Nedelchev
DP/22/2002	Fundamental Equilibrium Exchange Rates and Currency Boards: Evidence from Argentina and Estonia in the 90's Kalin Hristov
DP/23/2002	Credit Activity of Commercial Banks and Rationing in the Credit Market in Bulgaria *(in Bulgarian only)* Kalin Hristov, Mihail Mihailov
DP/24/2002	Balassa – Samuelson Effect in Bulgaria *(in Bulgarian only)* Georgi Choukalev
DP/25/2002	Money and Monetary Obligations: Nature, Stipulation, Fulfilment Stanislav Natzev, Nachko Staykov, Filko Rosov
DP/26/2002	Regarding the Unilateral Euroization of Bulgaria Ivan Kostov, Jana Kostova
DP/27/2002	Shadowing the Euro: Bulgaria's Monetary Policy Five Years on Martin Zaimov, Kalin Hristov
DP/28/2002	Improving Monetary Theory in Post-communist Countries – Looking Back to Cantillon Nikolay Nenovsky
DP/29/2003	Dual Inflation under the Currency Board: The Challenges of Bulgarian EU Accession *(in Bulgarian only)* Nikolay Nenovsky, Kalina Dimitrova
DP/30/2003	Exchange Rate Arrangements, Economic Policy and Inflation: Empirical Evidence for Latin America Andreas Freytag
DP/31/2003	Inflation and the Bulgarian Currency Board Stacie Beck, Jeffrey B. Miller, Mohsen Saad

DP/32/2003	**Banks – Firms Nexus under the Currency Board: Empirical Evidence from Bulgaria** Nikolay Nenovsky, Evgeni Peev, Todor Yalamov
DP/33/2003	**Modelling Inflation in Bulgaria: Markup Model *(in Bulgarian only)*** Kalin Hristov, Mihail Mihailov
DP/34/2003	**Competitiveness of the Bulgarian Economy** Konstantin Pashev
DP/35/2003	**Exploring the Currency Board Mechanics: a Basic Formal Model** Jean-Baptiste Desquilbet, Nikolay Nenovsky
DP/36/2003	**A Composite Tendency Indicator for Bulgaria's Industry *(in Bulgarian only)*** Tsvetan Tsalinsky
DP/37/2003	**The Demand for Euro Cash: A Theoretical Model and Monetary Policy Implications** Franz Seitz
DP/38/2004	**Credibility Level of the Bulgarian Exchange Rate Regime, 1991–2003: First Attempt at Calibration *(in Bulgarian only)*** Georgi Ganev
DP/39/2004	**Credibility and Adjustment: Gold Standards Versus Currency Boards** Jean-Baptiste Desquilbet, Nikolay Nenovsky
DP/40/2004	**The Currency Board: "The only game in town" *(in Bulgarian only)*** Kalin Hristov
DP/41/2004	**The Relationship between Real Convergence and the Real Exchange Rate: the Case of Bulgaria** Mariella Nenova
DP/42/2004	**Effective Taxation of Labor, Capital and Consumption in Bulgaria *(in Bulgarian only)*** Plamen Kaloyanchev
DP/43/2004	**The 1911 Balance of Payments of the Kingdom of Bulgaria *(in Bulgarian only)*** Martin Ivanov
DP/44/2004	**Beliefs about Exchange Rate Stability: Survey Evidence from the Currency Board in Bulgaria** Neven T. Valev, John A. Carlson
DP/45/2005	**Opportunities of Designing and Using the Money Circulation Balance *(in Bulgarian only)*** Metodi Hristov
DP/46/2005	**The Microeconomic Impact of Financial Crises: The Case of Bulgaria** Jonathon Adams-Kane, Jamus Jerome Lim

DP/47/2005 Interest Rate Spreads of Commercial Banks in Bulgaria *(in Bulgarian only)*
Mihail Mihailov

DP/48/2005 Total Factor Productivity Measurement: Accounting of Economic Growth in Bulgaria *(in Bulgarian only)*
Kaloyan Ganev

DP/49/2005 An Attempt at Measurement of Core Inflation in Bulgaria *(in Bulgarian only)*
Kalina Dimitrova

DP/50/2005 Economic and Monetary Union on the Horizon
Dr Tsvetan Manchev, Mincho Karavastev

DP/51/2005 The Brady Story of Bulgaria *(in Bulgarian only)*
Garabed Minassian

DP/52/2005 General Equilibrium View on the Trade Balance Dynamics in Bulgaria
Hristo Valev

DP/53/2006 The Balkan Railways, International Capital and Banking from the End of the 19th Century until the Outbreak of the First World War
Peter Hertner

DP/54/2006 Bulgarian National Income between 1892 and 1924
Martin Ivanov

DP/55/2006 The Role of Securities Investor Compensation Schemes for the Development of the Capital Market *(in Bulgarian only)*
Mileti Mladenov, Irina Kazandzhieva

DP/56/2006 The Optimal Monetary Policy under Conditions of Indefiniteness *(in Bulgarian only)*
Nedyalka Dimitrova

DP/57/2007 Two Approaches to Estimating the Potential Output of Bulgaria
Tsvetan Tsalinski

DP/58/2007 Informal Sources of Credit and the "Soft" Information Market (Evidence from Sofia)
Luc Tardieu

DP/59/2007 Do Common Currencies Reduce Exchange Rate Pass-through? Implications for Bulgaria's Currency Board
Slavi T. Slavov

DP/60/2007 The Bulgarian Economy on Its Way to the EMU: Economic Policy Results from a Small-scale Dynamic Stochastic General Equilibrium Framework
Jochen Blessing

DP/61/2007 Exchange Rate Control in Bulgaria in the Interwar Period: History and Theoretical Reflections
Nikolay Nenovsky, Kalina Dimitrova

DP/62/2007 Different Methodologies for National Income Accounting in Central and Eastern European Countries, 1950–1990
Rossitsa Rangelova

DP/63/2008 A Small Open Economy Model with a Currency Board Feature: the Case of Bulgaria
Iordan Iordanov, Andrey Vassilev

DP/64/2008 Potential Output Estimation Using Penalized Splines: the Case of Bulgaria
Mohamad Khaled

DP/65/2008 Bank Lending and Asset Prices: Evidence from Bulgaria
Michael Frömmel, Kristina Karagyozova

DP/66/2008 Views from the Trenches: Interviewing Bank Officials in the Midst of a Credit Boom
Neven Valev

DP/67/2008 Monetary Policy Transmission: Old Evidence and Some New Facts from Bulgaria
Alexandru Minea, Christophe Rault

DP/68/2008 The Banking Sector and the Great Depression in Bulgaria, 1924–1938: Interlocking and Financial Sector Profitability
Kiril Danailov Kossev

DP/69/2008 The Labour Market and Output in the UK – Does Okun's Law Still Stand?
Boris Petkov

DP/70/2008 Empirical Analisys of Inflation Persistence and Price Dynamics in Bulgaria
Zornitsa Vladova, Svilen Pachedjiev

DP/71/2009 Testing the Weak-form Efficiency of the Bulgarian Stock Market
Nikolay Angelov

DP/72/2009 Financial Development and Economic Growth In Bulgaria (1991–2006). An Econometric Analysis Based on the Logic of the Production Function)
Statty Stattev

DP/73/2009 Autonomy vs. Stability: the Relationship between Internal and External Money in Bulgaria (1879–1912)
Luca Fantacci

DP/74/2009 The Size of the Shadow Economy in Bulgaria: A Measurement Using the Monetary Method
Hildegart Ahumada, Facundo Alvarado, Alfredo Canavese, Nicolàs Grosman

DP/75/2009 Efficiency of commercial banks in Bulgaria in the wake of EU accession
Kiril Tochkov, Nikolay Nenovsky

DP/76/2009 Structural Current Account Imbalances: Fixed Versus Flexible Exchange Rates?
Slavi T. Slavov

DP/77/2009 Econometric Forecasting of Bulgaria's Export and Import Flows
Grigor Stoevsky

DP/78/2009 Explanations for the Real Exchange Rate Development in the New EU Member States in Transition
Galina Boeva

DP/79/2009 The Great Depression in the Eyes of Bulgaria's Inter-war Economists (How History of Economic Thought Could Matter for Today's Policy Advice)
Stefan Kolev

DP/80/2010 Modeling Interest Rates on Corporate Loans in Bulgaria *(in Bulgarian only)*
Mihail Mihailov

DP/81/2010 A Small Open Economy Model with Financial Accelerator for Bulgaria: The Role of Fiscal Policy and the Currency Board
Ivan Lozev

DP/82/2010 The Impact of the Global Economic Crisis on Bulgaria's Accession to the Euro Area *(in Bulgarian only)*
Tsvetelina Marinova