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by Marcello Miccoli and Stefano Neri

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INFLATION SURPRISES AND INFLATION EXPECTATIONS IN THE EURO AREA

by Marcello Miccoli[†] and Stefano Neri[†]

Abstract

Since 2013 the inflation rate in the euro area has fallen steadily, reaching all-time lows at the end of 2014. Market-based measures of inflation expectations (such as inflation swaps) have also declined to extremely low levels, which suggests increasing concern about the credibility of the ECB in maintaining price stability. Inflation releases have often surprised analysts on the downside. Our analysis shows that market-based inflation expectations, at medium-term maturities, are affected by these ‘surprises’, over and above the impact of changing macroeconomic conditions and oil prices.

JEL Classification: E31, E52 C22, C32.

Keywords: inflation; inflation expectations; inflation swap contracts.

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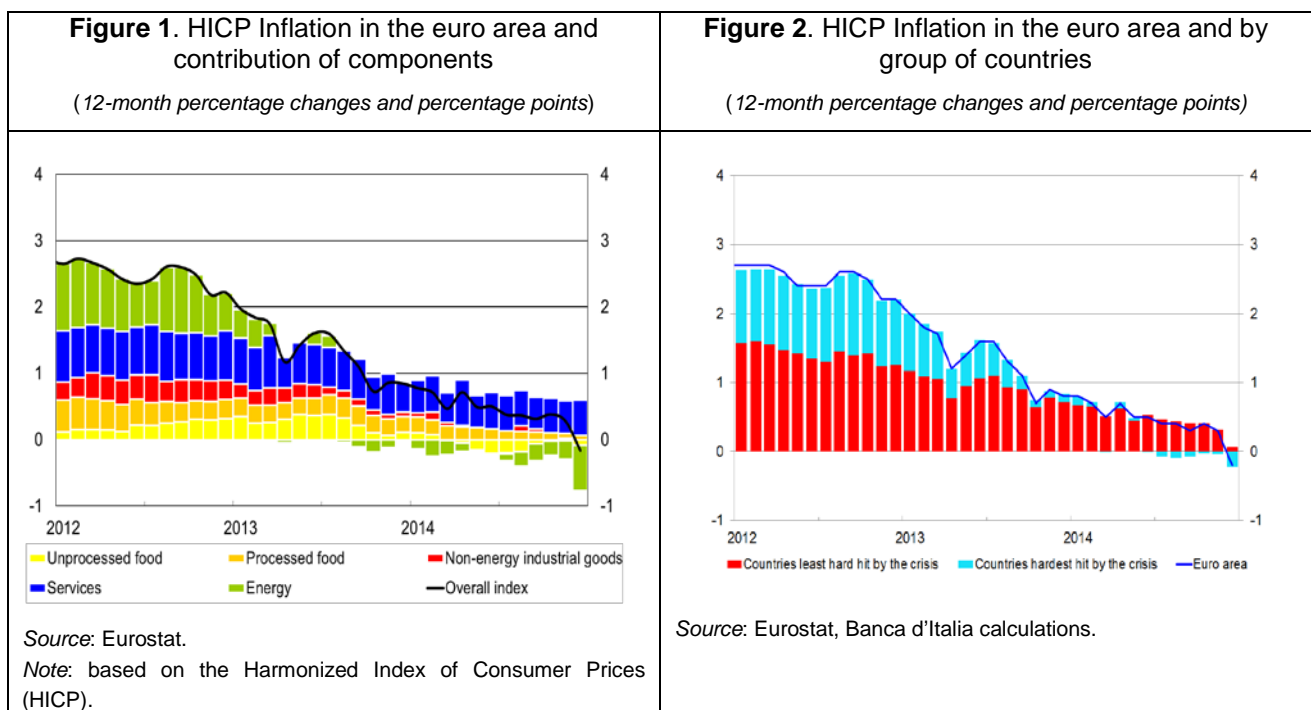
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1. Introduction

[...] The firm anchoring of inflation expectations is critical under any circumstances, as it ensures that temporary movements in inflation do not feed into wages and prices and hence become permanent. But it is even more critical in the circumstances we face today. This is because if inflation expectations fall, the real interest rate rises, which is the interest rate that matters most for investment decisions. And because nominal short-term rates in the euro area have already reached the effective lower bound, they cannot be adjusted downwards further to compensate for this. In other words, any de-anchoring of expectations would cause an effective monetary tightening – the exact opposite of what we want to see.

Mario Draghi, President of the ECB¹

Euro-area inflation fell throughout 2014 and reached a negative value, -0.2% in annual terms, in December 2014 (Figure 1);² core inflation was as low as 0.7%. The fall in inflation since early 2013 can be only in part attributed to the fall in prices of energy goods and unprocessed food. The other components (non-energy industrial goods, processed goods and services) have also been marked by subdued price dynamics. Part of the decline of core inflation can be explained by its increased sensitivity to the output gap, as recently shown by Riggi and Venditti (2014). Inflation has been falling to historically low levels not only in the countries which have been hit the hardest by the sovereign debt crisis; to the contrary, prices have been decelerating also in the countries less directly affected by the crisis (Figure 2); in December in no country of the euro area the inflation rate was above 1 per cent.

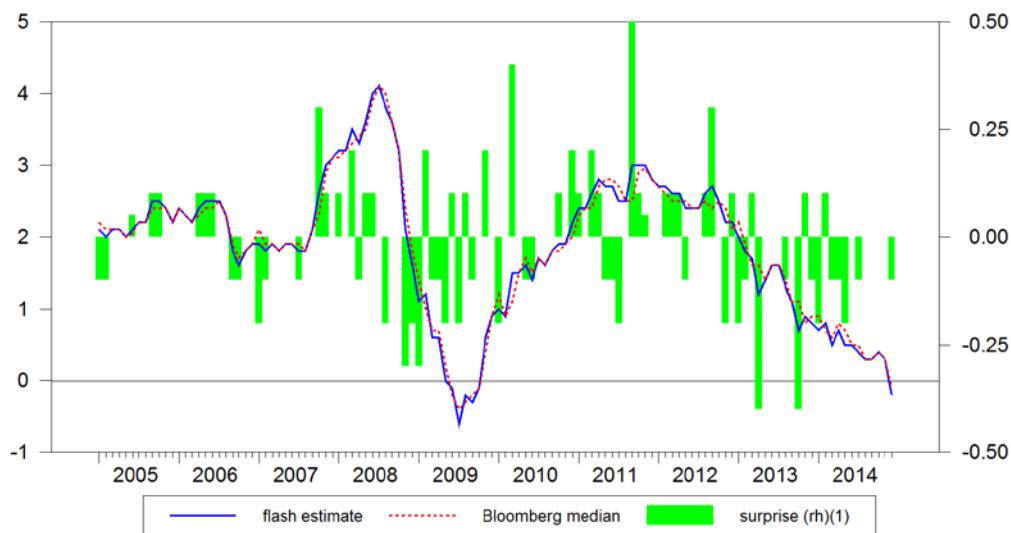


¹ “Monetary policy in the euro area”, speech by Mario Draghi at the Frankfurt European Banking Congress, Frankfurt am Main, 21 November 2014.

² A lower value had only been reached in July 2009 (-0.6 per cent), as the result of rapidly falling oil prices in late 2008.

Low inflation characterizes several sectors of economic activity and euro-area countries, supporting the view that weak aggregate demand is playing a key role in keeping inflationary pressures subdued.³ The strength of the decline in inflation has been largely unexpected by market analysts. Figure 3 shows the series for the flash release of HICP annual inflation together with the median of analysts' forecasts polled by Bloomberg and their difference (henceforth inflation "surprise").

Figure 3. Analysts' expectations on inflation and data releases
(percentage points)



Source: Bloomberg and Banca d'Italia calculations.

Note: (1) HICP inflation flash estimate minus the median of analysts' forecasts surveyed by Bloomberg.

Starting from the final months of 2012, analysts have very often under-predicted the decline in inflation. In 2013 the surprises were particularly negative and large (-0.4%) in April and October. In the first case, inflation was 1.7 per cent in the previous month (March), on a downward trend that had started in the summer of 2012. In the second case, inflation was at 1.1 per cent in September 2013.

The October surprise was particularly shocking for the markets.⁴ According to Bloomberg, "*Euro-area inflation cooled to the slowest in almost four years in October, moving further away from the European Central Bank's goal. [...] The data mark the ninth straight month that the rate has been less than the ECB's 2 per cent ceiling, and they prompted BNP Paribas SA and JPMorgan Chase & Co. to forecast an interest-rate cut by*

³ "Once again, a number of exogenous factors affected price developments, going from food and energy price declines, to the appreciation of the euro against the dollar since mid-2012 to May of this year, and finally to the relative price adjustment that had to happen in the stressed euro area countries. But there are increasing signals that insufficient aggregate demand is also playing an important role", Vítor Constâncio, speech at the 18th Annual Central Bank and Investment Authority Seminar, Berlin, 16 October 2014.

⁴ The markets' reaction to the April surprise was more muted since in that case the shock was less broad-based, being mainly due to unexpected seasonal changes in the prices of service in Germany.

the ECB in December [...]” (<http://www.bloomberg.com/news/2013-10-31/euro-area-inflation-rate-unexpectedly-falls-to-lowest-since-2009.html>).

The decline in inflation has clearly resulted in lower short-term market based inflation expectations: rates on inflation swaps contracts with maturity of two years have been constantly declining, reaching negative values in December 2014 (Figure 4). However also rates on longer maturities contracts and forward rates (e.g. five-year five-year ahead) have been declining, signalling expectations of persistent low inflation. The results of the Survey of Professional Forecasters (SPF), periodically released by the ECB, confirm this picture: the average forecast for inflation expectations in five years declined to 1.77 per cent in the 2014-Q4 survey, from 2.0 in the first quarter of 2013, the two-year ahead from 1.9 to 1.4. Concerns about the risk of a de-anchoring of inflation expectations have been voiced by several members of the Governing Council of the ECB (see, e.g., the quote at the beginning of this Section).

Figure 4: Inflation expectations based on inflation swap yields
(daily data, percentage points)



Source: Bloomberg.

In this work we analyse the extent to which inflation surprises have led investors to revise their inflation expectations, as measured by rates on inflation swap contracts, beyond what already implied by concurrent indicators of the economic cycle. We focus our analysis on market-based inflation expectations as they embody more up-to-date information compared with survey-based measures, which are usually available at quarterly frequency (e.g. the SPF of the ECB). The caveat is that given investors' risk aversion, market-based measures are also influenced by risk and liquidity premia that may distort their information content, which does not apply to survey-based expectations.

We perform a regression analysis of inflation swaps rates (at different maturities) in the days immediately following the release of the flash estimate of the HICP on inflation

surprises, controlling for other macroeconomic variables. Our results show that inflation surprises are significantly associated to revisions in inflation expectations. This is the case not only for rates on inflation swap contract at medium-term maturities (two or three years), but also for both longer term ones (five years) and forward rates. Bauer (2014) also documents that inflation swap contracts rates based on US price indexes are influenced by surprises on several types of macroeconomic data releases. Our analysis will focus on the inflation surprise only. However, differently from his work, our empirical strategy will also control for cyclical information available to market participants that might decrease the impact of inflation surprises.

The remainder of the paper is organised as follows. Section 2 describes the data and the statistical properties of inflation surprises. Section 3 assesses the impact of these surprises on market-based measures of inflation expectations. Section 4 carries out some robustness exercises and Section 5 concludes.

2. Data

2.1. Inflation surprises in the euro area

Our main explanatory variable is the surprise in realized inflation, measured by the difference between the monthly flash release by Eurostat of HICP annual inflation and the analysts' median expectation of its value as polled by the Bloomberg survey in the days immediately before the inflation release (Fig. 3). We focus on the median of analysts' expectations since it is less influenced by extreme values.

The surprises were persistently negative between August 2008 and June 2009, after the collapse of oil prices, and between the beginning of 2013 and the end of 2014. In these two periods the average surprise was, respectively, -0.10 and -0.07, compared with a zero average over the whole sample. Surprises were instead mostly positive in 2011 and 2012. Selected summary statistics are reported in Table 1.

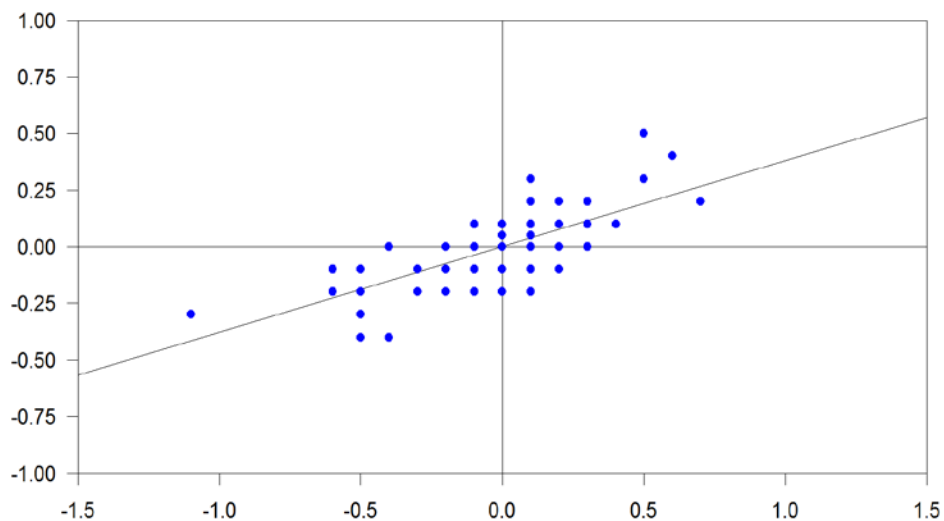
Table 1 – Statistical properties of inflation surprises

	value	<i>p</i> -value statistic = 0
<i>Mean</i>	-0.0079	0.522
<i>Median</i>	0	-
<i>Standard deviation</i>	0.135	-
<i>Skewness</i>	0.227	0.315
<i>Excess kurtosis</i>	2.295	0
<i>First order correlation</i>	0.069	0.418

Note: sample period: January 2005 – December 2014. Number of observations: 120. *Source:* Bloomberg.

The mean is almost zero and distribution of the surprises is symmetric. Out of 132 observations, 50 refer to a zero surprise, 33 to a positive surprise and 37 to a negative one. The mean in 2013 and 2014 is -0.075, ten times larger than in the full sample, indicating increased difficulties in forecasting current inflation. The tails of the distribution are fatter than those of a normal one; indeed, the test that excess (with respect to that of a normal distribution) kurtosis is zero is failed. The first order autocorrelation is zero. Inflation surprises are positively correlated with the monthly changes in annual inflation, as one would expect; when inflation decreases (increases), surprises tend to be negative (positive) (Fig. 5). The coefficient of regression of inflation surprises on monthly changes in inflation is equal to 0.38 and highly significant. This finding is important: in periods of prolonged decline of inflation, surprises tend to be persistently negative.

Figure 5: Inflation surprises and changes in realized inflation
(x-axis: inflation surprises; y-axis: monthly changes in inflation)



Source: Bloomberg. Note: The line represents the fit of a regression of the inflation surprise on the monthly changes in the inflation flash estimate.

Sample: January 2005 – December 2014.

2.2. Inflation swaps contracts

An inflation swap is a derivative contract by which one counterparty is entitled to receive a payment equal to the realised inflation rate over an agreed time horizon (e.g. two years) in exchange for a fixed rate, given a nominal amount of the contract. The fixed rate reflects the expected rate of inflation by the investor over the contract time horizon.

Three features of inflation swap contracts need to be mentioned. Firstly, the reference inflation rate for the contract is computed with respect to the index of euro-area HICP excluding tobacco (HICPxT); this could create a potential discrepancy in interpreting the yields on inflation swap contracts as a predictor of expected rates of inflation computed with respect to the euro area headline HICP; however, the two indexes are strongly

correlated and the average difference is small (0.07 per cent on average in the full sample). Secondly, the inflation swap contract features an indexation lag, that is, the starting reference value of the price index predates by three months the date of the contract. For instance, a two-year contract traded in month t compares changes in the price index between month $t-3$ and month $t+21$. This implies that surprises in expected inflation in month t will, as a rule, be mechanically reflected in the inflation swap rates, although this does not need to be always the case.⁵ We take into account this possible bias in our analysis by also considering forward inflation swap rates, that is rates implied by spot rates on inflation swap contracts, whose time horizon does not incorporate the value of the price index in month t .⁶ Lastly, inflation swap rates are not “pure” measures of inflation expectations, since they incorporate several types of risk premia. While a precise quantification of these premia is beyond the scope of this work, to the extent that these are not significantly time varying and/or correlated with inflation surprises, our analysis remains valid (see also the discussion in the Introduction).

The dataset includes rates (in annual terms) on inflation swap contracts with a maturity of one, two, three and five years between January 2005 and December 2014, as provided by Bloomberg.⁷ We use rates on the two, three and five years horizons directly as dependent variables in our analysis, while we use the rate on the one-year maturity only to compute forward rates: the one-year one-year ahead and the one-year two-year ahead rates will also be dependent variables in our regressions. Since flash inflation is released once a month, while inflation swap contracts are traded continuously, we take the average over the ten working days following the release of the close-of-business rate of inflation swap contracts, as provided by Bloomberg. Table 2 reports selected statistics.

Table 2 – Statistical properties of rates on inflation swap contracts

	two-year	three-year	five-year	one-year ahead	two-year ahead
<i>Mean</i>	1.70	1.76	1.86	1.78	1.89
<i>Median</i>	1.76	1.82	1.94	1.88	2.03
<i>Std. dev.</i>	0.55	0.49	0.40	0.50	0.40
<i>Skewness</i>	-0.64	-0.68	-0.71	-0.43	-0.72
<i>Excess kurtosis</i>	0.46	0.54	0.54	0.21	0.27
<i>First order corr.</i>	0.92	0.92	0.92	0.91	0.91

Source: Bloomberg. Note: sample period January 2005 – December 2014. Statistics based on the average yields on swap contracts in the ten days after the HICP inflation release.

⁵ To illustrate this point consider for instance the case of a lower than expected value of inflation in month t : if this is interpreted by investors as determined by particular instances that are going to be reversed, i.e. the price level is expected to increase with a higher pace (compared with before the release) over the following months of the contract, then inflation swap rates should not be revised.

⁶ For instance, a forward inflation swap rate one-year one-year ahead in month t defines the expected inflation rate between month $t+9$ and month $t+21$.

⁷ We do not consider five-year inflation expectations five-year ahead because in principle they should not be influenced by surprises to current price dynamics.

The average rate on inflation swap ranges between 1.7 per cent at the two-year horizon to 1.9 for the one-year two-year ahead rate. Similarly the median increases with the maturity of the contract. Both the median and the mean are higher in the pre-mid-2008 period and lower afterwards. The volatility, instead, declines with the maturity. All maturities display a negative skewness (i.e. the tail on the left side of the probability density function is longer or fatter than the right side) suggesting that values below the median are more likely. No yield displays excess kurtosis, i.e. the tails are as thick as those of the normal distribution. Finally, all the yields are very persistent, with an average first order correlation of 0.91.

3. Assessing the impact of inflation surprises on inflation expectations

In this Section, we quantify the impact of inflation surprises on market-based measures of expectations, taking macroeconomic conditions into account.

3.1. The econometric model

We estimate a simple linear model for k -year rates on inflation swaps ($\pi^{e,k}$) and one-year and two-year ahead rates. While many factors can explain the changes in inflation swaps rates, we take a parsimonious approach: the macroeconomic explanatory variables are the change in euro-denominated oil prices (ΔP^{oil}), the unemployment rate (u), a set of dummies D to account for anomalous observations in the 2008-2009 recession and the inflation surprise variable (π^s). The following equation defines our baseline linear model:

$$\pi_t^{e,k} = \alpha_0 + \alpha_1 \Delta P_t^{oil} + \alpha_2 u_{t-1} + \alpha_3 D + \alpha_4 \pi_t^s + \alpha_5 \pi_{t-1}^{e,k} + \varepsilon_t \quad (1)$$

where $\pi_t^{e,k}$ indicates the average inflation swap rate at the k -year maturity in the ten working days following the HICP release; ΔP_t^{oil} is the change in the monthly average of Brent crude oil one-month forward price; u_{t-1} is the latest available euro area unemployment rate figure; $\pi_{t-1}^{e,k}$ is the average inflation swap rate at the k -year maturity in the ten working days preceding the HICP release.

3.2. Results

The equation is estimated with Ordinary Least Squares (OLS) over the period January 2005 – December 2014. The changes in oil prices and the unemployment rate enter the equation as deviations from their respective sample means. Table 3 reports the estimated coefficients together with the t -statistics for their significance. Figure 6 reports the actual and fitted values.

Table 3 – Estimated coefficients

Coefficient	two-year		three-year		five-year		one-year ahead		two-year ahead	
	Value	<i>t-stat</i>	Value	<i>t-stat</i>	Value	<i>t-stat</i>	Value	<i>t-stat</i>	Value	<i>t-stat</i>
α_0 - constant	0.274	4.21	0.286	3.74	0.280	3.41	0.360	3.26	0.355	2.94
α_1 - Δ oil price	0.505	2.42	0.413	2.08	0.336	1.81	0.319	1.50	0.254	0.95
α_2 - unemployment	-0.035	-3.39	-0.035	-3.17	-0.029	-2.90	-0.049	-3.17	-0.040	-2.94
α_4 - infl. surprises	0.267	4.10	0.204	4.00	0.139	2.90	0.124	1.64	0.078	1.21
α_5 - infl. expect. lag	0.843	23.24	0.841	20.33	0.853	19.99	0.802	13.33	0.813	12.95

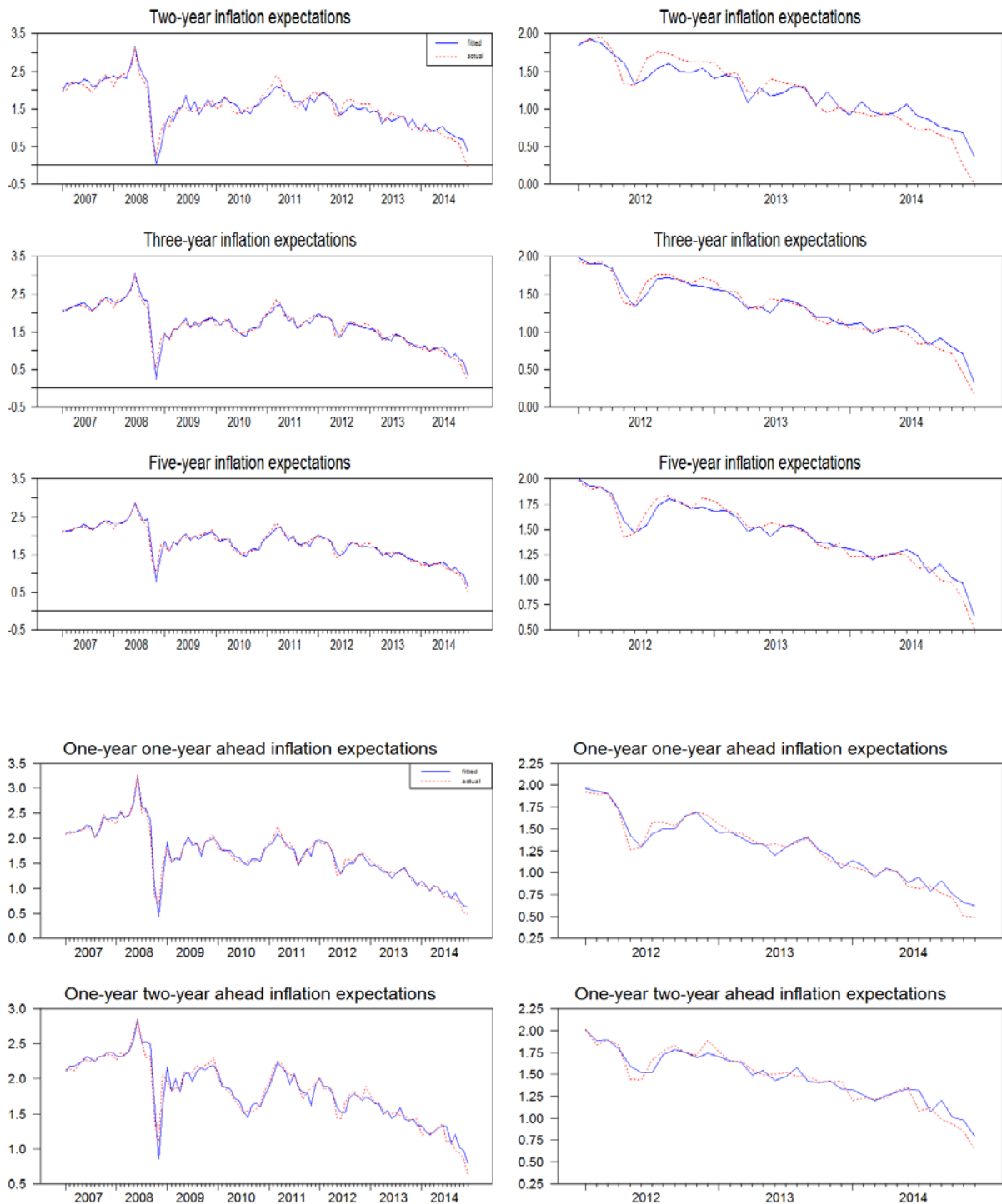
Note: equation estimated with OLS; standard errors are computed using the Heteroskedasticity and Autocorrelation Consistent (HAC) estimate of the covariance matrix of the coefficients; sample period January 2005 – December 2014.

As far as the point estimates are concerned, the coefficient on lagged inflation expectations ranges between 0.80 and 0.84, suggesting that inflation expectations based on inflation swap rates are characterized by a relatively high degree of persistence. The long-run value of inflation expectations, based on the coefficients of the two-year ahead equation, is estimated to be 1.9, close to the long-term expectations measured by Consensus Economics and by the Survey of Professional Forecasters of the ECB. The unemployment rate has a negative and statistically significant impact on inflation expectations at all maturities: a 1 per cent increase in the euro area unemployment rate is associated with a decrease of around 4 b.p. in inflation swap rates. Finally, changes in oil prices have a significant impact only on two and three-year inflation expectations, while it seems not to be relevant for the five year horizon and for forward rates.

The coefficient associated with inflation surprises is significant and equal to 0.27 for the two-year maturity; not surprisingly, the magnitude of the estimated coefficient decreases (and remains significant) with the maturity of the inflation swap rates: it is 0.20 for the three-year and falls to 0.14 for the five-year one. For the two-year maturity, the estimated coefficient implies that, on average, a negative inflation surprise of 0.4 p.p. (as the one observed in October 2013) lowers inflation expectations by 11 b.p. As to forward rates, the coefficient of inflation surprises is not statistically significant for the two-year ahead rate, but it is significant (at 10 per cent) for the one-year ahead rate: an inflation surprise similar in magnitude to the one observed in October 2013 is associated to a reduction of one year ahead inflation expectations of 5 b.p. Even though the magnitude of the coefficient seems small, this is the effect of a one-off surprise to inflation only, the consequences of a long sequence of negative surprises are clearly larger; moreover repeated negative surprises may lead investors to revise their expectation formation

process, by attaching a larger weight to the most recent information (Marcet and Nicolini, 2003).⁸

Figure 6: Actual and fitted values
(monthly data; per cent)



Note: Blue solid lines: fitted values; red dashed lines: actual values.

⁸ Hordal and Tristani (2010) document that inflation risk premia (based on the analysis of nominal and inflation linked bonds) vary with inflation. Adding inflation as a regressor in our model does not significantly alter our results.

Figure 6 shows that equation (1) provides a satisfactory description of inflation expectations for all the maturities. The right column, which zooms on the last three years, shows that the models have some difficulties in explaining the declines of inflation expectations in the last part of 2014, with persistent negative residuals.

To sum up, inflation surprises exert a significant impact on inflation expectations, the effect being stronger at shorter maturities. The inflation surprises also influence forward inflation expectations, which, as argued above, do not need to be mechanically affected by inflation surprises; this evidence suggests that news on price developments leads investors to revise their expectations about future inflation.

4. Assessing the robustness of the results

In this section we test the robustness of the results in section 3 by using different estimation methods, specification of the model and estimation periods.

4.1. SUR estimation

In this section we test the robustness of the findings to an alternative estimation procedure which takes into account the possibility that the error terms in the equations for the inflation expectations at various horizons may be correlated. The Seemingly Unrelated Regression (SUR) serves to this purpose, as it allows for a gain in efficiency by combining the information from the different equations (Moon and Perron, 2006).

Table 4 – Estimated coefficients: SUR estimation

Coefficient	two-year		three-year		five-year		one-year ahead		two-year ahead	
	Value	<i>T-stat</i>	Value	<i>T-stat</i>	Value	<i>T-stat</i>	Value	<i>T-stat</i>	Value	<i>T-stat</i>
α_0 - constant	0.336	5.50	0.347	5.54	0.347	5.65	0.396	5.23	0.370	5.57
α_1 - Δ oil price	0.562	2.53	0.461	2.09	0.377	1.86	0.352	1.62	0.260	0.96
α_2 - unemployment	-0.043	-4.75	-0.043	-4.97	-0.036	-4.87	-0.054	-4.72	-0.041	-4.79
α_4 - infl. surprises	0.281	4.15	0.213	3.79	0.142	2.74	0.126	1.68	0.078	1.20
α_5 - infl. expect. lag	0.807	23.85	0.807	23.8	0.817	25.2	0.782	18.98	0.807	23.6

Note: equations estimated with SUR; standard errors are computed using the Heteroskedasticity and Autocorrelation Consistent (HAC) estimate of the covariance matrix of the coefficients; sample period January 2005 – December 2014.

Comparison of Tables 3 and 4 confirms that the SUR approach yields more precise estimates for almost all the parameters.⁹ The point estimates are close to those obtained with OLS, confirming the results discussed in Section 3. The impact of inflation surprises is

⁹ The correlation between the residuals of the system is indeed large, ranging between 0.5 and 0.96.

lower for longer-term expectations and the unemployment rate is significant in all the equations; the effect of changes in oil prices decreases with the maturity and does not affect forward inflation expectations.

4.2. Sub-sample analysis

In this section we test the robustness of the findings to alternative sample periods. We consider the following samples: 2005:1–2008:6, 2008:7–2014:12 and 2010:5–2014:12. The first two samples are chosen on the basis of the evolution of oil prices, which surged in the first half of 2008 and then collapsed in the autumn of the same year. The second sample also corresponds to the post global financial crisis period, while the last sample, beginning in May 2010, corresponds to the euro-area sovereign crisis. Table 5 reports the results of the estimation of equation (1) over these periods.

Table 5 – Estimated coefficients: sub-sample estimation

Coeff.	Two-year			Three-year			Five-year		
	05:1-08:7	08:8-14:12	10:5-14:12	05:1-08:6	08:8-14:12	10:5-14:12	05:1-08:7	08:8-14:12	10:5-14:12
α_0	0.793**	0.252**	0.160**	0.715**	0.274**	0.167**	0.595**	0.272**	0.186**
α_1	0.407*	0.484	0.964**	0.340**	0.418	0.899**	0.275**	0.359	0.873**
α_2	-0.03	-0.037**	-0.017	-0.034**	-0.036**	-0.019	-0.032**	-0.029**	-0.018
α_4	0.461**	0.252**	0.339**	0.358**	0.190**	0.240**	0.241**	0.127**	0.133**
α_5	0.609**	0.857**	0.911**	0.647**	0.849**	0.911**	0.708**	0.857**	0.905**

Table – 5 cont'd

Coeff.	one-year ahead			two-year ahead		
	05:1-08:7	08:8-14:12	10:5-14:12	05:1-08:6	08:8-14:12	10:5-14:12
α_0	0.775**	0.346**	0.192**	0.227	0.378**	0.249**
α_1	0.381*	0.289	0.419	0.132	0.318	0.857**
α_2	-0.031**	-0.052**	-0.034*	-0.024**	-0.043*	-0.032**
α_4	0.474**	0.081	0.220**	0.123**	0.063	0.038
α_5	0.625**	0.811**	0.909**	0.884**	0.803**	0.877**

Note: standard errors are computed using the Heteroskedasticity and Autocorrelation Consistent (HAC) estimate of the covariance matrix of the coefficients. A * denotes statistical significance at 10 per cent, two ** at 5 per cent.

Inflation surprises have a significant effect on inflation expectations in all sample periods for the two, three and five-year horizons, confirming the results discussed in Section 3. As for one and two-year ahead expectations, in the first case the inflation

surprise is statistically significant in the pre 2008 and post 2010 sample periods while in the second case only in the pre-2008 period. These results broadly confirm those obtained with the full sample period. The unemployment rate is significant in almost all cases while the estimates of the coefficient on oil price changes significantly across sample periods and inflation expectations.

5. Conclusions

Central banks extensively monitor inflation expectations, which are crucial in calibrating the stance of monetary policy and measuring their credibility. In the euro area the persistent decline of longer-term expectations in 2014 has raised concerns about the credibility of the ECB.

In 2013 and 2014, in the context of weakening economic activity, inflation releases have often fallen short of market expectations. Several factors may have played a role in driving inflation expectations to unprecedented lows. In our analysis we have focused on a specific factor: the release of inflation data and the corresponding surprise for investors.

The paper finds that inflation “surprises” in the euro area have an impact on inflation expectations, thus suggesting that the expectation formation process is consistent with learning-type or, more generally, adaptive behaviour. A sequence of negative inflation surprises, in particular in periods when the economic cycle weakens, may lead to persistent deviations of expectations from the target of monetary policy.

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