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## Formation of inflation expectations in turbulent times: Can ECB manage inflation expectations of professional forecasters?

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**Formation of inflation expectations  
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Bank of Finland Research  
Discussion Paper  
13 • 2017

# Formation of inflation expectations in turbulent times

## Can ECB manage inflation expectations of professional forecasters?<sup>†</sup>

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### Abstract

*This paper studies the formation of inflation expectations in the euro area. We first analyse the forecast accuracy of ECB inflation projections relative to private sector forecasts. Then, using the ECB Survey of Professional Forecasters (ECB SPF), we estimate a general model integrating two theoretical concepts: the hybrid model of expectations, including rational and static expectations, and the sticky-information (epidemiological) model. When modelling inflation expectations we consider – except for backward-looking factors – the rational expectations assumption and the effects of ECB communication. More specifically, we examine whether ECB inflation projections are still important in expectations' formation once the impact of forward-lookingness of economic agents has been taken into account. We also derive implicit (perceived) inflation targets and assess their consistency with the official ECB inflation target.*

*Our analysis indicates that the recent turbulent times have contributed to changes in expectations' formation in the euro area, as the importance of backward-looking mechanisms has decreased, while the importance of the perceived inflation target has increased. We also find that the perceived inflation target has remained broadly consistent with the official ECB inflation target in the medium-term. However, the downward trend of the perceived target suggests some risks of de-anchoring of inflation expectations. The importance of ECB inflation projections for medium-term private sector inflation expectations has increased over time, but the magnitude of this effect is rather small. However, SPF inflation forecasts remain consistent with ECB communication, being either close to ECB projections or between ECB projections and the inflation target.*

**JEL:** D84, E52, E58.

**Keywords:** Formation of inflation expectations, survey data, euro area, financial crisis, low inflation

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## 1. Introduction

Management of inflation expectation plays a central role in monetary policy, since expectations are important determinants of actual inflation and their formation influences the effectiveness of monetary policy. Under credible monetary policy economic agents believe that deviations of inflation from the central bank inflation target are temporary, so they set wages and prices in the way consistent with preferences of monetary authorities.

Economic developments in the euro area have been very volatile in recent years. In 2009-2011 inflation was surprisingly high during the deep recession, but later the HICP inflation rate was permanently lower than expected in spite of ongoing recovery. Economic turbulences contributed to huge forecast errors and increasing complexity of the monetary policy making, as the standard interest rate policy approached its effective lower bound and new monetary policy instruments were introduced. The financial crisis and low inflation regime emphasise the need to understand central banks' management of expectations and the impact of monetary policy on private sector expectations. As pointed out by Yellen (2016), *“with nominal short-term interest rates at or close to their effective lower bound in many countries, the broader question of how expectations are formed has taken on heightened importance”*.

Central banks manage expectations by announcing their medium-term inflation targets and communicating with the public. The aim of communication is to increase monetary policy transparency and to reduce economic uncertainty. Qualitative communication refers to formal statements and reports and to more informal speeches and interviews, whereas quantitative communication means publication of central bank macroeconomic projections. In recent years several authors have analysed how inflation projections of central banks affect private sector forecasts (e.g. Hubert, 2015a; Pedersen, 2015, Hattori et al., 2016, Łyziak and Paloviita, 2017a). However, in these studies, a potential role of rational expectations assumption has been ignored, while the role of official or perceived inflation targets has not been analysed. Our study continues our earlier analysis of the euro area inflation expectations (Łyziak and Paloviita, 2017a) and aims to fill this gap in the literature. We attempt to analyse simultaneously the importance of the rational expectations hypothesis and published ECB inflation projections for the formation of private sector expectations. We also study whether implicit inflation targets perceived by economic agents are consistent with the official ECB inflation target.

Our study analyses formation of inflation expectations in the euro area. Using ECB inflation projections and inflation forecasts in the ECB Survey of Professional Forecasters we first compare forecast accuracy of the ECB and private sector experts. Then we assess the formation of short- and medium-term SPF inflation expectations by estimating two models of expectations, i.e. the hybrid model, including rational and static expectations, and the sticky-information (epidemiological) model, emphasizing the tendency of well-informed professionals to keep their forecast unchanged unless they are fully convinced about the usefulness of the information content of central bank projections. We combine both models to integrate underlying theoretical approaches, in order to assess the relative weights of different factors in expectations' formation.

Our sample period is 1999Q1-2016Q3, which covers recent years characterised by the financial crisis, sovereign debt crisis and low inflation regime. Estimating sub-sample and rolling regressions we examine possible changes of expectations' formation over time.

The paper is organised in the following way. Related literature is summarised in section 2 and the data are described in section 3. The empirical model of expectation formation and its results are presented in section 4, which includes also the assessment of robustness of our results. Concluding remarks are provided in section 5.

## **2. Review of the literature**

There are many potential reasons why central bank projections can be useful for private sector agents. If the central bank has more resources, better forecasting models or more detailed and timely information about economic developments, it may be able to assess future price developments more accurately than the private sector. In addition, central bank projections may include useful information about economic developments and/or future monetary policy actions.

Our analysis is closely linked to studies testing the impact of central bank forecasts on private sector ones or central banks' forecast performance. Romer and Romer (2000) compare forecast accuracy of the Federal Reserve with forecasts from Blue Chip Economic Indicators. They find that the Federal Reserve has substantially more information about future inflation relative to private sector and the private sector forecasters revise their forecasts in response to monetary policy signals of the Federal Reserve. Hubert (2015a) finds that inflation projections of five central banks (Canada, Japan, Sweden, Switzerland and the United Kingdom) affect private sector forecasts, proxied by Consensus Economics survey. However, only in the case of Sweden the central bank's projections outperform private sector forecasts. The same conclusions for Japan is presented by Hattori et al. (2016), who analyse the effects of central bank's inflation forecasts and the adoption of inflation targeting regime on private sector inflation forecasts. Contrary to Ehrmann (2015), who shows that in the low inflation regime inflation expectations are less likely to be anchored and are more sensitive to negative than positive inflation surprises, Hattori et al. (2016) find that the effects of Bank of Japan forecasts on private sector expectations are substantial. Therefore, they argue that targeting inflation from below does not necessarily weaken the effects of inflation forecasts published by the central bank. Since forecasting performance of the Bank of Japan is not significantly better than that of private sector, the authors conclude that inflation projections of the central bank include useful complementary information for private agents about future monetary policy actions. Łyziak and Paloviita (2017a) examine anchoring of inflation expectations in the euro area. Using the ECB SPF as a proxy for private sector expectations, they show that the ECB inflation projections have recently become more important for short- and medium-term expectations of professional forecasters.

Pedersen (2015) investigates changes (updates) of Chilean private sector inflation expectations using Economic Expectation Survey conducted by the Central Bank of Chile. He finds that the central bank's projections have substantial impact on private sector short-term expectations, while the impact on medium-term expectations is weaker. Hubert (2015c) uses structural VAR models to study the impact of central bank forecast shocks on private sector expectations. He finds that the FOMC forecasts, which include policy signals, affect private sector forecasts, proxied by the US Survey of Professional Forecasters (US SPF). In his another study, Hubert (2015b) also estimates structural VAR models to study the impact of ECB inflation projection shocks on private sector forecasts, which are proxied by the ECB SPF and Consensus Forecasts. His results indicate that private sector expectations are substantially influenced by the ECB projections.

Some authors examine also the impact of central bank inflation projections on dispersion of private sector forecasts. Fujiwara (2005) argues that publishing the Bank of Japan's inflation projections decreased forecasts disagreement among private sector forecasters. Ehrmann et al. (2012) examine projections of central banks in 12 advanced economics and they also find that central bank projections decrease dispersion of private sector forecasts. Kotłowski (2015) argues, however, that in Poland the central bank's release of CPI projections neither influences the cross-sectional dispersion nor the level of expectations of professionals. This can be due to the fact that the central bank inflation target is a dominant factor influencing inflation expectations of professionals (Łyziak, 2013).

Hubert (2017) studies extensively how ECB inflation projections and Governing Council members' speeches affect survey and market-based inflation expectations of the private sector in the euro area. He shows that ECB projections have a positive effect on current-year forecasts and ECB projections and speeches are substitutes at longer horizons. According to Hubert (2017), the speeches by Governing Council members and the ECB policy rate strengthen the effect of ECB projections when they are consistent, and convey the same signal about future price developments.

Our focus is on the ECB inflation projections and inflation expectations of experts, which are proxied by the ECB SPF. Our main contribution to the literature is twofold. First, integrating two theoretical approaches we examine backward- and forward-looking determinants of private sector expectations and – in this set-up – the role of implicit inflation target and ECB inflation projections. Our approach enables us to assess whether ECB projections are still important in expectations' formation once the forward-lookingness of economics agents has been taken into account. Second, we provide evidence whether the recent turbulent times have evoked to changes in expectations' formation.

### 3. Data analysis

#### 3.1. Data description

Our data set, which covers the period 1999Q1-2016Q3, includes the euro area HICP inflation rate, ECB SPF inflation forecasts, ECB inflation projections and the ECB inflation target. The ECB SPF has been conducted quarterly since 1999Q1.<sup>1,2</sup> In every survey round, the survey panel consists of around 50 professional forecasters, who represent both financial and non-financial institutions in the European Union. Forecasters are asked to report, inter alia, their expectations for the euro area HICP inflation rate. Six different forecast horizons are distinguished. In addition to current and next two calendar years, inflation is forecasted in the longer-term horizon. It depends on the quarter, in which the survey is conducted: in the Q1 and Q2 survey rounds it refers to forecasts four calendar years ahead, while in the Q3 and Q4 survey rounds – to forecasts five calendar years ahead.<sup>3</sup> Inflation is also forecasted in short- and medium-term fixed horizons, i.e. one year and two years ahead, relative to the month for which the latest official release of the HICP inflation rate is available.<sup>4</sup>

In our study we analyse short- and medium-term expectations since 1999Q1. Before 2014, when inflation expectations for the second calendar year (i.e. the year after the next one) have been surveyed only in quarters Q3 and Q4, we use linear interpolation in order to construct expectations for quarters Q1 and Q2. The ECB SPF is always conducted in the first month of every quarter after the HICP inflation rate for the previous month has been released and its results are published in the mid-month of the same quarter. The latest HICP inflation rate is presented to survey participants in the ECB SPF questionnaire.

The ECB inflation projections for the euro area are prepared four times a year. The projections are performed twice a year by the ECB-staff and the Eurosystem National Central Banks in the context of the Eurosystem Staff Broad Macroeconomic Projection Exercise (BMPE). Twice a year these projections are made by the ECB-staff in the context of the ECB-staff Macroeconomic Projection Exercise (MPE). The ECB publishes macroeconomic projections for the current and next two calendar years.<sup>5</sup> In order to emphasize the degree of uncertainty attached to inflation projections, up to March 2013 the ECB published inflation projections in the form of ranges. Therefore, we use midpoints of these ranges until 2013Q1. Since June 2013 we use published midpoints of the ranges for inflation. The ECB projections, which are

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<sup>1</sup> Euro area inflation expectations based on the ECB SPF have been analysed in many recent studies. See for example, Conflitti (2012), Rich et al. (2016), Tsenova (2012), Andrade and Le Bihan (2013), Kenny et al. (2014), Dovern and Kenny (2017) as well as Łyziak and Paloviita (2017a).

<sup>2</sup> Data source: <http://www.ecb.europa.eu/stats/prices/indic/forecast/html/index.en.html>. The ECB SPF is described in detail in Bowles et al. (2007). See <http://www.ecb.europa.eu/stats/pdf/spfquestionnaire.pdf?a9c65f6e4b965a8832693dcb0aebff66> for a survey questionnaire in January 2013 and [http://www.ecb.europa.eu/stats/prices/indic/forecast/shared/files/dataset\\_documentation\\_csv.pdf?76c07dc372dffabc3fec09d8cef682](http://www.ecb.europa.eu/stats/prices/indic/forecast/shared/files/dataset_documentation_csv.pdf?76c07dc372dffabc3fec09d8cef682) for a description of the ECB SPF data set.

<sup>3</sup> For example, in the 2014Q1 and 2014Q2 surveys, the long-term referred to calendar year 2018 and in the 2014Q3 and 2014Q4 surveys – to calendar year 2019.

<sup>4</sup> For example, in the 2015Q1 survey (after release of the HICP inflation rate in December 2014) the forecasters were asked to report their expectations for the HICP inflation rate in December 2015 and in December 2016.

<sup>5</sup> In our data set, the ECB inflation projections for the current and next calendar years are available since 2000Q4 and for the year after next calendar year since 2001Q4.

published in the last month of every quarter, are based on information available until the first month of the same quarter. These cut-off dates reflect relatively long forecasting process in the Eurosystem.<sup>6</sup>

The ECB inflation projections for full calendar years are fully comparable with corresponding ECB SPF inflation forecasts (the same target horizon). For our estimation purposes we construct proxies for one-year-ahead and two-years-ahead ECB inflation projections. One-year-ahead projections are constructed as weighted averages of projections for the current and next calendar years (see: Gerlach, 2007 and Doovern et al., 2012). Two-years-ahead projections are assumed to be equal to the ECB projections for the calendar year after the next one. These projections have been published only once a year before 2014 (in last quarters). We use linear interpolation in order to construct observations for quarters Q1-Q3 for those years.<sup>7</sup>

All variables in our data set are shown Figure 1 and basic statistics for the full sample (1999Q1-2016Q3) and the two sub-samples (pre-crisis period: 1999Q1-2008Q3 and post-crisis period 2008Q4-2016Q3) are summarised in Table 1. The two sub-samples are separated by the onset of the financial crisis.<sup>8</sup> We can observe that inflation expectations of professional forecasters have been more stable than the actual HICP inflation rate and that they have been either close to the ECB inflation projections or between ECB inflation projections and the inflation target. It suggests some degree of their anchoring. Short-term inflation expectations have been more volatile than the medium-term ones. In the pre-crisis period short-term projections of the ECB were somewhat higher than those of professionals, but the opposite is true in the case of medium-term expectations. Since 2006 both actual and expected inflation have been more volatile than previously. After 2012, higher short-term predictions have been observed for professional forecasters than for the ECB.

[here: Figure 1]

[here: Table 1]

### 3.2. Forecasting performance

As indicated in the literature review above, better forecasting accuracy of central bank projections is mentioned as the reason why the private sector can be motivated to follow central bank projections. However, empirical verification of this proposition seems to us problematic. If the private sector believes in information advantages of the central bank and follows central bank communication, then, as a consequence, the forecasting errors committed by the private sector become similar to those of the central bank. Therefore the lack of statistical difference

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<sup>6</sup> See Alessi et al. (2014) and ECB (2016) for a detailed description of the ECB/Eurosystem macroeconomic projection exercises.

<sup>7</sup> Since the ECB does not publish long-term inflation projections, they are not included in our analysis. Analysis of the anchoring of short- and medium- term inflation expectations seems to us even more important given their role in price formation in the euro area (ECB, 2017).

<sup>8</sup> The Lehman Brothers collapsed in September 2008.



between average forecast errors, found often in the literature and interpreted as a lack of incentives to follow central bank communication by the private sector, results simply from the fact that the credible central bank is effective in managing expectations.

Comparing forecasting accuracy of ECB inflation projections and SPF forecasts, we construct forecast errors of the ECB projections in two different ways. First, we analyse forecasting accuracy of ECB projections from the point of view of the private sector, i.e. we consider ECB projections from the previous quarter, available for SPF experts when they report their forecasts. Second, being aware of the fact that the previous quarter projections released by the central bank are inevitably based on outdated information<sup>9</sup>, we use ECB projections published in the current quarter, i.e. the same quarter when the ECB SPF is conducted. This seems a reasonable proxy for the current content of ECB communication concerning future price developments, since the same quarter ECB projections include recent price developments and timely information about economic developments, reflected in other (qualitative) forms of ECB communication (speeches and interviews etc.) available to SPF experts. The information delay between the cut-off date of lagged ECB projections and the conduct of the ECB SPF (deadline to reply) is two months (as an example, see Table 2 for important dates in 2013). Instead, the current quarter ECB projections are published only one month after the survey is conducted.

[here: Table 2]

To compare accuracy of ECB inflation projections and SPF inflation forecasts, we follow Romer and Romer (2000) and estimate the following equation:

$$(e_{t|t+n}^{SPF})^2 - (e_{t|t+n}^{CB})^2 = \alpha_n + \varepsilon_t. \quad (1)$$

Inflation forecast errors in both forecasting horizons are expressed as the difference between expected and actual inflation. The left-hand-side variable in the above equation measures the difference between mean squared errors of SPF and ECB forecasts,  $\alpha_n$  refers to the constant term and  $\varepsilon$  to the error term. The null hypothesis of this test is that on average there is no statistical difference in forecasting accuracy, i.e.  $\alpha_n = 0$ . If the estimated constant is statistically different from zero, the test indicates that there are systematic differences in the forecasting accuracy. A positive value of  $\alpha_n$  would mean that central bank inflation projections are systematically more accurate than SPF forecasts.

Test results (Table 3) suggest that in the pre-crisis period the average mean squared error (MSE) of short-term expectations is somewhat lower for professionals, but differences between medium-term forecast accuracies are marginal. In the crisis period smaller errors are observed

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<sup>9</sup> Due to the relatively long forecasting process in the Eurosystem, the delay between the cut-off date and publication of projections is several weeks and therefore ECB projections available at the time of SPF round do not include timely information about economic developments and ECB communication. Therefore, it is reasonable to assume that in addition to the latest projections, private sector agents follow continuously ECB communication in real time.

for the ECB projections in most of the cases. However, the null hypothesis, according to which the forecasting errors are equal to each other, is rejected in none of the cases. Therefore, in a statistical sense, the ECB's forecasting accuracy seems not to be significantly different from that of professional forecasters.

[here: Table 3]

Comparable forecasting accuracy of ECB projections and SPF forecasts reflects the fact that on average they are similar to each other. It can result either from paying attention by SPF experts to ECB projections and adjusting their forecasts to central bank views or from similar schemes of processing available information.

Although both the ECB experts and professionals make substantial forecasting errors, it is possible that combination of their forecasts improves forecasting accuracy of individual predictions. If both forecasts are not perfectly correlated, the use of the combined model enables us to distinguish superior and inferior forecasts. Especially, if the ECB and SPF experts have different abilities to adjust their forecasts to structural breaks and regime changes, the combined model may perform better than individual forecasts. Several authors have found support for models based on combination of individual forecasts (e.g. Granger and Ramanathan, 1984; Timmermann, 2006; Stock and Watson, 2001). We follow this type of analysis estimating the equation<sup>10</sup>:

$$\pi_{t+n} = \alpha + \gamma^{SPF} \pi_{t|t+n}^e + \gamma^{CB} \pi_{t|t+n}^{CB} + \mu_t, \quad (2)$$

where  $\pi_{t+n}$  denotes the HICP inflation rate at time  $t + n$ , while  $\pi_{t|t+n}^e$  and  $\pi_{t|t+n}^{CB}$  denote, respectively, SPF inflation forecasts and ECB inflation projections set at time  $t$  with the horizon  $t + n$ . In this unconstrained linear combination of SPF and ECB forecasts, the parameter  $\alpha$  reflects a possible bias in individual forecasts, while parameters  $\gamma^{SPF}$  and  $\gamma^{CB}$  provide information on a relative importance of individual forecasts in the combined model. If  $\gamma^{SPF}$  coefficient is high relative to  $\gamma^{CB}$ , it reveals that the information content of private sector forecasts is superior as compared to the ECB inflation projections. If instead the estimated  $\gamma^{CB}$  parameter is very high compared to  $\gamma^{SPF}$  parameter, central bank projections possess extra information useful for professionals. It can be shown that negative coefficients are also possible in the above equation, if the covariance between SPF and ECB forecasting errors exceeds one of the variances.

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<sup>10</sup> For example, Timmermann (2006) and Jansen and de Winter (2016) have evaluated combined models using this specification. Timmermann (2006) compares forecast accuracy of the IMF World Economic Outlook Forecasts and Consensus Forecasts. His extensive forecast performance analyses cover several variables in 178 countries. Jansen and de Winter (2016) compare Consensus and Dynamic Factor Model forecasts for real GDP forecasts in G7 countries.

According to estimation results (Table 4), in the short-term forecast horizon the SPF inflation forecasts seem superior to the lagged ECB projections. This result is quite reasonable, since recent energy and food price developments, which affect substantially short-term inflation prospects, are not reflected in the lagged ECB projections. However, current quarter ECB projections, which include more timely information about price developments, contain useful information for professionals. As far as medium-term horizon is considered, our estimation results stress the usefulness of ECB inflation projections for the private sector, since information content of both lagged and current ECB projections potentially allow professionals improving their own forecasts.

[here: Table 4]

Overall, we find that central bank and professional forecasters commit similar forecasts errors, which results from the fact that their assessments of inflation prospects are broadly similar to each other. Moreover, SPF experts have incentives to follow the ECB communication, especially trying to extract information on current views of the central bank regarding inflation prospects.

#### **4. How professional forecasters form their inflation expectations?**

##### **4.1. Two models of expectations' formation**

Our analysis of the formation of inflation expectations is based on two theoretical models of expectations used in empirical literature, both of which include backward- and forward-looking determinants of expectations.

The first model (M1) is the hybrid model of expectation formation, similar to models used by Gerberding (2001), Carlson and Valev (2002), Heineman and Ullrich (2006) and Łyziak and Mackiewicz-Łyziak (2014). It combines the models of static (simple adaptive) expectations and rational expectations, i.e.:

$$\pi_{t|t+n}^e = \alpha_0 + \alpha^{BL}\pi_{t-1} + \alpha^{FL}\pi_{t+n} + \varepsilon_t, \quad (3)$$

where  $\pi_{t|t+n}^e$  denotes inflation expectations set at time  $t$  with the horizon  $t + n$ ,  $\pi_{t-1}$  denotes the most recent HICP inflation rate, known when the ECB SPF is conducted, while  $\pi_{t+n}$  is the future inflation in the month corresponding to forecasting horizon. Time horizons refer to one year (12 months) and two years (24 months) ahead relative to the month for which the latest HICP inflation rate is available for professionals when they form their own expectations,  $n = \{4, 8\}$ .<sup>11</sup> The model can be reduced to the model of rational (unbiased) expectations if  $\alpha_0 = 0$ ,  $\alpha^{BL} = 0$  and  $\alpha^{FL} = 1$ .

The constant term in the equation (3) enables us to calculate so-called implicit (perceived) inflation target, to which a part of economic agents anchor their expectations. We assume that the expected inflation (dependent variable) can be expressed as the weighted average of three factors, i.e. the implicit target (constant over time), past inflation and future inflation, with weights reflecting the shares of economic agents using the above factors in setting their expectations. We assume that the shares of agents using static and rational models of expectation formation are given by the estimated parameters  $\hat{\alpha}^{BL}$  and  $\hat{\alpha}^{FL}$ . Using the estimated constant term,  $\hat{\alpha}_0$ , we are able to calculate the parameter  $\alpha^{IT}$ , which denotes the share of economic agents whose expectations are anchored to the implicit (perceived) target,  $\pi^*$ :

$$\hat{\alpha}_0 = \alpha^{IT} \pi^* \quad (4)$$

Shares of agents, who form their expectations on the basis of the implicit inflation target, past inflation and future inflation are assumed to sum to one, which implies that:

$$\alpha^{IT} = 1 - \hat{\alpha}^{BL} - \hat{\alpha}^{FL} \quad (5)$$

As a result, the implicit inflation target can be calculated with the formula:

$$\pi^* = \frac{\hat{\alpha}_0}{1 - \hat{\alpha}^{BL} - \hat{\alpha}^{FL}} \quad (6)$$

A similar approach was used by Kabundi et al. (2015). Analysing inflation expectations in South Africa they derive separate implicit targets for analysts, business and trade unions.<sup>12</sup>

The second model of expectations' formation (M2) is based on epidemiological models suggested by Carroll (2003, 2006), rooted in the sticky information paradigm (Mankiw and Reis, 2002). Epidemiological models have been used mainly in modelling consumer inflation

<sup>11</sup> Strictly speaking, forecast horizons refer to certain months in the future, not quarters (see section 3.1).

<sup>12</sup> It is worth mentioning that there is also another way of calculating the implicit inflation targets, based on VAR models, proposed by Demertzis et al. (2008, 2009) and used recently by Łyziak and Paloviita (2017a) in the context of inflation expectations in the euro area.

expectations. They assume that agents not experienced in macroeconomic forecasting, like consumers, update their information set occasionally, so their inflation predictions adjust with delay to information provided by the media, including forecasts of professional experts.

In the present study we apply the sticky-information model to analyse how information on inflation prospects released by the central bank affects forecasts of professionals. In this case the stickiness in expectations' formation is not necessarily related to irregular updating of information, which can be viewed as questionable assumption in the case of professional forecasters<sup>13</sup>, but rather to other reasons that make experts stick to their previous forecasts. In general, forecasters face a strategic trade-off: on the one hand, they attempt to avoid large forecasts errors, while on the other hand – due to reputation reasons – they are reluctant to make large forecast revisions. Jain (2014) convincingly shows that indeed, forecasts of professional forecasters in the US exhibit conservatism bias, i.e. “true” inflation expectations are more volatile than the announced ones. It can explain why well-informed professionals may prefer to keep their forecast unchanged and only if they are fully confident that the central bank projections include useful information about future economic developments and/or future monetary policy actions, they take central bank projections into account in their own forecasts.

To test how professional forecasters in the euro area process central bank projections when they form their own expectations we estimate the following epidemiological model proposed by Carroll (2003):

$$\pi_{t|t+n}^e = \beta^{BL} \pi_{t-1|t+n-1}^e + \beta^{CB} \pi_{t|t+n}^{CB} + \mu_t, \quad (7)$$

where  $\pi_{t|t+n}^{CB}$  denotes the most recent central bank inflation projection available at the time when ECB SPF experts make their own forecasts. We assume that professional forecasters gradually adjust their views to central bank projections and their forecasts converge to central bank forecasts in the long-run. This imposes the restriction:  $\beta^{BL} + \beta^{CB} = 1$ . Therefore the final model to be estimated is the following:

$$\pi_{t|t+n}^e = \beta^{BL} \pi_{t-1|t+n-1}^e + (1 - \beta^{BL}) \pi_{t|t+n}^{CB} + \mu_t. \quad (8)$$

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<sup>13</sup> Some studies, however, indicate that even in the case of professional forecasters some signs of information rigidities can be found. Coibion and Gorodnichenko (2012) show that the reaction of forecasts of professional experts in the US to macroeconomic shocks is delayed. According to Andrade and Le Bihan (2013), professional forecasters in the euro area fail to systematically update their forecasts.

## 4.2. Integrating both models

Using hybrid and epidemiological models of expectations' formation, we construct a general model, which integrates them, showing their relative information content in explaining inflation forecasts of professional experts in the euro area. It also serves to assess the importance of individual factors, including backward-looking factors, unbiased expectations, ECB projections and implicit inflation target, in inflation forecasting.

Our approach to combine models M1 and M2 is inspired by Fair and Shiller (1990). We estimate the following equation:

$$\pi_{t|t+n}^e = \omega^{M1} \hat{\pi}_{t|t+n}^{e,M1} + (1 - \omega^{M1}) \hat{\pi}_{t|t+n}^{e,M2} + \vartheta_t, \quad (9)$$

where  $\hat{\pi}_{t|t+n}^{e,M1}$  stands for fitted values from the model M1, while  $\hat{\pi}_{t|t+n}^{e,M2}$  for fitted values from the model M2. The weights of both models are assumed to sum to one.<sup>14</sup>

When analysing information content of different models, Fair and Schiller (1990) used ex-ante forecasts instead of fitted values in the equation (8). In contradiction to forecasts, fitted values from both models can be highly correlated. In order to address this problem, we estimate an equivalent version of the equation (9) that subtracts  $\hat{\pi}_{t|t+n}^{e,1}$  from both sides of the equation, i.e.:

$$\pi_{t|t+n}^e - \hat{\pi}_{t|t+n}^{e,M1} = (1 - \omega^{M1})(\hat{\pi}_{t|t+n}^{e,2} - \hat{\pi}_{t|t+n}^{e,M1}) + \vartheta_t. \quad (10)$$

Having the weights of both models, i.e.  $\hat{\omega}^{M1}$  and  $\hat{\omega}^{M2} = 1 - \hat{\omega}^{M1}$ , we are able to assess the importance of all explanatory variables in expectations' formation, i.e. past inflation and lagged forecasts, unbiased expectations as well as the central bank inflation projections and the implicit inflation target. The weights of those factors in the combined model – denoted as  $\kappa_t^{BL}$ ,  $\kappa_t^{FL}$ ,  $\kappa_t^{CB}$  and  $\kappa_t^{IT}$ , respectively – can be calculated in the following way:

$$\kappa_t^{BL} = \hat{\omega}^{M1} \hat{\alpha}^{BL} + (1 - \hat{\omega}^{M1}) \hat{\beta}^{BL}, \quad (11)$$

$$\kappa_t^{FL} = \hat{\omega}^{M1} \hat{\alpha}^{FL}, \quad (12)$$

$$\kappa_t^{CB} = (1 - \hat{\omega}^{M1})(1 - \hat{\beta}^{BL}), \quad (13)$$

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<sup>14</sup> Analysing robustness of our results we relax this assumption, applying a more general version of the equation (9) – see section 4.4.

$$\kappa_t^{IT} = \hat{\omega}^{M1}(1 - \hat{\alpha}^{BL} - \hat{\alpha}^{FL}). \quad (14)$$

### 4.3. Estimation results

In our estimations we use information available for professionals at the time of forecasting. When the ECB SPF is conducted in the 1<sup>st</sup> month of every quarter, the same quarter ECB projections are not available for professionals – they are published in the last month of the same quarter. Therefore, we use lagged ECB projections in our estimations, which are summarised in Tables 5-7 and Figures 2-5.

Table 5 presents estimation results in the whole sample period and two sub-samples, separated by the onset of the financial crisis. According to estimated coefficients of the model M1, private sector agents seem to be strongly backward-looking in their expectations' formation – only 10% of agents approximately make unbiased short-term forecasts in the whole sample period. When considering two sub-periods separately, the share of forward-looking agents in the post-crisis period is lower than in pre-crisis period. As far as the formation of medium-term forecasts is considered, the forward-looking component can be ignored independently of the sample period.

The largest group of ECB SPF experts use the implicit inflation target as the benchmark for their forecasts. In the formation of short-term inflation forecasts, this share accounts for 65% of all forecasters – it has slightly increased from 63% in the pre-crisis period to 70% in post-crisis period. Medium-term forecasts are more anchored than the short-term ones – 85% of ECB SPF forecasters base their predictions on the perceived target. Interestingly, in the financial crisis period the implicit (perceived) inflation target for short-term expectations has decreased from 1.6% to 1.4% and for medium-term inflation expectations – from 1.8% to 1.7%. The latter change is statistically significant.

The epidemiological model (M2) allows for another source of potentially forward-looking information, i.e. ECB inflation projections. Estimation results (Table 5) suggest that professional forecasters are persistent in their expectations' formation, being reluctant to change their forecasts considerably, especially in the case of the medium-term horizon. The share of experts updating immediately their expectations on the basis of ECB projections is about 20% in the case of short-term forecasts and 10% in the case of medium-term forecasts. Interestingly, in both forecasting horizons the importance of ECB projections has increased in the post-crisis period compared to the pre-crisis one, but this effect is not statistically significant.

[here: Table 5]

All in all, estimation results in Table 5 suggest that inflation expectations of professional forecasters in the euro area are formed with a small amount of forward-looking information, but they are also weakly sensitive to changes in current inflation. The dominant mechanisms of

expectations' formation, seen through the lenses of the estimated models, rely either on implicit targets, to which experts anchor their expectations or on their previous forecasts, only gradually adjusted towards ECB inflation projections. Since the beginning of the financial crisis the fully forward-looking component (given by unbiased forecasts) in the formation of short-term forecasts has disappeared, while the importance of current HICP inflation has diminished. In the case of medium-term inflation expectations, the willingness of ECB SPF forecasters to adjust their forecasts to the ECB inflation projections has recently increased. On the other hand, both short- and medium-term implicit targets perceived by SPF experts have decreased somewhat recently, deviating more from the ECB official target than in the past.

The next step of our analysis is to derive the weights of both estimated models that minimize the squared deviations of fitted values from the combined model (8) from actual ones. Estimation results (Table 6) indicate that in the whole sample period the weight of model M1 (based on rational and static expectations) is slightly lower than the weight of model M2 (the epidemiological model). However, the model of expectations' formation by ECB SPF experts has changed considerably over time. It seems that in the pre-crisis period the epidemiological model is sufficient to adequately reflect inflation forecasts of ECB SPF experts, while in the post-crisis period its weight is reduced to 0.16 for short-term forecasts and to 0.39 for medium-term forecasts.

[here: Table 6]

Combining the importance of single factors affecting expectations in each of two estimated models (Table 5) with derived weights of both models (Table 6) we obtain the final ranking of determinants of SPF inflation forecasts, in line with the equations (11)-(14). The results, presented in Table 7, indicate that backward-looking factors dominate the formation of private sector forecasts in the whole sample period and, even more strongly, in the pre-crisis period. An important driver of ECB SPF experts' expectations is the implicit (perceived) inflation target, the role of which has strongly increased in the recent sub-sample. As far as the model of unbiased expectations is concerned, we can find its minor importance only for short-term inflation expectations and in the whole sample period. The ECB inflation projections seem not to be very relevant in the formation of ECB SPF forecasts, although we can observe a slight increase in their role in the case of medium-term SPF forecasts.

[here: Table 7]

The above observations suggest that in recent turbulent years the formation of inflation expectations by professional forecasters has substantially changed. Nowadays those forecasts are driven mainly by the implicit inflation target, which – as discussed above – has been reduced recently, deviating slightly from the ECB official target. It can signal increasing risks of inflation expectations' de-anchoring. At the same time we can observe a small compensating



effect in terms of the increase of the role of ECB inflation projections in affecting medium-term ECB SPF forecasts.

Our results confirm the observation of Łyziak and Paloviita (2017a) that even if ECB SPF forecasts have become slightly de-anchored with respect to the ECB inflation target, there has been the compensating effect in terms of increased role of ECB inflation projections for medium-term inflation expectations. It should be noted, however, that the above conclusions are based on two separate models, without assessing their relative usefulness in fitting ECB SPF forecasts.

In order to analyse possible changes in expectations formation in more detail, we repeat the analyses using rolling regressions. In our estimations, the size of the rolling window is 33 quarters: the sample period in the first rolling regression is 1999Q1-2007Q1, in the last one it is broadly consistent with the financial crisis period (2008Q2-2016Q2).<sup>15</sup>

Rolling regression results for the hybrid model M1 (Figure 2) are broadly consistent with findings presented above. The share of forward-looking agents, making unbiased forecasts of future inflation, is low in the case of short-term forecasts and negligible in the case of medium-term forecasts. The importance of this determinant of short-term ECB SPF inflation forecasts displays a downward trend. The role of past inflation, even if gradually rising in the case of medium-term SPF forecasts, is not prominent. Majority of professional forecasters base their forecasts, especially the medium-term ones, on the perceived inflation target. We can observe that implicit targets are rather stable over time, although at the end of the sample period we can observe a benign downward trend.

[here: Figure 2]

Rolling regression results based on the epidemiological model M2 (Figure 3) suggest that ECB SPF experts are rather reluctant to change their forecasts, although the share of experts updating their forecasts on the basis of ECB inflation projections seem to be slightly going up since 2008, especially in the case of short-term forecasts.

[here: Figure 3]

It seems that the weights of both models of expectation formation were changing substantially over time (Figure 4). Before the financial crisis the epidemiological model was dominant in both forecast horizons. From 2009 to 2014 the weights of both models were relatively stable and close to each other in the case of medium-term forecasts. Since 2015 the hybrid model

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<sup>15</sup> Due to the fact that the model M1 contains forward-looking variables, the last rolling regression period is different in the case of short- (2008Q2-2016Q2) and medium-term forecasts (2007Q2-2015Q2). Assessing robustness of our results we make the rolling window wider (36 quarters) – see section 4.4.

based on rational and static expectations has been getting importance again for short-term forecasts<sup>16</sup> – its weight at the end of the sample period is approximately 80%.

[here: Figure 4]

Analysis of individual determinants of expectations' formation in the combined model reveals that private sector expectations' formation has changed since the beginning of the financial crisis (Figure 5). The most significant change is the reduction of backward-lookingness of ECB SPF forecasts and increased role of the perceived inflation target. The importance of ECB inflation projections for setting short-term expectations by ECB SPF experts was increasing in 2009-2014, although since mid-2014 this trend has reversed. The degree of rationality of expectations (unbiasedness condition) has slightly increased after the crisis, but rather temporarily and in the case of short-term forecasts only.

[here: Figure 5]

Our empirical analyses suggest that recent years have contributed to substantial changes in expectations' formation in the euro area. The degree of expectations' backward-lookingness has recently decreased, while the importance of perceived target has increased. The perceived inflation target is broadly consistent with the official ECB inflation target in the medium-term; however, we find some evidence of its recent downward trend indicating increasing risks of de-anchoring inflation expectations. The forward-looking component in the formation of inflation expectations, given by unbiased predictions, is small in the case of short-term forecasts and null in the case of medium-term ones, while the direct impact of ECB inflation projections on private sector expectations is quite limited.

#### 4.4. Assessing robustness of the results

To assess the robustness of the results presented above a number of additional exercises were performed. The first exercise uses a more general specification to combine hybrid and sticky-information models, i.e. we allow for constant in the estimated equation (9) and do not assume that the coefficients of both models sum to one:

$$\pi_{t|t+n}^e = \omega_0 + \omega^{M1} \hat{\pi}_{t|t+n}^{e,M1} + \omega^{M2} \hat{\pi}_{t|t+n}^{e,M2} + \vartheta_t, \quad (15)$$

---

<sup>16</sup> As indicated above, due to the fact that the model M1 contains the forward-looking element, the estimation ends in 2015Q2, so we are not able to assess if the increase of the importance of the hybrid model since 2015, observed in the case of short-term forecasts, applies also in the case of medium-term forecasts.

In the second exercise we modify the forward-looking component in the hybrid model of inflation expectations. Instead of using HICP inflation in the equation (3), we use future values of core inflation excluding food and energy items ( $\pi^{core}$ ):

$$\pi_{t|t+n}^e = \alpha_0 + \alpha^{BL}\pi_{t-1} + \alpha^{FL}\pi_{t+n}^{core} + \varepsilon_t, \quad (16)$$

In this way we relax the assumption that forward-looking agents predict the whole HICP inflation, but check the unbiasedness of their expectations with respect to the inflation trend, represented by the core inflation measure. Finally, we check the robustness of our results with respect to the size of the rolling window, increasing it from 33 to 36 quarters.

The results of the above exercises (Figure 6, Figure 7, Figure 8), in terms of the weights of individual determinants of SPF inflation forecasts and implicit inflation targets assessed in the rolling regression manner, suggest that our qualitative conclusions are robust. Interestingly, using core inflation instead of HICP inflation in the forward-looking part of the hybrid model noticeably increases the estimated share of forward-looking agents in the case of short-term SPF forecasts, while increasing the rolling window size makes the weights of individual determinants of inflation expectations smoother.

[here: Figure 6]

[here: Figure 7]

[here: Figure 8]

## 5. Conclusions

Rational expectations have been typically assumed in macroeconomic modelling, although empirical evidence is widely at odds with this hypothesis. As it is also unrealistic to assume fully backward-lookingness of expectations, several models have been proposed to capture both backward- and forward-looking factors in expectations' formation. For central banks recent turbulent times have emphasised the need to understand formation of inflation expectations in order to maintain price stability.

Central banks communicate with the public – among other things – by publishing macroeconomic projections. Many authors have studied the impact of central forecasts on private sector inflation forecasting. However, in these studies economic agents have been typically assumed backward-looking and central bank inflation projections have been treated as the only forward-looking factor affecting expectations. Using our novel approach, we analyse

simultaneously the importance of the rational expectations hypothesis and ECB inflation projections for the formation of private sector expectations.

The impact of central bank forecasts on private sector forecasting has been often assessed comparing forecasting performances. It has been argued that only smaller forecast errors of the central bank reveal motivation of the private sector follow central bank communication. Our interpretation is different. We find only marginal differences in forecast errors of the ECB and professionals, which, according to our interpretation, indicates that the ECB is able to manage expectations – SPF forecasters seem to base their forecasts on the views of the central bank or transform available information in their inflation forecasts in the way similar to the monetary authorities. Our combined model estimations reveal that the information content of ECB projections is potentially useful for professionals in forecasting.

To assess the direct role of ECB projections in the formation of SPF inflation forecasts, we apply the model, in which we try to control for different forward-looking and backward-looking determinants of inflation expectations. We find that in recent turbulent times the importance of backward-looking mechanisms has decreased and the importance of the perceived target has increased in expectations' formation. The perceived inflation target has remained broadly consistent with the official ECB inflation target in the medium-term, which supports inflation targeting monetary policy strategy. It is worth noting, however, that we find some signals of its downward trend, reflecting increasing risks of de-anchoring. The immediate impact of ECB inflation projections on private sector inflation forecasts is relatively small once the impact of forward-lookingness of economic agents has been taken into account. However, SPF inflation forecasts remain consistent with the ECB communication – they have been more stable than the actual HICP inflation rate and either close to the ECB inflation projections or between ECB inflation projections and the ECB inflation target. All in all, our analysis reveals that turbulent times can contribute substantially to changes in expectations' formation. Therefore, monetary policy makers should be continuously vigilant in the analysis of inflation expectations' dynamics.

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## Tables and figures

**Table 1.** HICP inflation rate, ECB SPF inflation expectations and ECB projections

	HICP	SPF_1Y	SPF_2Y	ECB_1Y	ECB_2Y
Whole sample, 1999Q1-2016Q3					
Mean	1.738	1.629	1.749	1.661	1.612
Maximum	3.800	2.401	2.109	2.900	2.000
Minimum	-0.400	0.755	1.221	0.375	1.300
Std. dev.	0.973	0.322	0.167	0.578	0.184
Observations	71	71	71	64	60
Pre-crisis period, 1999Q1-2008Q3					
Mean	2.185	1.791	1.825	2.027	1.730
Maximum	3.800	2.401	2.109	2.900	2.000
Minimum	0.800	1.154	1.501	1.600	1.500
Std. dev.	0.602	0.224	0.109	0.329	0.155
Observations	39	39	39	32	28
Crisis period, 2008Q4-2016Q3					
Mean	1.194	1.432	1.657	1.296	1.508
Maximum	2.900	1.946	1.981	2.200	1.800
Minimum	-0.400	0.755	1.221	0.375	1.300
Std. dev.	1.065	0.314	0.179	0.543	0.140
Observations	32	32	32	32	32

*Note:* HICP denotes actual inflation. 1Y (2Y) refers to expectations one year ahead (two years ahead). Inflation expectations are dated at the time when the ECB projections and ECB SPF were published.

*Source:* own calculations.

**Table 2.** Timing of ECB projections and ECB SPF forecasts in 2013Q1-2013Q4

	Previous quarter ECB projections		Current quarter ECB projections		Current quarter ECB SPF	
	Cut-off date	Publication date	Cut-off date	Publication date	Deadline to reply	Publication date
2013Q1	23-Nov-2012	3-Dec-2012	22-Feb-2013	4-March-2013	22-Jan-2013	14-Feb-2013
2013Q2	22-Feb-2013	4-March-2013	22-May-2013	3-June-2013	19-Apr-2013	09-May-2013
2013Q3	22-May-2013	3-June 3-2013	23-Aug-2013	2-Sep-2013	19-Jul-2013	08-Aug-2013
2013Q4	23-Aug-2013	2-Sep 2-2013	22-Nov-2013	2-Dec-2013	22-Oct_2013	14-Nov-2013

*Source:* based on ECB documents.

**Table 3.** Forecasting accuracy of ECB and SPF experts – Romer and Romer (2000) test

	whole sample			pre-crisis sub-sample			crisis sub-sample		
	MSE average			MSE average			MSE average		
	SPF	ECB	<i>p</i> -value	SPF	ECB	<i>p</i> -value	SPF	ECB	<i>p</i> -value
Previous quarter ECB projections									
1-year horizon	0.905	1.032	0.464	0.789	0.952	0.310	1.034	1.125	0.748
2-year horizon	1.217	1.077	0.281	0.998	1.000	0.982	1.462	1.164	0.181
Current quarter ECB projections									
1-year horizon	0.887	1.026	0.451	0.769	1.227	0.214	1.027	0.787	0.269
2-year horizon	1.180	1.077	0.505	0.966	0.965	0.996	1.441	1.214	0.308

*Note:* Forecast errors refer to expected minus actual inflation. With previous (current) quarter ECB projections the sample starts in 2001Q1 (2000Q4) for 1-year-ahead forecasts and in 2002Q1 (2001Q4) for 2-years-ahead forecasts. Ordinary least squares with Newey-West HAC standard errors. The *p*-value is for the test of null hypothesis that the private sector errors and ECB errors are equal.

*Source:* own calculations.

**Table 4.** Combination of inflation forecasts

	SPF 1Y				SPF 2Y			
	$\alpha$	$\gamma^{SPF}$	$\gamma^{CB}$	Adj. R <sup>2</sup>	$\alpha$	$\gamma^{SPF}$	$\gamma^{CB}$	Adj. R <sup>2</sup>
Previous quarter ECB projections	-1.529 (1.074)	3.081*** (1.136)	-1.078 (0.826)	0.193	0.085 (4.011)	-1.845 (1.998)	3.049** (1.262)	0.161
Current quarter ECB projections	0.451 (1.408)	-0.446 (1.139)	1.193** (0.533)	0.236	0.217 (4.111)	-1.783 (2.119)	2.911** (1.187)	0.146

*Notes:* 1Y (2Y) refers to forecasts one year ahead (two years ahead). Numbers in parentheses below estimated coefficients are standard errors. \*\*\* denotes confidence level at 99 per cent; \*\* denotes confidence level at 95 per cent; \* denotes confidence level at 90 per cent. \*\*\* denotes significance level at 99 per cent; \*\* denotes significance level at 95 per cent; \* denotes significance level 90 per cent.

*Source:* own calculations.



**Table 5.** Models of expectation formation

	SPF 1Y				SPF 2Y			
	whole sample	pre-crisis sub-sample	crisis sub-sample	F [F-prob] H <sub>0</sub> : equal coefficients in sub-samples	whole sample	pre-crisis sub-sample	crisis sub-sample	F [F-prob] H <sub>0</sub> : equal coefficients in sub-samples
Model 1 – eq. (3)								
Constant term	1.026*** (0.052)	1.006*** (0.366)	1.049*** (0.056)	0.014 [0.906]	1.478*** (0.033)	1.672*** (0.112)	1.430*** (0.036)	4.035 [0.050]
Past inflation	0.254*** (0.022)	0.158 (0.109)	0.279*** (0.024)	1.142 [0.290]	0.148*** (0.013)	0.077* (0.045)	0.150*** (0.014)	2.331 [0.132]
Future inflation	0.091*** (0.028)	0.204** (0.078)	0.025 (0.038)	5.639 [0.021]	0.007 (0.003)	0.000 (0.018)	0.021 (0.016)	0.808 [0.373]
Implicit target	1.57	1.58	1.45	0.136 [0.714]	1.75	1.81	1.73	6.060 [0.014]
Adj. R <sup>2</sup>	0.77	0.77		x	0.70	0.74		x
J-prob.	0.19	0.76		x	0.12	0.11		x
Model 2 – eq. (8)								
Past SPF forecast	0.808*** (0.056)	0.877*** (0.109)	0.782*** (0.065)	0.551 [0.461]	0.895*** (0.040)	0.977*** (0.080)	0.867*** (0.047)	1.384 [0.244]
ECB projection	0.192	0.123	0.218		0.105	0.023	0.133	
Adj. R <sup>2</sup>	0.82	0.82		x	0.81	0.81		x

Notes: 1Y (2Y) refers to forecasts one year ahead (two years ahead). Actual future inflation is used in the model 1 as a measure of rational expectations. As a consequence, the error term of the estimated equation includes the expectational error of rational expectations (Fair, 1993). Therefore, the two-stage least squares method (2SLS) is used to estimate the model 1. The set of instruments contains 6-8 lags of HICP inflation, GDP growth, real interest rate, USD/EUR exchange rate and oil prices. Numbers in parentheses below estimated coefficients are standard errors. \*\*\* denotes confidence level at 99 per cent; \*\* denotes confidence level at 95 per cent; \* denotes confidence level at 90 per cent.

Source: own calculations.

**Table 6.** Weights of models of expectation formation

	SPF 1Y				SPF 2Y			
	whole sample	pre-crisis sub-sample	crisis sub-sample	F [F-prob] H <sub>0</sub> : equal weights in sub-samples	whole sample	pre-crisis sub-sample	crisis sub-sample	F [F-prob] H <sub>0</sub> : equal weights in sub-samples
Model 1	0.441*** (0.085)	0.147 (0.121)	0.797*** (0.130)	13.425 [0.001]	0.430*** (0.104)	0.120 (0.206)	0.615*** (0.123)	4.265 [0.044]
Model 2	0.559	1	0.203		0.5370	1	0.385	
Adj. R <sup>2</sup>	0.87	0.89		x	0.83	0.85		x

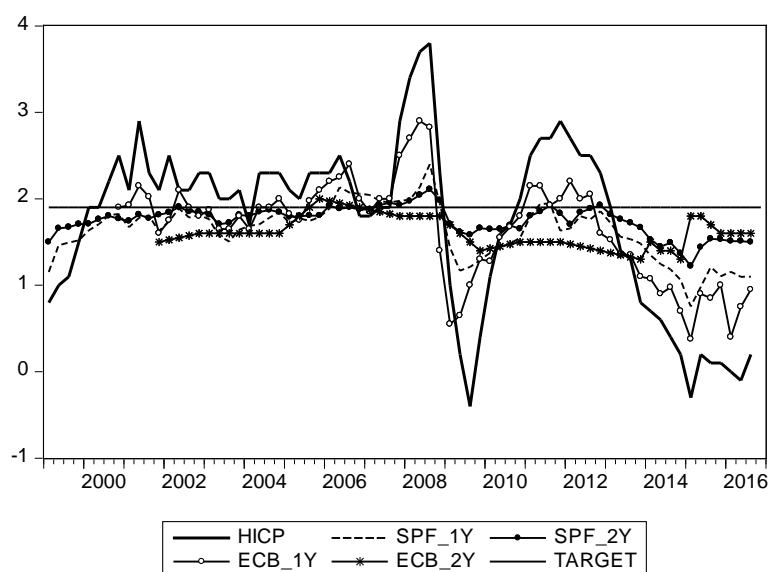
Notes: 1Y (2Y) refers to forecasts one year ahead (two years ahead). Numbers in parentheses below estimated coefficients are standard errors. \*\*\* denotes confidence level at 99 per cent; \*\* denotes confidence level at 95 per cent; \* denotes confidence level at 90 per cent. \*\*\* denotes significance level at 99 per cent; \*\* denotes significance level at 95 per cent; \* denotes significance level 90 per cent.

Source: own calculations.

**Table 7.** Weights of factors affecting SPF forecasts in the combined model of expectation formation (%)

	SPF 1Y			SPF 2Y		
	whole sample	pre-crisis sub-sample	crisis sub-sample	whole sample	pre-crisis sub-sample	crisis sub-sample
backward-looking factors	56.3	87.7	36.1	57.6	97.7	43.3
unbiased prediction of future inflation	4.0	0.0	0.0	0.0	0.0	0.0
ECB projections	10.8	12.3	3.5	6.0	2.3	5.2
implicit (perceived) inflation target	28.9	0.0	60.3	36.4	0.0	51.5

Source: own calculations.

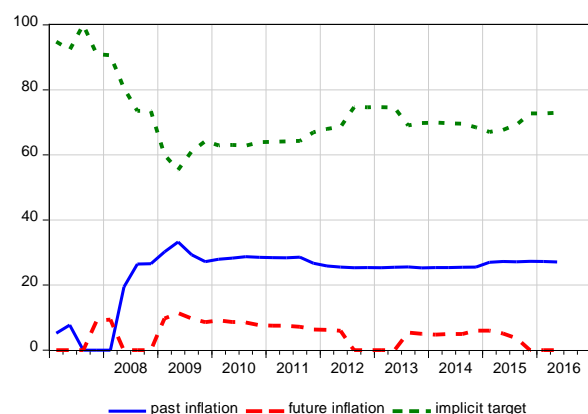
**Figure 1.** HICP inflation rate, ECB SPF inflation expectations and ECB projections

Note: HICP denotes actual inflation and TARGET the ECB inflation target. 1Y (2Y) refers to expectations one year ahead (two years ahead). Inflation expectations are dated at the time when the ECB projections and ECB SPF were published.

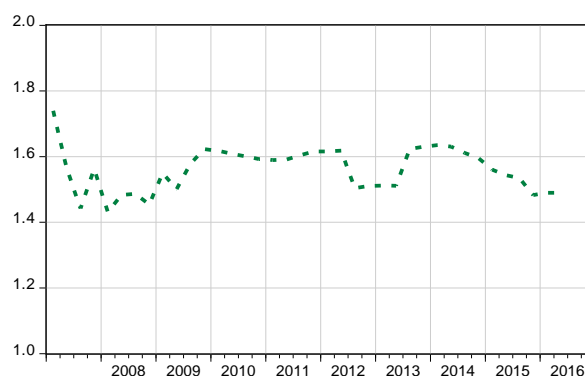
Source: Eurostat, ECB and own calculations.

**Figure 2.** Weights of factors affecting SPF forecasts in the hybrid model of expectation formation, eq. (1) (%) and implicit targets for expectations

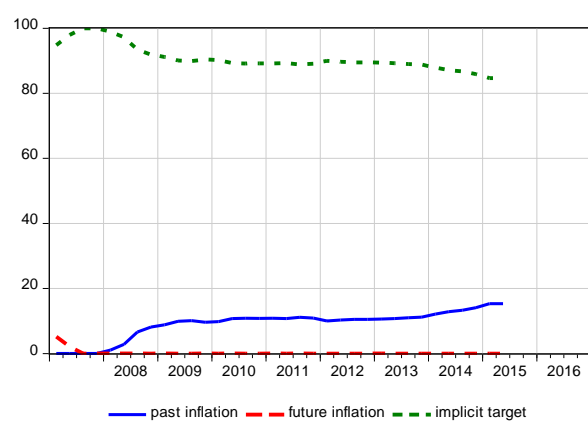
**2.A.** Determinants of short-term SPF forecasts (SPF\_1Y)



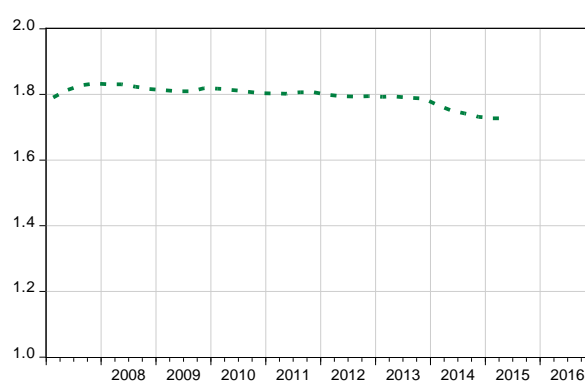
**2.B.** Implicit target for short-term SPF forecasts



**2.C.** Determinants of medium-term SPF forecasts (SPF\_2Y)



**2.D.** Implicit target for medium-term SPF forecasts

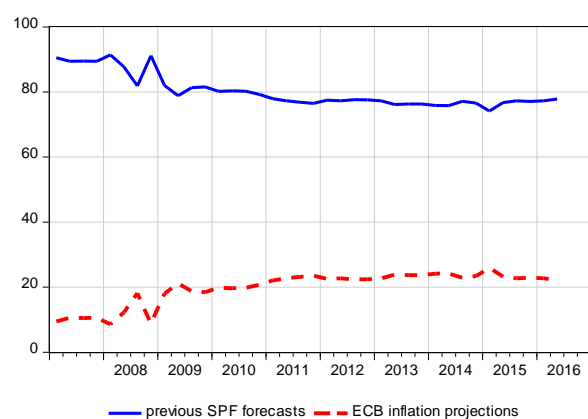


Notes: The weight is set to zero if the estimated coefficient is not statistically significant.

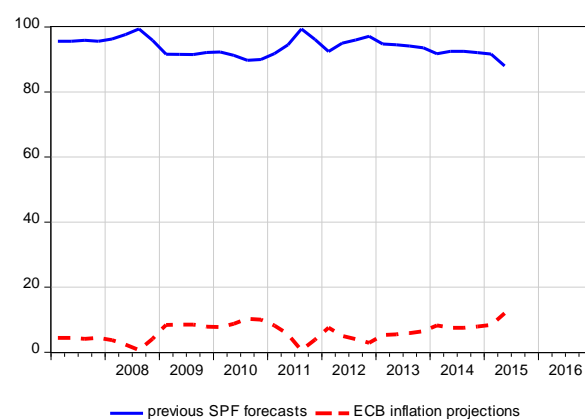
Source: own calculations.

**Figure 3.** Weights of factors affecting SPF forecasts in the epidemiological model of expectation formation, eq. (6) (%)

**3.A.** Determinants of short-term SPF forecasts (SPF\_1Y)

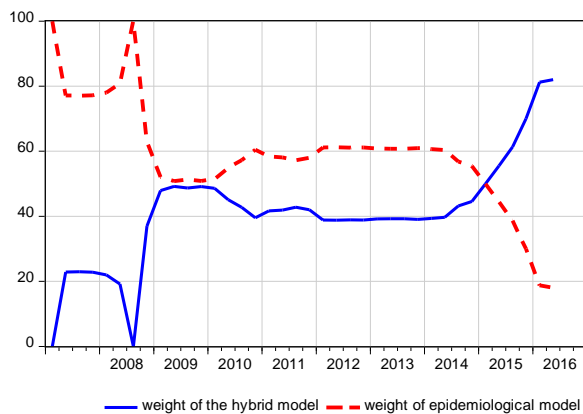
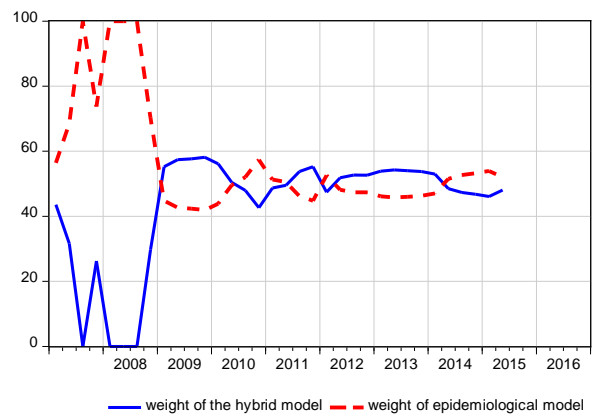


**3.B.** Determinants of medium-term SPF forecasts (SPF\_2Y)



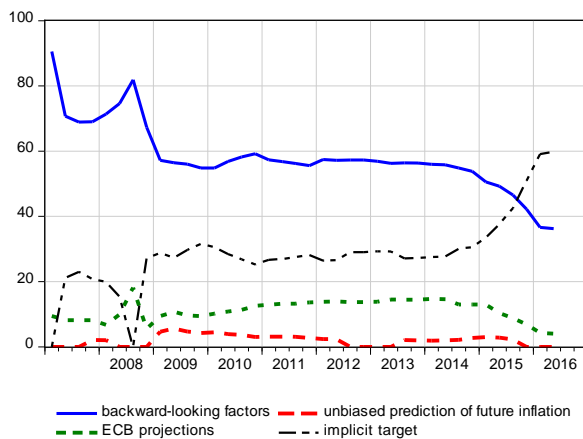
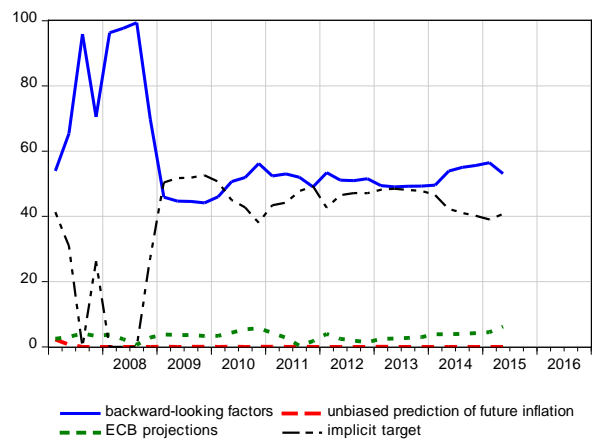
Notes: The weight is set to zero if the estimated coefficient is not statistically significant.

Source: own calculations.

**Figure 4.** Weights of models of expectation formation (%)**4.A.** Short-term SPF forecasts (SPF\_1Y)**4.B.** Medium-term SPF forecasts (SPF\_2Y)

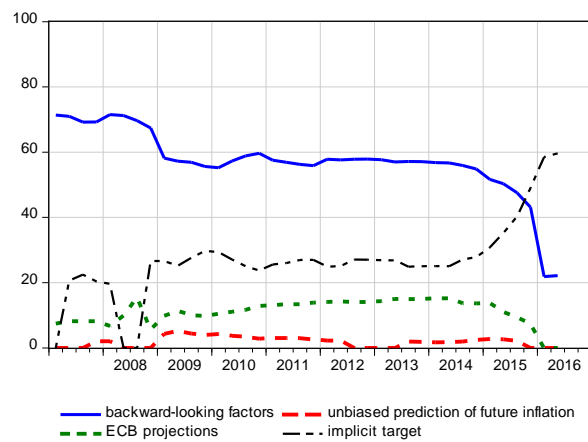
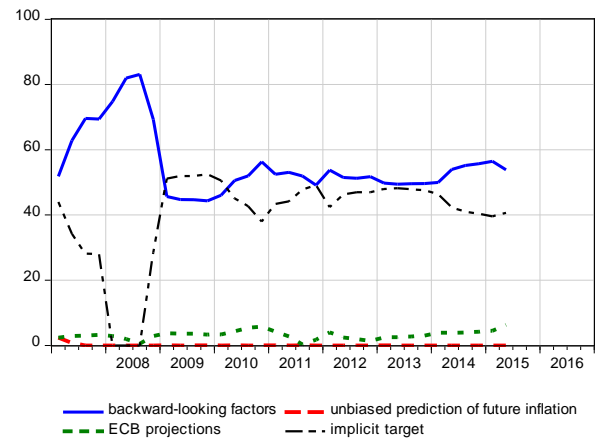
Notes: The weight is set to zero if the estimated coefficient is not statistically significant.

Source: own calculations.

**Figure 5.** Weights of factors affecting SPF forecasts in the combined model of expectation formation (%)**5.A.** Short-term SPF forecasts (SPF\_1Y)**5.B.** Medium-term SPF forecasts (SPF\_2Y)

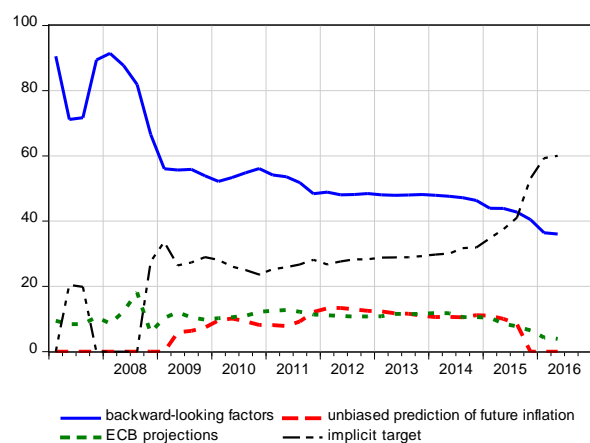
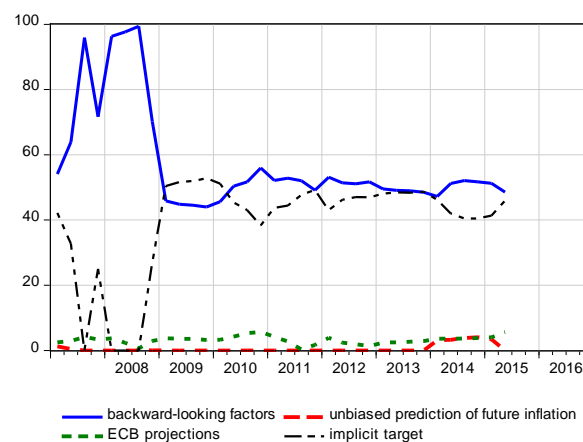
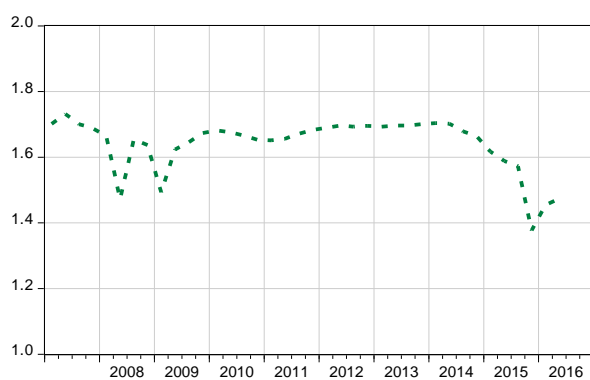
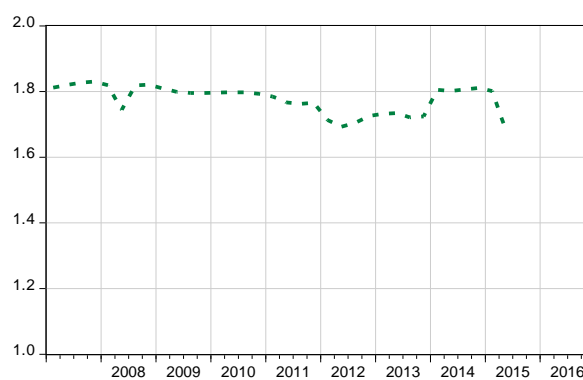
Notes: The weight is set to zero if the estimated coefficient is not statistically significant.

Source: own calculations.

**Figure 6.** Robustness check – more general combined model**6.A.** Weights of determinants of short-term SPF forecasts (%)**6.B.** Weights of determinants of medium-term SPF forecasts (%)

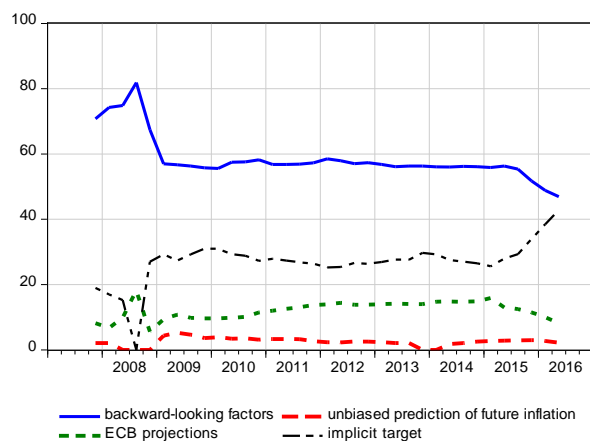
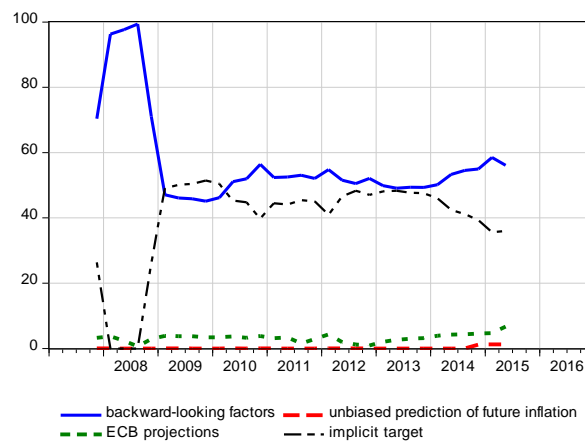
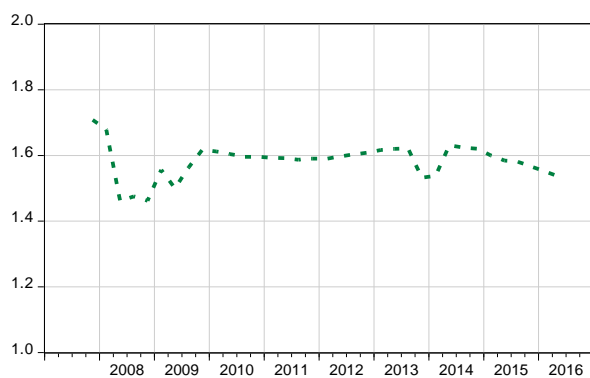
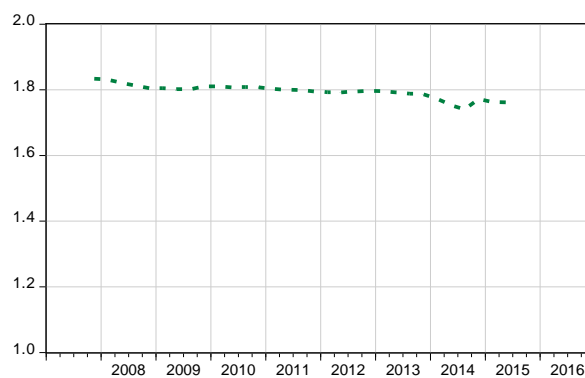
*Notes:* Contrary to equation (9), the model contains a constant and the sum of weights of fitted values from both individual models are not restricted to one. The weight is set to zero if the estimated coefficient is not statistically significant.

*Source:* own calculations.

**Figure 7.** Robustness check – core inflation in the hybrid model**7.A.** Weights of determinants of short-term SPF forecasts (%)**7.B.** Weights of determinants of medium-term SPF forecasts (%)**7.C.** Implicit target for short-term SPF forecasts**7.D.** Implicit target for medium-term SPF forecasts

*Notes:* Contrary to HICP inflation in equation (3), the core inflation (excluding food and energy items) is used as a forward-looking explanatory variable in the hybrid model. The weight is set to zero if the estimated coefficient is not statistically significant.

*Source:* own calculations.

**Figure 8.** Robustness check – increased rolling window's size**8.A.** Weights of determinants of short-term SPF forecasts (%)**8.B.** Weights of determinants of medium-term SPF forecasts (%)**8.C.** Implicit target for short-term SPF forecasts**8.D.** Implicit target for medium-term SPF forecasts

*Notes:* The size of the rolling window is increased from 33 to 36 quarters. The weight is set to zero if the estimated coefficient is not statistically significant.

*Source:* own calculations.

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