

Unexpected the expected in forecasting inflation: a real-time analysis for the euro area

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work in progress

Outline

1. Motivation
2. Literature
3. Inflation expectations in empirical (NK)PC models
 - * Conceptual framework
 - * Data
 - * Empirical strategy
4. What we find
5. Conclusions and next steps

Motivation

Motivation

Can we **robustly identify whose inflation expectations** matter the most - if any - to EA inflation dynamics?

Is there an expectations channel of monetary policy?

- ▶ We take it to the **analysis of the predictive power and forecasting stability** of inflation models in the open-economy (NK)PC tradition.
- ▶ We take it to the **real-time** realm since the update of inflation expectations contains information at time t about the (perceived) future, and since a snapshot is not enough for identification.
- ▶ Rich EA real-time quarterly dataset (1st **vintage** 2009:Q1).
- ▶ Is there an agent whose **expectational shifts** affect EA inflation dynamics?

Literature

Literature

- ▶ On the causal effects that run from inflation expectations to the economic decision-making of households and firms (e.g., Crump et al. (2015), D'Acunto et al. (2016), Dräger and Nghiem (2018), Duca et al. (2018), Coibion et al. (2019, 2020)).
- ▶ On the inclusion of expectations measures in PC model:
 - * Empirical limitations of the PC when combined with the FIRE assumption (NKPC as in Woodford, 2003). By limitations, the low predictive power of out-of-sample forecasts, the sensitivity to the slack variable used, the absence of inflation persistence, or the missing disinflation puzzle (e.g., Stock and Watson (2007, 2010), King and Watson (2012), Mavroeidis *et al.* (2014), Coibion *et al.* (2018), Bobeica and Sokol (2019)).
 - * The use of survey expectations appears to alleviate many of these shortcomings (e.g., Brissimis and Magginas (2008), Adam and Padula (2011), Fuhrer *et al.* (2012), Fuhrer (2017), Coibion and Gorodnichenko (2015)).
 - * For the US, Coibion *et al.* (2018) find that HHs expectations make the PC more stable and with more predictive power than other real-time expectations (financial, expert).
 - * On the evaluation of the PC as a forecasting tool (Bańbura and Bobeica, 2023).

Literature

- ▶ For EA inflation dynamics, smaller literature, e.g.:
 - * On the existence of a PC and its main determinants (Cicarelli and Osbat (2017), Bobeica and Sokol (2019), Eser *et al.* (2020)).
 - * On the role of global factors (Béreau *et al.*, 2018).
 - * On the probability of inflation convergence to its long-term mean (Moretti *et al.*, 2019).
 - * On the predictive power of survey- and market-based inflation expectations (Bańbura and van Vlodrop (2018), Grothe and Meyler (2018), Kulikov and Reigl (2019), Álvarez and Correa-López (2020)).
- ▶ **Our contribution:**
 - * **Real-time forecast evaluation (predictiveness and stability)** of inflation models (headline, core).
 - * **Robust identification of the type of inflation expectations** that matter the most to EA inflation dynamics.

Inflation expectations in empirical (NK)PC models

Conceptual framework

Estimate inflation models in vintage ν of the form (headline and core):

$$\pi_{\nu,t} = c + \alpha\pi_{\nu,t-1} + \beta E_{\nu,t}(\pi_{t+j}) + \sum_{l=0}^{l_{max}} [\gamma_l s_{\nu,t-l} + \delta_l p_{\nu,t-l}^{input}] + \epsilon_{\nu,t} \quad (1)$$

- ▶ Quarter t , structure $l : l \in \{0, 1\}$, vintages ν for 2009:Q1 - 2023:Q4.
- ▶ $E_{\nu,t}(\pi_{t+j})$ denotes expected inflation conditional on information available in quarter t .
- ▶ $s_{\nu,t}$ is a macro measure of excess demand (ogap, ugap, GDP growth, unemployment rate); $p_{\nu,t}^{input}$ captures the evolution of input costs, both domestic (ULC) and imported (import prices, NEER); $\epsilon_{\nu,t}$ is an idiosyncratic disturbance.

Conceptual framework

- We can distinguish among: **backward-looking**, **forward-looking** and **hybrid** structures.

$$\pi_{u,t} = c + \alpha\pi_{u,t-1} + \sum_{l=0}^{l_{max}} [\gamma_l s_{u,t-l} + \delta_l p_{u,t-l}^{input}] + \epsilon_{u,t}, \quad (2)$$

$$\pi_{u,t} = c + \beta E_{u,t}(\pi_{t+j}) + \sum_{l=0}^{l_{max}} [\gamma_l s_{u,t-l} + \delta_l p_{u,t-l}^{input}] + \epsilon_{u,t}, \quad (3)$$

$$\pi_{u,t} = c + \alpha\pi_{u,t-1} + \beta E_{u,t}(\pi_{t+j}) + \sum_{l=0}^{l_{max}} [\gamma_l s_{u,t-l} + \delta_l p_{u,t-l}^{input}] + \epsilon_{u,t}, \quad (4)$$

Data

- ▶ Vintages starting in 2009:Q1 up to 2023:Q4 for the Euro Area.
- ▶ Data series for headline (1995:Q1) and core (1997:Q2), both expressed as annualized quarterly rates.
- ▶ **Inflation expectations measures** considered:
 - * **Backward-looking:** Lagged inflation.
 - * **Households:** EC consumer-based survey (standardized) qualitative response on inflation over next 12 months, EC consumer-based survey expected value of inflation over next 12 months, EC imputed consumer's expectations over next 12 months.
 - * **Firms:** Output price of the composite Purchasing Manager's Index (PMI), EC expected prices in manufacturing, retail, other services, and services over the next 3 months.
 - * **Financial markets:** constructed from data on inflation-linked swaps at horizons 1-year, 2-year and 5-years.
 - * **Experts:** constructed from data on inflation expectations in 1-year, 5-years and 6-10 years from Consensus Forecast and ECB's Survey of Professional Forecasters (SPF).

Empirical strategy

1. For each vintage u , we perform (pseudo) out-of-sample conditional forecasting with rolling windows of 40-quarters length, with first end-date at 2005:Q4.
2. For each rolling window in a vintage u , we obtain inflation forecasts at different horizons ($h=1$ to 8-quarters ahead).
3. In order to compute inflation forecasts, we must previously obtain forecasts of the regressors by fitting AR processes to:
 - * Exogenous variables.
 - * Agent's inflation expectations.

Empirical strategy

4. We address the issue of model instability at each horizon h by computing, for each expectations measure, the **median over specifications of the corresponding quarterly forecast** - which helps to 'hedge against breaks in forecast performance' caused by outliers.

At this point we develop two alternative computations:

- * **WITHIN-VINTAGE analysis**: we compute the median forecast constrained to each vintage and then obtain the corresponding RMSFE.
 - + Do models that use expectations measure k systematically produce a lower RMSFE at horizon h as new and revised data is available, if compared to other measures?
- * **ACROSS-VINTAGE analysis**: we compute the median forecast across vintages and then obtain RMSFEs over a 20-quarter rolling window, in the spirit of Bańbura and Bobeica (2023).
 - + Do models that use expectations measure k improve their relative predictive capacity over time?

Empirical strategy

5. We consider two **reference models**:

- * **(i) backward-looking PC model**
- * **(ii) naive random walk** [Atkeson and Ohanian (2001)].

6. Evaluation is based on **RMSFE criterion**:

- * Relative RMSFEs (relative to reference models).
- * Meta-regressions.

What we find

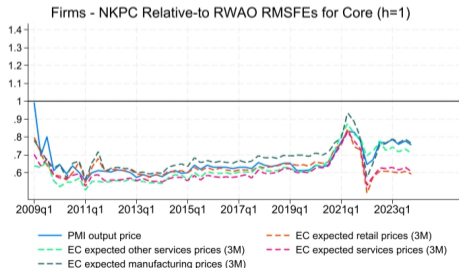
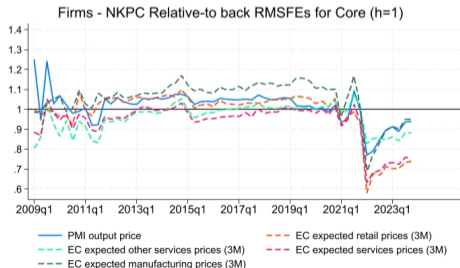
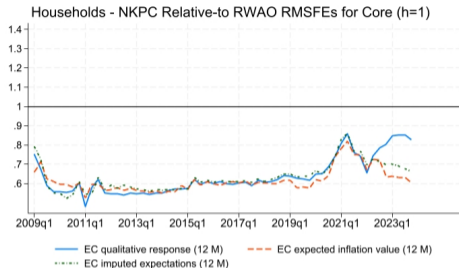
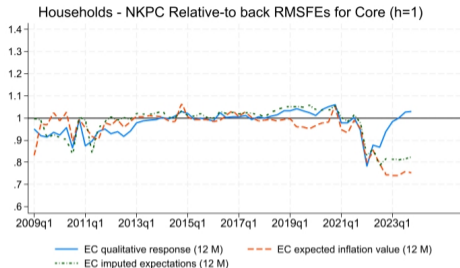
WITHIN analysis - core inflation

1. Relative RMSFEs:

- * **Short-term horizon ($h=1$).** No expectation measure seems to systematically outperform *backward-looking* model, while the opposite is observed relative to the naive *random walk* specification. [▶ Go to h1](#)
- * **Medium-term horizon ($h=4$).** Short-term financial market expectations outperform reference models. Not considering the end of the sample period, we should also add households' qualitative response (EC), firms' output expected price (PMI) and expected other services prices (3M-EC), and longer-term experts' and financial markets' expectations. [▶ Go to h4](#)
- * **Long-term horizon ($h=8$).** Households' imputed expectations, firms' PMI output price and expected services prices, and financial markets' expectations outperform reference models. [▶ Go to h8](#)

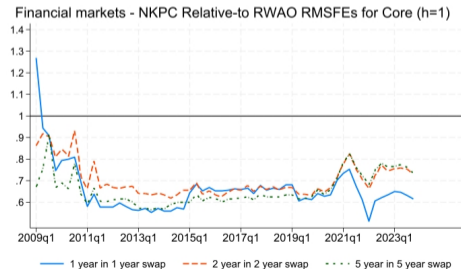
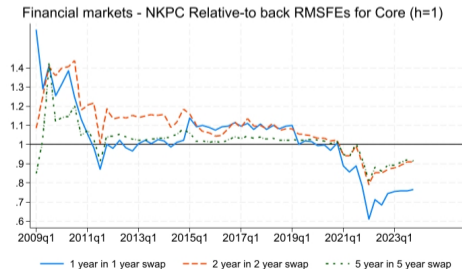
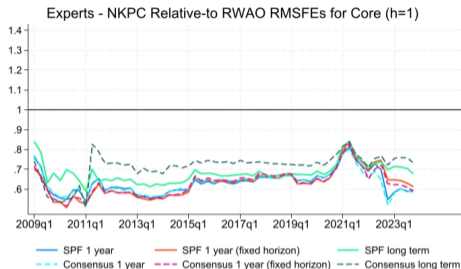
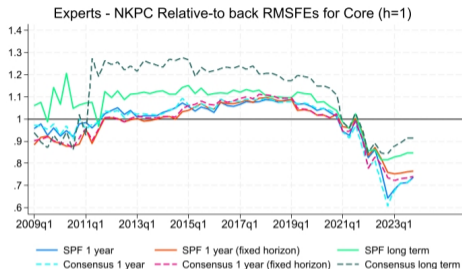
WITHIN Analysis - Core - RMSFEs relative to *backward* and RW (h=1)

Return



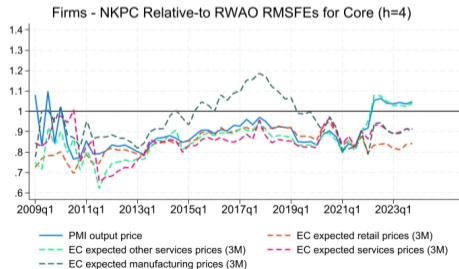
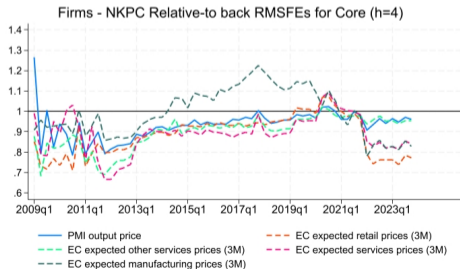
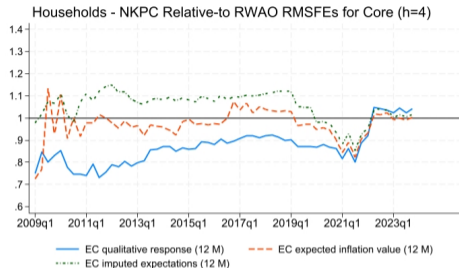
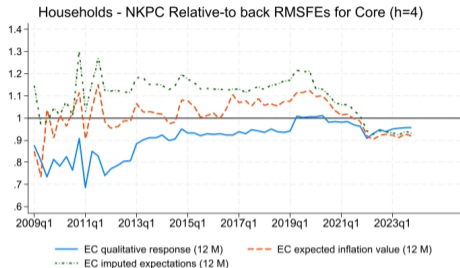
WITHIN Analysis - Core - RMSFEs relative to backward and RW (h=1)

Return



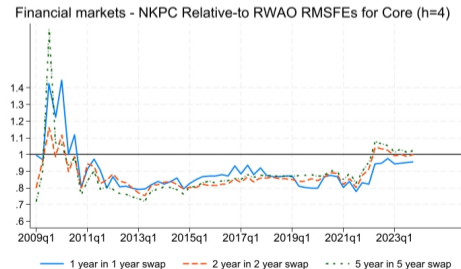
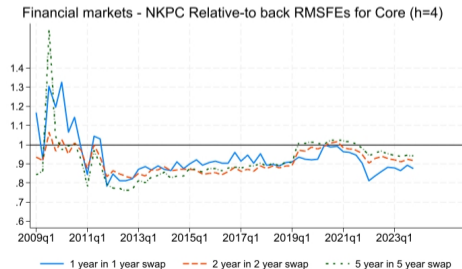
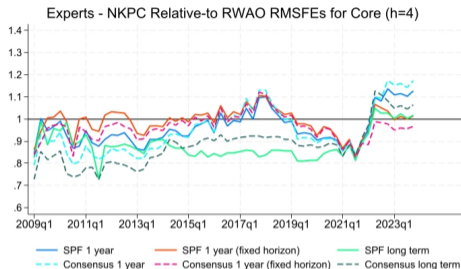
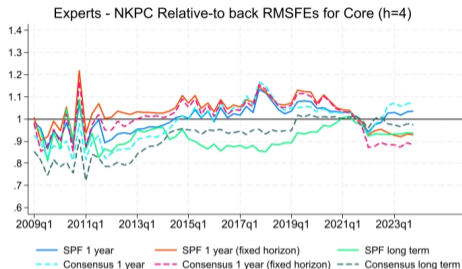
WITHIN Analysis - Core - RMSFEs relative to *backward* and RW ($h=4$)

Return



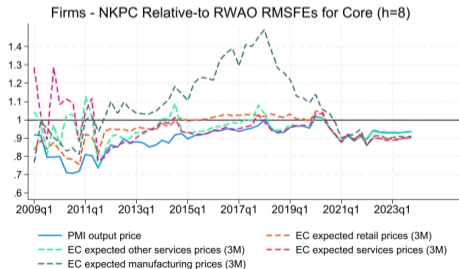
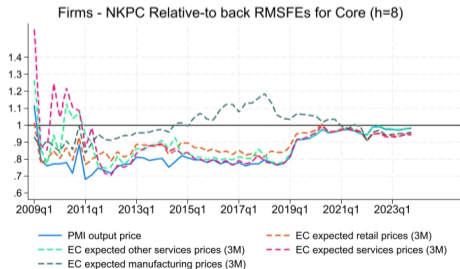
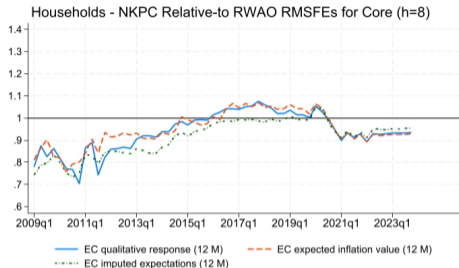
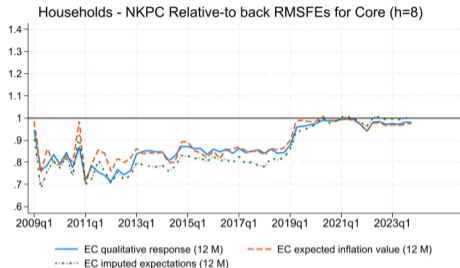
WITHIN Analysis - Core - RMSFEs relative to backward and RW (h=4)

Return



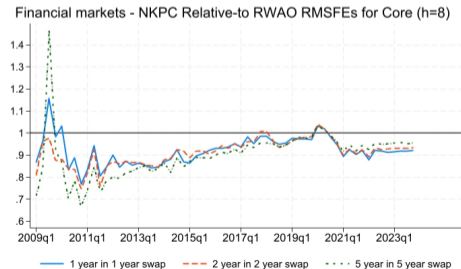
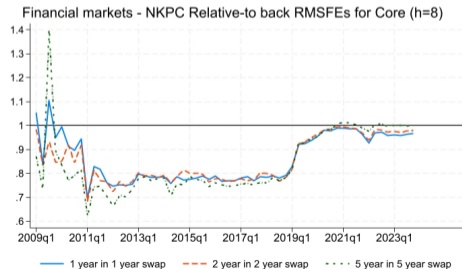
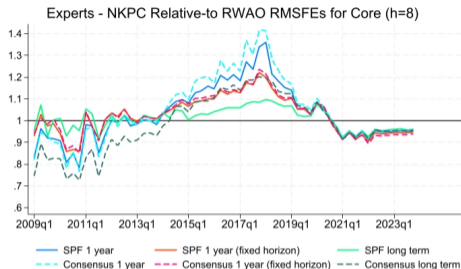
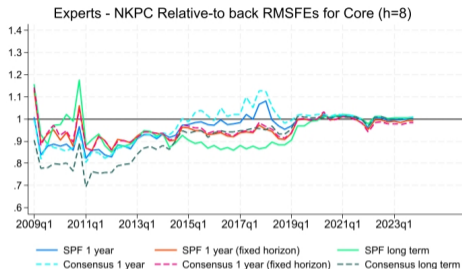
WITHIN Analysis - Core - RMSFEs relative to *backward* and RW (h=8)

Return



WITHIN Analysis - Core - RMSFEs relative to backward and RW (h=8)

Return



WITHIN Analysis - Core inflation - Meta-regressions

RMSFE regressed on model characteristics:

$$RMSFE_{u,k}^h = \phi_0 + \phi_1 expectations_k + \phi_2 h + \phi_3 u + \eta_{u,k}^h \quad (5)$$

- ▶ h and u are dummy variables for horizons and *vintages*, respectively.
- ▶ $\{expectations_k\}$ are dummy variables referring to expectation measure k , with excluded category being *backward-looking* or *random walk*.
- ▶ $\eta_{u,k}^h$ is an error term.
- ▶ We estimate the regression also for each horizon subsample.

Meta-regressions RMSFEs for Euro Area core inflation: short-term horizon (h=1)

| | RMSFE - All slacks | RMSFE - Output gap | MAFE - All slacks | MAFE - Output gap |
|-----------------------------------|--------------------|--------------------|-------------------|-------------------|
| EC expected inflation value (12M) | -0.035 *** | -0.031 *** | -0.000 | -0.006 |
| EC qualitative response (12M) | -0.012 | -0.017 | -0.003 | -0.006 |
| EC imputed expectations (12M) | -0.024 *** | -0.016 ** | -0.002 | 0.007 * |
| PMI output price | -0.007 | -0.001 | 0.006 | 0.007 * |
| EC expected services prices (3M) | -0.051 *** | -0.028 *** | -0.015 *** | -0.003 |
| Consensus 1 year (fixed horizon) | -0.031 *** | -0.035 *** | -0.011 *** | -0.015 *** |
| Consensus 1 year | -0.033 *** | -0.042 *** | -0.008 * | -0.016 *** |
| Consensus long term | 0.020 ** | 0.019 ** | 0.001 | 0.001 |
| SPF 1 year (fixed horizon) | -0.028 *** | -0.033 *** | -0.012 *** | -0.015 *** |
| SPF 1 year | -0.030 *** | -0.039 *** | -0.010 ** | -0.015 *** |
| SPF long term | 0.001 | -0.009 | 0.021 *** | 0.007 ** |
| 1 year in 1 year swap | -0.020 * | -0.018 | 0.006 | 0.013 ** |
| 2 year in 2 year swap | 0.014 | 0.008 | 0.027 *** | 0.025 *** |
| 5 year in 5 year swap | -0.006 | 0.002 | 0.014 *** | 0.016 *** |
| Number of observations | 900 | 900 | 900 | 900 |
| Adjusted R-squared | 0.96 | 0.96 | 0.94 | 0.94 |
| Mean dep. variable | 0.384 | 0.386 | 0.276 | 0.275 |

*** p-value<.01, ** p-value<.05, * p-value<.1

RMSFEs and MAFEs based on median of forecasting models. Regressions include constant and vintage dummies. Excluded category: backward-looking models. Robust standard errors. In bold, negative and statistically significant coefficients.

Meta-regressions RMSFEs for Euro Area core inflation: short-term horizon (h=4)

| | RMSFE - All slacks | RMSFE - Output gap | MAFE - All slacks | MAFE - Output gap |
|-----------------------------------|--------------------|--------------------|-------------------|-------------------|
| EC expected inflation value (12M) | -0.005 | -0.056 *** | 0.020 *** | -0.017 *** |
| EC qualitative response (12M) | -0.055 *** | -0.088 *** | -0.026 *** | -0.040 *** |
| EC imputed expectations (12M) | 0.039 *** | 0.024 *** | 0.037 *** | 0.042 *** |
| PMI output price | -0.039 *** | -0.011 | -0.024 *** | -0.030 *** |
| EC expected services prices (3M) | -0.094 *** | -0.092 *** | -0.056 *** | -0.051 *** |
| Consensus 1 year (fixed horizon) | -0.013 * | -0.048 *** | -0.010 ** | -0.027 *** |
| Consensus 1 year | -0.006 | -0.016 * | -0.002 | -0.017 *** |
| Consensus long term | -0.044 *** | -0.061 *** | -0.022 *** | -0.038 *** |
| SPF 1 year (fixed horizon) | 0.006 | -0.022 *** | 0.000 | -0.011 *** |
| SPF 1 year | -0.003 | -0.020 *** | -0.001 | -0.014 *** |
| SPF long term | -0.047 *** | -0.067 *** | -0.032 *** | -0.062 *** |
| 1 year in 1 year swap | -0.048 *** | -0.040 *** | -0.025 *** | -0.030 *** |
| 2 year in 2 year swap | -0.052 *** | -0.046 *** | -0.044 *** | -0.053 *** |
| 5 year in 5 year swap | -0.043 *** | -0.044 *** | -0.039 *** | -0.057 *** |
| Number of observations | 900 | 900 | 900 | 900 |
| Adjusted R-squared | 0.98 | 0.97 | 0.96 | 0.95 |
| Mean dep. variable | 0.602 | 0.622 | 0.428 | 0.432 |

*** p-value<.01, ** p-value<.05, * p-value<.1

RMSFEs and MAFEs based on median of forecasting models. Regressions include constant and vintage dummies. Excluded category: backward-looking models. Robust standard errors. In bold, negative and statistically significant coefficients.

Meta-regressions RMSFEs for Euro Area core inflation: short-term horizon (h=8)

| | RMSFE - All slacks | RMSFE - Output gap | MAFE - All slacks | MAFE - Output gap |
|-----------------------------------|--------------------|--------------------|-------------------|-------------------|
| EC expected inflation value (12M) | -0.086 *** | -0.141 *** | -0.045 *** | -0.085 *** |
| EC qualitative response (12M) | -0.092 *** | -0.139 *** | -0.064 *** | -0.086 *** |
| EC imputed expectations (12M) | -0.104 *** | -0.130 *** | -0.081 *** | -0.088 *** |
| PMI output price | -0.117 *** | -0.101 *** | -0.088 *** | -0.082 *** |
| EC expected services prices (3M) | -0.096 *** | -0.164 *** | -0.088 *** | -0.114 *** |
| Consensus 1 year (fixed horizon) | -0.036 *** | -0.084 *** | -0.025 *** | -0.051 *** |
| Consensus 1 year | -0.021 ** | -0.048 *** | -0.013 ** | -0.027 *** |
| Consensus long term | -0.061 *** | -0.089 *** | -0.039 *** | -0.057 *** |
| SPF 1 year (fixed horizon) | -0.036 *** | -0.086 *** | -0.025 *** | -0.054 *** |
| SPF 1 year | -0.032 *** | -0.072 *** | -0.021 *** | -0.040 *** |
| SPF long term | -0.040 *** | -0.070 *** | -0.030 *** | -0.062 *** |
| 1 year in 1 year swap | -0.104 *** | -0.124 *** | -0.071 *** | -0.095 *** |
| 2 year in 2 year swap | -0.106 *** | -0.127 *** | -0.083 *** | -0.105 *** |
| 5 year in 5 year swap | -0.110 *** | -0.143 *** | -0.091 *** | -0.113 *** |
| Number of observations | 900 | 900 | 900 | 900 |
| Adjusted R-squared | 0.99 | 0.98 | 0.97 | 0.97 |
| Mean dep. variable | 0.812 | 0.819 | 0.588 | 0.584 |

*** p-value<.01, ** p-value<.05, * p-value<.1

RMSFEs and MAFEs based on median of forecasting models. Regressions include constant and vintage dummies. Excluded category: backward-looking models. Robust standard errors. In bold, negative and statistically significant coefficients.

Conclusions, more questions and next steps

Conclusion, more questions and next steps

- ▶ It seems that households' and firms' expectations may impact on inflation dynamics in the Euro Area.
- ▶ However, this result depends on the specific expectation measure considered.
- ▶ It also seems to depend on the characteristics of the period.

- ▶ Should we focus on some specific expectations measures?
- ▶ Should we focus on a specific forecasting horizon?

- ▶ Sub-sample analysis: low-inflation period, COVID-19 pandemic, Russia's invasion of Ukraine.
- ▶ Alternative forecast accuracy metric: MAFE.

Thank you for your attention!

Unexpected the expected in forecasting inflation: a real-time analysis for the euro area

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