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Questioni di Economia e Finanza

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A COMPOSITE INDEX OF INFLATION TENDENCIES IN THE EURO AREA

by Marcello Miccoli*, Marianna Riggi,* Lisa Rodano* and Laura Sigalotti**

Abstract

Assessing underlying inflation developments is crucial for a correct calibration of the monetary policy stance. To monitor the adjustment in the path of euro area inflation towards the ECB's definition of price stability, we select a number of indicators of price dynamics in the area. We then construct a composite index summarizing the information contained in those indicators by estimating several univariate probability models. The index, which provides a synthetic measure of inflationary pressures net of the most volatile components, can be interpreted as gauging the probability of inflation returning to 1.9 per cent or over within a given time horizon. Our findings, which are based on the information available in July 2017, signal that, despite the improvement in price dynamics since the beginning of the year, the adjustment of inflation rates towards levels below, but close to, 2 per cent over the medium term is still limited and far from being sustained.

JEL Classification: C35, C38, E31, E58

Keywords: euro area, determinants of inflation, inflation, statistical aggregation

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1. Introduction¹

In order to counter the risks of an excessively long period of low inflation, on 22 January 2015 the Governing Council of the European Central Bank decided to expand the programme of asset purchases announced in September 2014 to include euro-denominated investment-grade securities issued by euro area governments and agencies and European institutions (Expanded Asset Purchase Programme). The programme was intended to be conducted until September 2016, and in any case until the Government Council saw a sustained adjustment in the path of inflation consistent with its aim of achieving inflation rates below, but close to, 2% over the medium term. The end-date of the programme (which was later enhanced with the inclusion of other asset classes) was subsequently postponed until December 2017 or beyond, if necessary, and in any case until the Governing Council sees a sustained adjustment in the path of inflation consistent with its inflation aim.

To monitor the adjustment in the path of euro area inflation towards the ECB's definition of price stability, in this paper we first select a number of indicators that are related to price dynamics in the euro area, both at the aggregate and country level; these indicators are reported in the form of a dashboard. A composite index is then derived that summarizes the information contained in those indicators, providing a synthetic measure of inflationary pressures net of the most volatile components. The composite index, obtained by the estimation of several univariate probability models and aggregated using principal component weights, provides an estimate of the probability that inflation will return to a level of at least 1.9 per cent within a given time horizon (which may vary between 3 and 24 months).

According to the information available in July 2017, the probability that headline inflation returns to values equal to 1.9 per cent or more in the next 12 months is slightly above 30 per cent, higher than the average level in 2015-16 (20 per cent). The synthetic index has trended upwards since late 2016, mostly reflecting the fall in the number of countries where the inflation rate is below 1 per cent and the improvement in inflation expectations (two of our selected indicators). However it is still well below the 50 per cent threshold (corresponding to the average frequency of episodes in which the inflation rate was higher or equal to 1.9 per cent in the sample), signalling that the adjustment in the path of prices is still limited and far from being sustained.

2. A dashboard of euro area inflation

The inflation dashboard provides a snapshot of inflation measures; it includes 15 indicators that capture price dynamics (net of the most volatile components) from various perspectives. By providing a multi-dimensional visualization of the phenomenon, the dashboard allows to timely monitor early signals of an adjustment in the path of inflation towards levels consistent with the ECB objective. The number of indicators has been restricted to 15, in order to make the dashboard an effective, immediate and easy-to-consult graphical tool.

¹ We gratefully acknowledge insightful comments and suggestions from Fabio Busetti and Stefano Siviero. We also wish to thank Sara Cecchetti, Cristina Conflitti, Antonio Conti and Sergio Santoro.

The 15 elementary indicators included in the dashboard belong to four categories: (a) measures of realized inflation (core components, producer price pressures and domestic components); (b) measures of dispersion among countries and among elementary items in the HIPC basket; (c) one-year ahead projections of the annual change in the HIPC, compensation per employee and profit margins (calculated by the ECB and Eurosystem staff); and (d) measures of inflation expectations.²

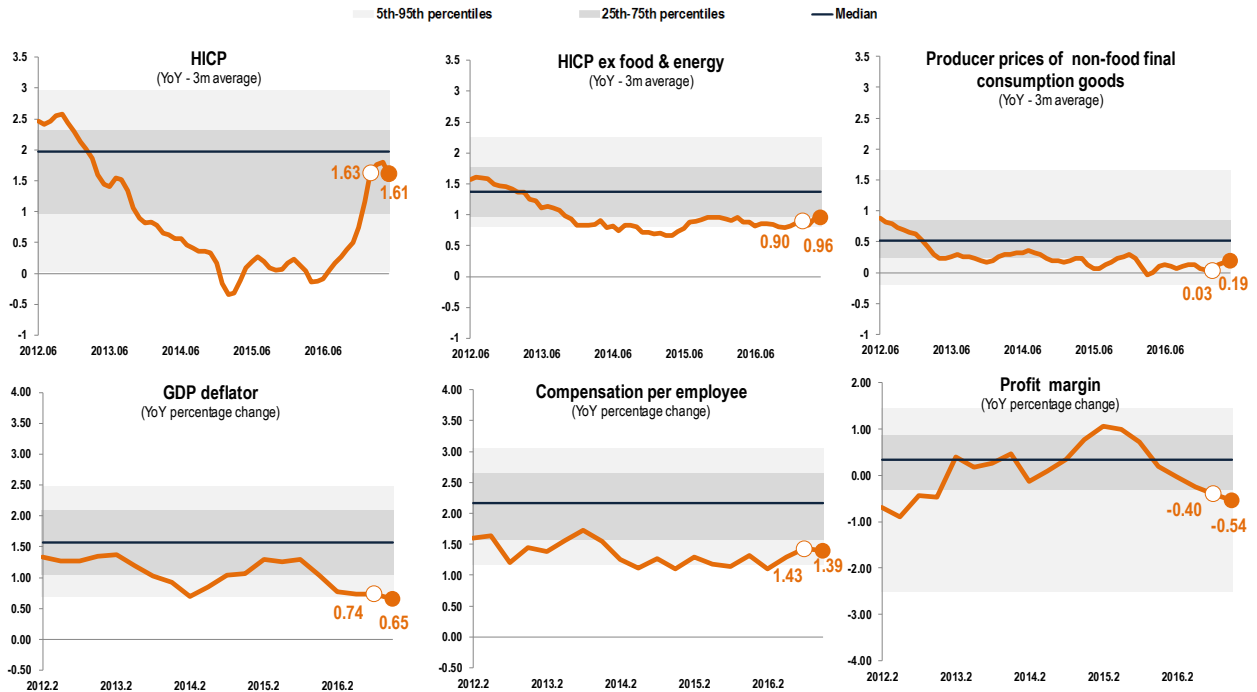
The first category of variables captures current trends in realized inflation. The indicators considered are: the annual growth rate of the harmonized index of consumer prices (HICP); a measure of core inflation, as given by the annual growth rate of the HICP net of food and energy products; underlying inflation pressures captured by the annual growth rate of producer prices of non-food final consumption goods and other domestic components (annual growth rate of the GDP deflator, profit margins and wages). Overall, this set of indicators suggests that the sharp deceleration in euro area consumer prices that has occurred since late 2014 was due not only to a fall in energy prices, but also to the fall of core inflation to historically low values (see Conti, Neri and Nobili, 2015). Domestic price pressures remained extremely weak: producer prices of non-food final consumption goods were barely above zero. Domestic inflation, measured by the GDP deflator, was affected by the level of economic slack. In the labour market, the dynamics of the compensation per employee remained weak in historical perspective. Between May 2016 and June 2017, headline inflation increased noticeably and returned to values closer to 2 per cent, mainly due to the most volatile components. Overall, the indicators of realized inflation included in the dashboard however showed little or no improvement.

The second group of indicators captures the heterogeneity of the inflation rates across countries and across items in the harmonized index of consumer prices. The variables considered are: the shares of items in the HICP index with year-on-year changes within selected ranges; the difference in euro area core inflation and the first principal component extracted from member states' core inflation rates; the number of euro area countries with annual headline inflation lower than 1 per cent. Since 2014 price developments were subdued for a large number of items in the HICP index: in January 2015 the share of HICP components with a negative year-on-year percentage change in the previous year reached a maximum of 35 per cent; the percentage fell to 20 per cent in the first half of 2017, twice as much as the level of 2012. In 2014-15 the weakness in inflation rates was widespread among euro area countries: in early 2015 the number of countries with a HICP rate lower than 1 per cent went up to 19. The difference between euro area core inflation and the principal component extracted from individual member states core inflation suggests that since the beginning of 2014 idiosyncratic country-level dynamics are generating some upward pressure on core inflation in the euro area. In June 2017 the HICP annual growth rate was lower than 1 per cent in six member states only.

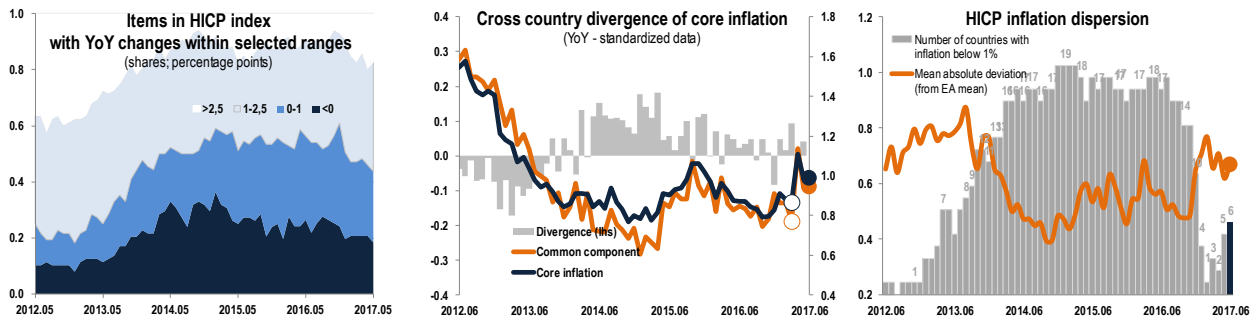
² The full list with data sources is available in Appendix A.

Figure 1: Dashboard

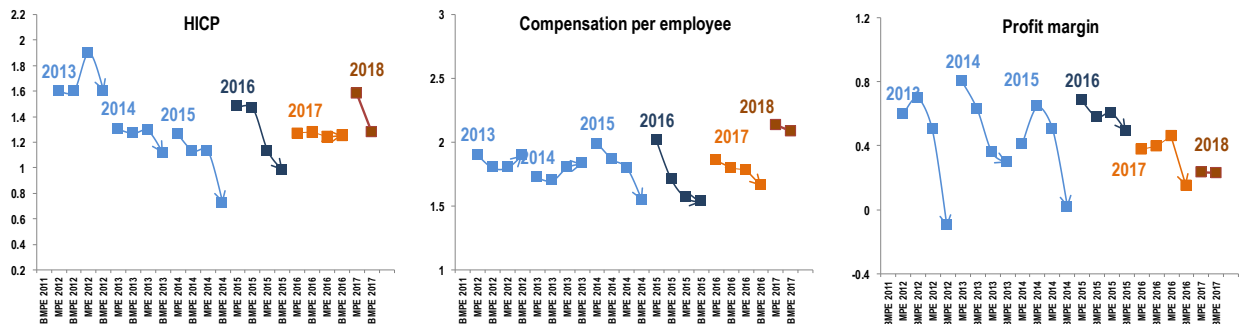
MEASURES OF PAST TRENDS IN REALIZED INFLATION



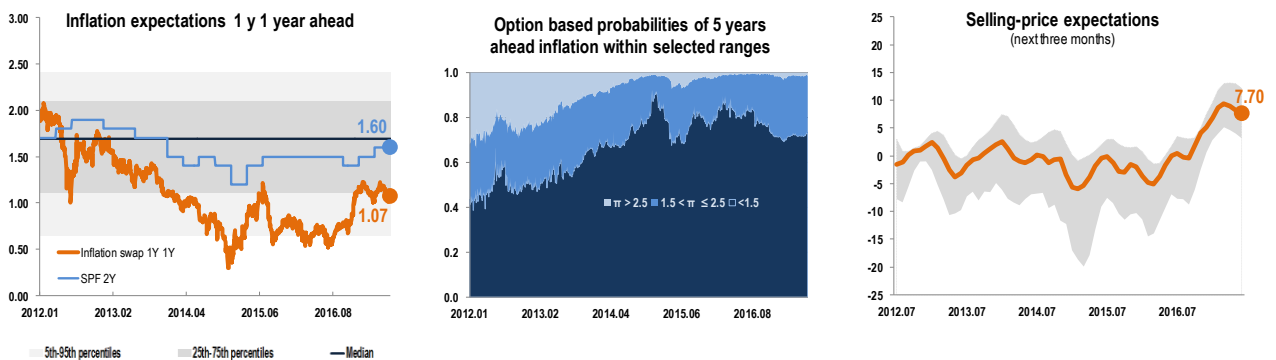
MEASURES OF DISPERSION AND HETEROGENEITY OF REALIZED INFLATION



ONE-YEAR-AHEAD (B)MPES FORECASTS



INFLATION EXPECTATIONS



The last two categories of indicators focus on expected inflation. They include revisions of Eurosystem staff projections on HICP annual growth rate; compensation per employee and profit margins, at a 1-year horizon; annual inflation expectations two-year-ahead as provided by the Survey of Professional Forecasters; market based expectations – extracted from forward rates on market quotes on euro area inflation swaps – on the 1-year, 1-year ahead horizon; option-based probability of a 5-year ahead inflation rate within selected ranges; selling-price expectations in the manufacturing sector¹ on a 3-month horizon. Between 2013 and 2015 inflation expectations were gradually adjusted downwards at all time-horizons, reflecting a sequence of negative news, as the intensity of the decline of the inflation rate had indeed often surprised analysts to the downside;² these surprises have affected market-based inflation expectations, consistently with a learning-type behaviour (see Miccoli and Neri, 2015). Inflation expectations started to rise in late 2016 and picked up in the first part of 2017, reflecting a stronger confidence in the economic recovery.

The dashboard for 2012-2017 is shown in Figure 1. Whenever possible the indicators are coupled with measures of trend and dispersion (i.e. median and inter-quartile range) computed on the entire sample (1999-2017). Overall, the dashboard suggests that, despite the increase in the HICP rate in the first half of 2017, the improvement is still limited to a small number of indicators (in particular, the number of countries with an inflation rate greater than 1 per cent and inflation expectations); in some cases, i.e. profit margins, the recovery observed in 2016 was only temporary. The overall picture is still not consistent with the achievement of a sustained adjustment in the path of inflation towards the policy objective.

3. Deriving a synthetic indicator of inflationary pressures

The dashboard includes a number of variables that conveniently summarize euro area inflation along different dimensions. As new data becomes available, though, the issue arises as to what is the implicit underlying signal that such information brings about.

Aggregation is a non-trivial issue in this context, as the selected variables differ considerably among them, most notably by unit of account, but fundamentally because they represent different aspects of the inflation phenomenon. For instance, wage dynamics reflects price pressures coming from factors of production, while selling price expectations refer to expectation for both costs of production and future demand. If the former increases by 1 percentage point and the latter increases by 1 per cent, what do they imply as to future inflation? In order to meaningfully assess the relative contribution of each variable to the underlying inflation dynamics, a common metric is needed.

¹ These are measured by the balance between the share of manufacturing firms expecting to raise their prices and that of those planning to reduce them (source: European Commission).

² The sequence of negative surprises registered between 2013 and 2015 was a distinctive feature of the recent disinflationary phase; according to recent studies, this may be due to an increased responsiveness of price developments to the high levels of economic slack in comparison with past recessions (see Riggi and Venditti, 2014).

3.1 Methodology

Simple probability models are used to transform the information conveyed by each variable into a single measure. Specifically a *probit* model is estimated for each variable of the dashboard $x_{t,i}$:³

$$\Pr(y_{t,h} = 1 | x_{t,i}) = F(x_{t,i}\beta_{i,h}) \quad i = 1, 2, \dots, N \text{ and } h = 3, 6, \dots, 12, \dots, 24$$

where the dependent variable is binary and defined as follows:

$$y_{t,h} = \begin{cases} 1 & \text{if } \pi_{t+h} \geq 1,9 \\ 0 & \text{otherwise} \end{cases}$$

and π_{t+h} is the year-on-year change of the HICP in the month $t+h$; $F(\cdot)$ denotes the cumulative density function of a standard normal distribution, for each variable $x_{t,i}$ and each time horizon h .

The fitted values, $F(x_{t,i}\hat{\beta}_i)$, span similar ranges, as they are bound by construction to vary within the (0,1) interval, and are homogeneous in nature, as each of them can be thought of as the prospective probability of inflation in the euro area being larger than or equal to 1.9 per cent, for each of the h periods ahead considered, given the information contained in the i -th variable at time t . Fitted probabilities can thus be aggregated in a synthetic index which meaningfully incorporates all the relevant information of the variables included in the dashboard.

The composite index of the inflationary pressures at $t+h$, conditional on the information available at time t , is then derived as a weighted average of the N fitted probabilities:

$$I_{t+h|t} = \sum_{i=1}^N \omega_i^h \cdot F(x_{t,i}\hat{\beta}_i^h) \quad \text{for each } h = 3, 6, 9, 12, 15, 18, 21, 24$$

where ω_i^h is the weight associated to the i -th fitted probability. For each period h , the set of weights $\{\omega_i^h\}_{i=1}^N$ are the loadings from the first principal component of the N fitted probabilities ensuing from the *probit* estimation.⁴ The choice of using principal components as a methodology to derive the weights has at least two advantages. First, it allows the extraction of the components with the highest degree of co-movement, while discarding at the same time the most volatile components. This is of paramount relevance since our index is meant to measure underlying inflation pressures, which are arguably not volatile. Second, it allows the possibility to transparently map the contribution of each variable to the change in the overall index, so that an increase or decrease of the index can be meaningfully decomposed into variations of the underlying variables. Based on our estimates, the weights assigned to the different variables included in the indicator amount to about 0.48 for those related to current trends in realized inflation, to 0.27 for the measures of dispersion and heterogeneity and to 0.25 for inflation expectations.

³ Revisions of (B)MPE forecasts are not included in the computation of the index.

⁴ The first principal component accounts for around 40 per cent of the total variance for each of the horizons considered. The loadings of the first component are positive (showing a positive correlation of the selected indicators with the underlying common phenomenon, i.e. euro area price dynamics). The loadings are rescaled to sum to 1, in order to conveniently allow the composite index to vary within the same range (0,1) as the underlying fitted probabilities.

Figure 2: Composite index of euro area inflationary pressures at t+3
(monthly data)

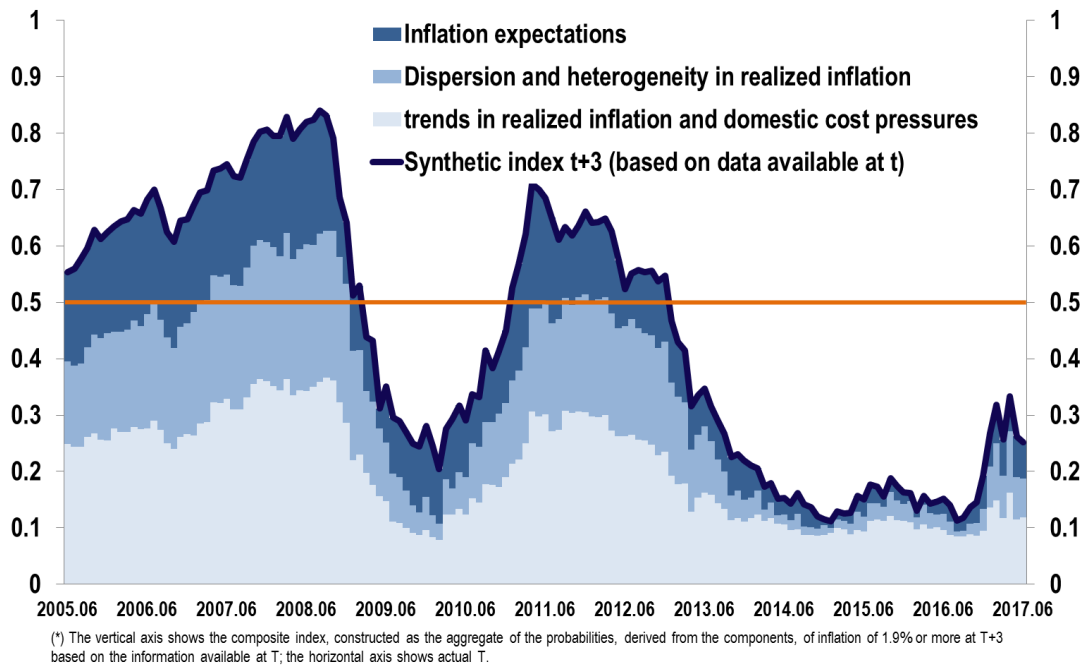


Figure 3: Composite index of euro area inflationary pressures at t+12
(monthly data)

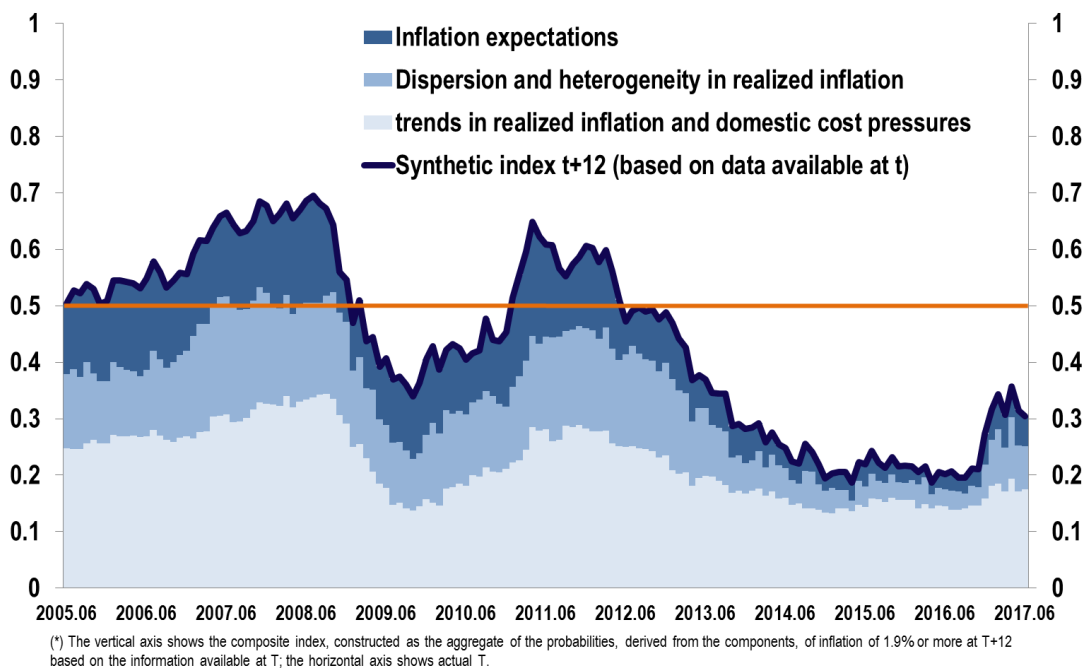


Figure 4: Composite index of euro area inflationary pressures at t+24
(monthly data)

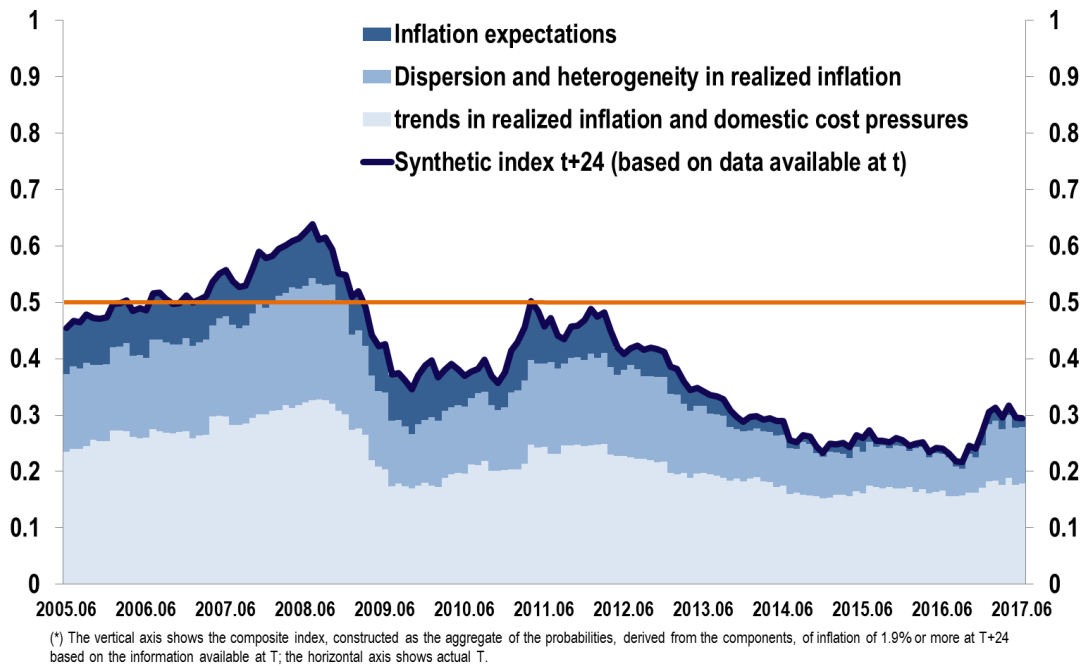
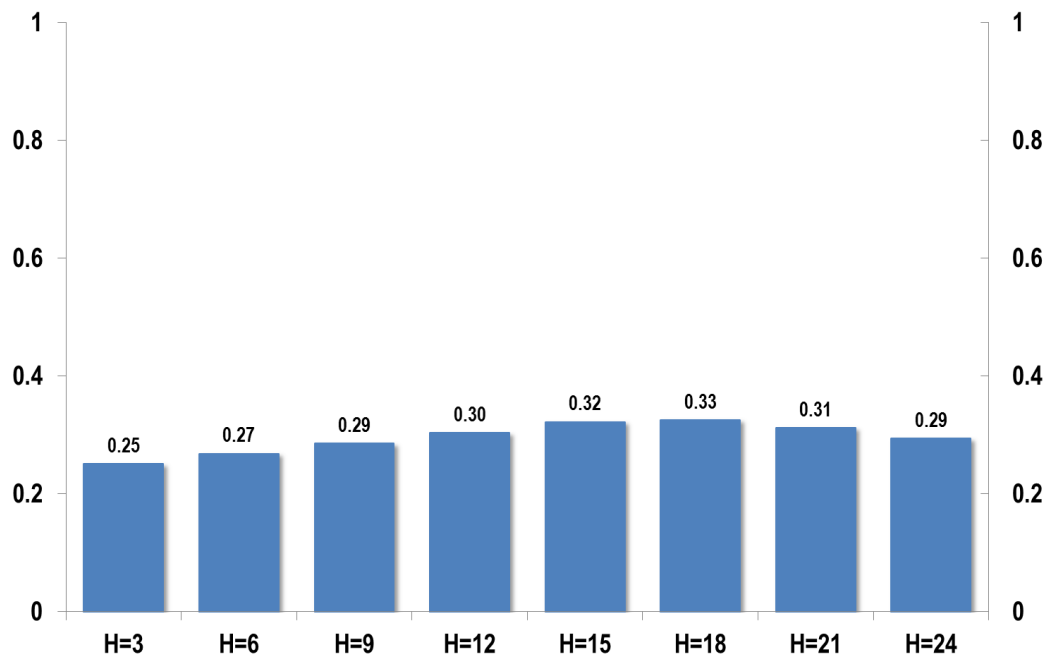


Figure 5: Estimated probability of euro area inflation at t+h being 1.9 per cent or more
(based on information available at t)



3.2 Results

The composite index $I_{t+h|t}$ of euro area inflationary pressures, where $h=3, 12$ and 24 months ahead, is reported in Figures 2, 3 and 4, respectively; in addition to plotting the composite index, each figure highlights the contribution of each group of variables (i.e. trends in realized inflation, dispersion and heterogeneity, inflation expectations). All in all, the composite indexes at different horizons provide broadly similar results.

The probability that the inflation rate returns to values equal to 1.9 per cent or more has declined since mid-2011, reaching a minimum (around 20 per cent) in the biennium 2015-16, for each of the horizons considered. The gradual deterioration of inflation expectations, the spreading of deflationary pressures to an increasing number of euro area countries, and the negative contribution of the domestic components of price dynamics determined its reduction.

In recent months, the composite index exhibited signs of recovery, mainly reflecting the fall of the number of countries with inflation rate below 1 per cent, and the slight improvement of inflation expectations. However, based on the information available in July 2017, the upswing in inflationary pressures seems to have come to a halt. The probability of inflation being 1.9 per cent or more remains in a range of values comprised between 25 and 31 per cent, depending on the horizon considered (Figure 5), much below the reference threshold of 50 per cent, which corresponds to the historical frequency of euro area inflation being 1.9 or more in the sample. These results signal that the adjustment of inflation towards the medium term objective is still limited.

In Appendix B we explore the robustness of our estimates with respect of choosing a different threshold than 1.9 per cent in the *probit* models. We find that the results are qualitatively very similar to those presented here.

3.3 Predictive ability of the indicator of inflationary pressures

In this paragraph we test whether the information provided by our synthetic index is statistically relevant, or else it is redundant with respect to that contained in past and current euro area inflation *per se*. In this section we check the predictive ability of the composite index to fit the episodes of euro area inflation rate being at 1.9 per cent or above, at each $t+h$ horizon. Specifically, we perform a “semi-partial correlation” analysis. In a nutshell, this analysis measures the additional explanatory power of the composite index in predicting future inflation with respect to current inflation only.

The procedure to compute the semi-partial correlation coefficients (and their associated t-statistics) is based on a two-step approach. First, we run a regression of the composite index $I_{t+h|t}$ on the euro area inflation rate:

$$I_{t+h|t} = a + b \cdot \pi_t + e_{t,h}$$

The estimated residuals of this regression, $\hat{e}_{t,h}$, carry the additional information contained in the synthetic index $I_{t+h|t}$ that is orthogonal to the euro area inflation rate. The residuals $\hat{e}_{t,h}$ are then used as regressor in a univariate linear model, with $y_{t,h}$ (which identifies the episodes of euro area inflation h-month ahead greater than or equal to 1.9 per cent) as the dependent variable:

$$y_{t,h} = \alpha + \gamma \cdot \hat{e}_{t,h} + \varepsilon_t$$

The semi-partial correlation coefficient is given by the following formula: $r_{y,(I.\pi)} = \frac{cov(Y, \hat{e}_{t,h})}{\sigma_Y \cdot \sigma_{\hat{e}_{t,h}}}$, with a corresponding t-statistic given by $t_\gamma = \hat{\gamma} / \sigma_{\hat{\gamma}}$. The estimate of the semi-partial correlation coefficient is directly related to the increase in the R-squared achieved when the composite index is added as a regressor to a linear estimation model in which the binary variable $y_{t,h}$ is regressed on current euro area inflation. The estimated values for the semi-partial correlation coefficients, their t-statistic and the associated change in R-squared that would follow the inclusion of the composite index in a model for the prediction of the binary variable $y_{t,h}$, at each $h=3, 6, \dots, 24$ are reported in table 1 (left panel). Results of a similar exercise for a prediction model of euro area core inflation at $t+h$ are shown in the right panel of the table.

Table 1. The semi-partial correlation coefficients

	Binary variable Y_{t+h}			Core Inflation at $t+h$		
	$r_{y,(I.\pi)}$	change in R-squared	t-statistic	$r_{y,(I.c)}$	change in R-squared	t-statistic
<i>h periods:</i>						
3	0.12	0.01	1.48	0.27	0.07	4.53
6	0.20	0.04	2.56	0.40	0.16	6.47
9	0.31	0.10	4.03	0.54	0.29	10.02
12	0.43	0.18	5.45	0.55	0.30	9.97
15	0.46	0.21	6.73	0.51	0.26	9.42
18	0.46	0.22	7.11	0.41	0.17	6.08
21	0.43	0.19	6.73	0.32	0.10	4.41
24	0.41	0.17	6.21	0.31	0.10	3.73

Semi-partial correlation analysis shows that, after controlling for euro area inflation and core inflation, the additional information contained in the composite indicator is statistically relevant for forecasting the episodes of inflation larger than or equal to 1.9 per cent as well as for predicting core inflation, at all time-horizons (with the sole exception of $y_{t,3}$, whose coefficient is statistically different from zero only at a 10 per cent confidence level). Semi-partial correlation coefficients, and their associated increase in R-squared, tend to increase for time-horizons h included in the 12-18 months interval. Based on this evidence, focusing on the composite indicator that provides a measure of inflationary pressures at $t+12$ months appears a sensible choice.

4. Concluding remarks

The timely monitoring of consumer price trends in the euro area is crucial to evaluate the progress towards a sustained adjustment in the path of inflation to the objective of price stability. To this aim, we select a set of indicators, belonging to four broad categories, related to the main underlying

determinants of inflation in the euro area, both at an aggregate and country level. The indicators are illustrated in the form of a dashboard, i.e. an effective, immediate and easy-to-consult graphical tool.

Moreover we derive a composite index that condenses the information carried by the selected variables and provides a synthetic measure of the inflationary pressures in the euro area, net of the most volatile components. Since the indicators included in the dashboard are very diverse, the issue of aggregation is not straight-forward. We resort to *probit* estimation in order to normalize the indicators, allowing to meaningfully assess the relative contribution of each of them.

The synthetic index, obtained by estimation of several univariate probability models aggregated using principal component weights, provides an estimate of the probability of inflation in the euro area being 1.9 per cent or more. The index adds statistically relevant information to that already contained in current trends of inflation; its information content is highest for future horizons of about twelve months.

According to our estimates, the probability that inflation returns to values equal to 1.9 per cent or over in the next twelve months is currently slightly above 30 per cent, higher than the average level in 2015-16 (20 per cent). The synthetic index has trended upwards since late 2016, mostly reflecting the decline in cross country inflation heterogeneity and the recovery in inflation expectations. However, it remains well below the 50 per cent historical threshold, signalling that the adjustment in the path of prices in the euro area is still limited and far from being sustained.

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APPENDIX A – LIST OF SELECTED INDICATORS

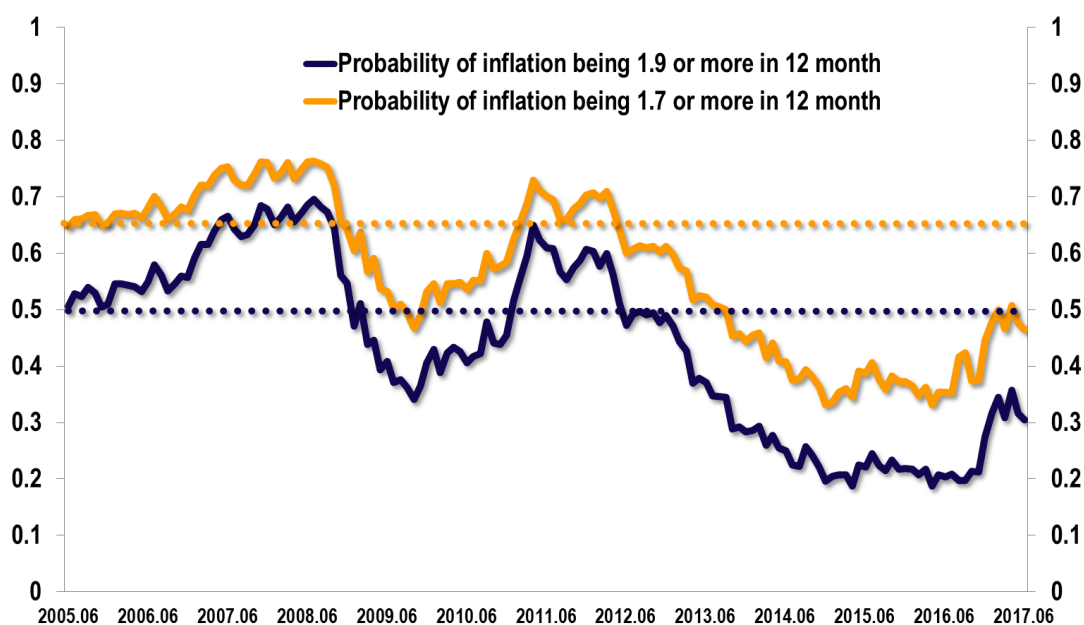
- 1) Measures of past trends in realized inflation
 - 1.1 Euro Area Harmonized Index of Consumer Prices (HICP), year on year percentage change, three months moving average (source: Eurostat).
 - 1.2 Euro Area HICP net of food and energy products, year on year percentage change, three months moving average (source: Eurostat).
 - 1.3 Producer prices of industrial products sold on the domestic market - consumer goods (except food, beverages and tobacco), year on year percentage change, three months moving average (computations on Eurostat data).
 - 1.4 GDP deflator, quarterly data; year on year percentage change (source: Eurostat).
 - 1.5 Compensation per employee – total economy, quarterly data; year on year percentage change (computations on Eurostat data).
 - 1.6 Profit margins, quarterly data; year on year percentage change (computations on Eurostat data).
- 2) Measures of dispersion and heterogeneity in realized inflation
 - 2.1 Share of elementary items of HICP index with year-on-year changes within selected ranges (computations on Eurostat data).
 - 2.2 Annual euro area core inflation and first principal component extracted from the panel of (19) euro-area countries y-o-y percentage change in HICP net of energy and food (computations on Eurostat data).
 - 2.3 Number of euro area countries with year-on-year headline inflation lower than 1.0 per cent and absolute mean deviation from the euro area mean of inflation rates in euro area countries (computations on Eurostat data).
- 3) One year ahead (B)MPE projections:
 - 3.1 HICP, growth rates on previous year.
 - 3.2 Compensation per employee, growth rates on previous year.
 - 3.3 Profit margins, growth rates on previous year.
- 4) Inflation expectations
 - 4.1 1-year 1-year ahead forward rates of inflation swap contracts on euro area inflation (computations on Bloomberg data); Expectations of annual inflation two-year-ahead in the euro area as polled by the *Survey of Professional Forecasters* (source: ECB).
 - 4.2 Risk-neutral probability of annual inflation taking values within selected ranges in the average of the next five years; computations (see Natoli and Sigalotti 2017) on options contracts on euro area inflation (source: Bloomberg).
 - 4.3 Balance of expectations of price increase and decrease of euro area manufacturing firms in the next three months, three months moving average (source: European Commission).

APPENDIX B – CHOICE OF ALTERNATIVE THRESHOLDS

The methodology to derive the composite indicator is based on *probit* estimations, whose dependent variable assumes values zero or 1 depending on prospective inflation being lower or higher than a given threshold. The threshold adopted in this paper is 1.9 per cent. The choice is reasonable for two reasons. Firstly, it conforms to the ECB definition of price stability, defined as inflation being below but close to 2 per cent. Secondly, the frequency of the episodes of inflation being 1.9 per cent or higher is about 50 per cent in the sample, which is a convenient feature when *probit* estimation is performed, as the number of occurrences for both the outcomes of the binary variable $y_{t,h}$ is balanced (Cramer, 1999). However given the arbitrary choice of the threshold, we check whether our results are robust with respect to the choice of an alternative threshold.

Specifically, we present the composite index obtained for a threshold of 1.7 per cent (Figure B1). In June, the indicator based on the 1.9 threshold (blue line) was 30.4 per cent (roughly 20 p.p. below its historical average of 50 per cent); the alternative indicator (yellow line) – measuring the probability that inflation in 12 months is higher than or equal to 1.7 per cent – records larger values (46.4). The historical frequency of inflation of 1.7 per cent or more is however around 65 per cent, much higher than 50 per cent, and once again well above the current value of the index. All in all, the information provided by the two indicators is very similar.

Figure B1. Euro area inflationary pressures at t+12: comparison between alternative threshold



(*) The vertical axis shows the composite index, constructed as the aggregate of the probabilities, derived from the components, of inflation of 1.9% or more at T+12 (blue solid line) or 1.7% or more (yellow solid line) based on the information available at T; the horizontal axis shows actual T.