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Abstract

This paper empirically explores the pass-through channel of inflation expectations to inflation by looking at a real-time macroeconomic forecasting exercise conducted by an exogenous observer. Models that are informed either by households' updated beliefs about future inflation or, especially, by services firms' expected changes in their own prices can systematically predict core inflation more accurately – and do so in a stable way – than a class of commonly used models that do not use this information. Qualitative updates in households and firms price surveys emerge as relevant signals of consumer and firm behavior, since they influence aggregate inflation dynamics. These results point to an economically meaningful pass-through channel of short-term inflation expectations to inflation.

Keywords: inflation, inflation expectations, Phillips curve, real-time forecasting.

JEL classification: E31, E37, E52.

Resumen

En este documento se explora empíricamente el canal de transmisión de las expectativas de inflación hacia la inflación bajo la óptica de un ejercicio de previsión macroeconómica llevado a cabo por un observador exógeno en tiempo real. Los modelos que incorporan las creencias actualizadas de los hogares sobre la inflación futura o, especialmente, los cambios que esperan en sus propios precios las empresas de servicios pueden predecir sistemáticamente la inflación subyacente de manera estable, y con mayor precisión, que una clase de modelos de uso común que no utilicen esta información. Las actualizaciones cualitativas en las encuestas de los precios a hogares y empresas surgen como señales relevantes del comportamiento de los consumidores y las empresas, ya que inciden en la dinámica de la inflación a nivel agregado, lo que apunta a un canal de transmisión económicamente significativo de las expectativas de inflación a corto plazo hacia la inflación.

Palabras clave: inflación, expectativas de inflación, curva de Phillips, previsión en tiempo real.

Códigos JEL: E31, E37, E52.

1 Introduction

Whose economic agents' inflation expectations updates matter for inflation? Are inflation expectations from either households, firms, professional forecasters or financial markets participants the most relevant for inflation dynamics? Do short-run, long-run, or both, inflation expectations influence inflation? The recent empirical literature provides comprehensive evidence supporting the relevance of inflation expectations to the economic decision-making of households and firms (Coibion and Gorodnichenko, 2015; D'Acunto et al., 2016; Coibion et al., 2018a, 2020b; Dräger and Nghiem, 2021; Duca-Radu et al., 2021; Crump et al., 2022; Coibion et al., 2022, 2023). Randomized controlled trials, for example, have shown that there is a pass-through mechanism that runs from firms' own updates of inflation expectations to their price-setting behavior (Coibion et al., 2018b, 2020b; Abberger et al., 2024), as featured in sticky-price models of the New Keynesian tradition (Galí and Gertler, 1999; Woodford, 2003). Also, households' own inflation expectations appear to be a good proxy for the expectations of price-setting firms and provide a better fit than professional forecasters' expectations in Phillips Curve inflation models (Coibion and Gorodnichenko, 2015, 2025). While the evidence from information treatment trials of the link between households' and firms' inflation expectations and firms' price-setting behavior is mounting, a comprehensive empirical exploration of the aggregate price effects of these agents' own expectational updates, and whether and how these agents' updates are the most informative for inflation dynamics, is still lacking (Coibion et al., 2020a; Álvarez and Correa-López, 2020; Coibion and Gorodnichenko, 2025). Improving our understanding of the macroeconomic significance of this mechanism is key for monetary policy-making, since the potential of inflation expectations management as an instrument for inflation stabilization cannot be overemphasized (see, e.g., Coibion et al., 2020a, 2022; Reis, 2023; Coibion and Gorodnichenko, 2025).

Through the lens of a macroeconomic forecasting exercise carried out by an exogenous observer in real time, this paper investigates to what extent households' and firms' own inflation expectations matter for inflation, pointing to the existence (or not) of an economically meaningful pass-through channel of these agents' inflation expectations to realized inflation. Our approach consists of comparing the inflation forecasts that an exogenous observer may produce once information about agents' inflation expectations is accounted for, to the forecasts that the observer may produce if inflation were modeled with no explicit use of information about agents' expectations. If firms' or households' expectational updates consistently help deliver a more accurate forecast, it may be argued that these agents' beliefs and behavior influence inflation in the aggregate. The predictive accuracy of inflation models is evaluated and compared in a real-time fashion. We use a measure of inflation that excludes its highly volatile components (energy and food). We disregard this price volatility as central banks tend to pursue medium-term inflation stabilization once high-frequency price shocks, typically from oil, are passed through the entire price chain. In other words, core inflation is plausibly less contaminated by supply disturbances (Ball and Mazumder, 2011; Barnichon and Shapiro, 2024). In addition, the analysis focuses on euro area inflation. To explore the connection between inflation and inflation expectations, the euro area emerges as a useful economic entity since it transitioned from a period of "missing" disinflation -after the global financial crisis and the euro area debt crisis- to a prolonged episode of very low core inflation, from 2013 to 2019, when the region hit the effective lower bound (ELB) on nominal interest rates (Draghi and Constâncio, 2015, October 22; Rostagno et al., 2021). Analytically, during the ELB episode, any movement in the perceived real interest rate might be more readily ascribed to inflation expectations since changes in the nominal interest rate were bounded.[1] After the ELB episode, the euro area suffered two major consecutive shocks, the COVID-19 pandemic and Russia's invasion of the Ukrainian sovereign nation, which led to a surge in inflation dynamics post-2020. All in all, the recent economic history of the euro area provides fertile ground for studying the dynamic process of inflation and its connection to expectations.

Advancing some results from our empirical exploration, we find that models that are informed by households' and firms' -especially, retailers' and other services firms'- own inflation expectations at short-term horizons systematically anticipate core inflation more accurately, and do so in a stable way, than models that do not use this information. This result appears reinforced in two recent episodes of very distinct inflation dynamics. On the one hand, the ELB period, when inflation was exceedingly stable and nominal interest rates were bounded such that one might have expected a simple univariate framework to outperform models informed by inflation expectations. And, on the other hand, the post-COVID-19 period, when firms' beliefs about the evolution of their short-term pricing in manufacturing and, especially, in retail, better signaled firms' prospective behavior at the time, helping the observer forecast the aggregate inflation surge. The evidence is thus

[1] If a consumption Euler equation were at work during this period, higher expected inflation would lower the perceived real interest rate, increase current consumption and, assuming a full unfolding of this mechanism, raise realized inflation. At the ELB, Duca-Radu et al. (2021) find a stronger response of consumers' current spending from higher anticipated inflation. Likewise, Coibion et al. (2020b) find that during the ELB period demand-side channels were reinforced in that higher expected inflation by Italian firms led them to raise their prices and investment by more than if they were outside the ELB.

suggestive of a causal and economically relevant effect of households' and firms' own inflation expectations on their decisions and, through general equilibrium effects, on inflation. Furthermore, a horse race of these expectations measures confirms a central prediction of the New Keynesian Phillips Curve (NKPC) theoretical framework regarding the relevance of firms' short-run inflation expectations to the dynamics of inflation. Finally, when we run conditioned models on real activity and input costs that include both, firms' short-run inflation beliefs and financial markets participants' long-run inflation expectations, the results point to different pass-through channels of inflation expectations to inflation, one that may operate via price-setters' short-run beliefs and another one via financial actors' long-run beliefs.

The literature that studies the nexus between inflation and inflation expectations is vast (for a review, see Coibion et al., 2022). This paper intends to contribute to the strand that explores the causal link between households' and firms' short-run inflation expectations, firm-level pricing and inflation behavior, see, e.g., Coibion et al. (2018b); Acharya et al. (2025); Beaudry et al. (2024a, 2025); Coibion and Gorodnichenko (2025). This literature has regained momentum due to the intensification of inflationary pressures after the supply-side shocks of the early 2020s. Beaudry et al. (2024a), for example, argue that households' inflation expectations were crucial drivers of inflation dynamics in the US, with the key mechanism being ignited by supply-side shocks that were broad-based and affected many sectors. As a novelty and contribution to this literature, we exploit the real-time dimension of inflation expectations and argue that the updating of inflation expectations readily tracked by an exogenous observer can help identify the pass-through of expectations to realized inflation. In the exploration of an ample set of inflation expectations updates (over time and across economic agents and horizons), we show that the real-time short-term beliefs of firms (especially, in services) emerge as central to inflation in the aggregate. Nonetheless, when the economy is hit by a variety of shocks, the exogenous observer may need to track updates across all agents in the economy to fully capture the extent of the pass-throughs at work. Our paper also relates to the strands of the literature that explore the significance of inflation expectations management as a stabilization tool to add to the portfolio of central banks during periods of binding constraints (see, e.g., Coibion et al., 2020a; Reis, 2023); that consider the (conditional) Phillips Curve as a guide for explaining inflation dynamics and understanding the transmission of monetary policy (see, e.g., Ball and Mazumder, 2011; Hooper et al., 2020; Eser et al., 2020; Reis, 2023; Mankiw, 2024; Barnichon and Shapiro, 2024; Beaudry et al., 2024a, 2025); and that is concerned with inflation drivers and forecasting (see, e.g., Atkeson and Ohanian, 2001; Orphanides and van Norden, 2005; Stock and Watson, 2007, 2008; Dotsey et al., 2018), especially in the euro area (see, e.g., Ciccarelli and Osbat, 2017; Béreau and Faubert, 2018; Grothe and Meyler, 2018; Jarociński and Lenza, 2018; Bobeica and Jarociński, 2019; Bobeica and Sokol, 2019; Kulikov and Reigl, 2019; Álvarez and Correa-López, 2020; Ball and Mazumder, 2021; Bańbura and Bobeica, 2023). To the latter literature, we contribute by producing a comprehensive real-time out-of-sample forecasting evaluation that uses a wide range of inflation specifications and expectations measures. In doing so, we show that univariate models can be beaten in a stable manner if the relevant expectational updates are systematically tracked in a multivariate Phillips Curve environment.

The structure of the paper is as follows. In order to inform the empirical part, section 2 depicts the evolution of the relevant macroeconomic variables in the euro area. Section 3 discusses the data and the econometric strategy that may help characterize the connection between inflation expectations and realized inflation. Section 4 presents and discusses the main results, first, by means of graphical analysis and, second, by meta-regressions. In this section, we also examine various aspects of the real-time distribution of the pass-through parameter, we explore its configuration when the exogenous observer corrects for potential sources of endogeneity, we compare our recursive forecasting approach to an alternative direct method, and we carry out a horse race of expectations measures using the last vintage of the data in order to investigate the economic significance of the inflation expectations channel. Section 5 concludes.

2 Inflation expectations in the euro area

As documented in the literature, views about future inflation differ greatly among economic agents, furthermore, it is not clear whose expectations are more relevant to which macroeconomic outcome. In particular, households and firms seem inattentive as to inflation and to (even major) central bank's policy shifts in the low inflation environments of advanced economies, in contrast to professional forecasters' and financial markets participants' proven attentiveness (Ranyard et al., 2008; Kumar et al., 2015; van der Cruijsen et al., 2015; Binder, 2017; Blinder, 2018; Coibion et al., 2018b, 2020a; Dräger and Nghiem, 2021; Duca-Radu et al., 2021; Candia et al., 2024).[2]

[2]However, households are not so inattentive when it comes to price changes in items of the consumption basket that are more often visible to them, such as gasoline prices, which strongly influence their perceptions on overall inflation (Coibion and Gorodnichenko, 2015, 2025).

To illustrate these different views about inflation, Figure 1 depicts the evolution of inflation expectations, core inflation, and a measure of the state of the euro area economy. In particular, panel A reports the 12-month-ahead quantitative inflation expectations for households (European Commission (EC) consumer survey), professional forecasters (Consensus Economics survey of leading economists; Survey of Professional Forecasters (SPF) conducted by the European Central Bank (ECB)) and financial markets agents (the 1-year inflation-linked swap from Reuters).[3] In the euro area, there is a sizable difference between households expectations and those of professional forecasters and financial markets participants, the latter two being more closely tied to each other and closer to the evolution of core inflation than the former. The difference is evident not only on the mean but also on the volatility of the inflation beliefs series.[4]

Panel B presents the standardized qualitative response to the aforementioned consumer survey (EC), which is available over a longer time span. It also depicts several measures of firms' inflation expectations that are qualitative in nature and refer to firms' changes in their own pricing. In particular, the response of managers in manufacturing and services from the Purchasing Managers Index (PMI) survey (S&P Global) reflects own price changes over the current quarter. The panel also includes the expected price change over the next 3 months from firms in three sectors of the economy, namely, manufacturing, retail, and other services sectors (EC business survey). Recent survey evidence shows that firms' expectations about their own price are positively related to their expectations about aggregate inflation and that firms form beliefs about the economy from their experience at the local level (Andrade et al., 2022; Savignac et al., 2024). All these time series are provided as balance of responses that we subsequently standardize. Note that standardized time series provide a statistically meaningful and comparable measure of variation in inflation beliefs to otherwise qualitative survey response data. Despite the difference along various dimensions (agents, horizons, and beliefs), all measures depicted in panel B move relatively close to each other. There are more substantial differences between households' and firms' expectations in the years around the inception of the euro area, the beginnings of the low inflation era, and the two disruptive shocks of the early 2020s when expectations accelerated quickly and then subsided. Also, notice some similarities between these qualitative measures of inflation expectations and the output gap,

[3] Appendix *A* provides a detailed account of data definitions, measures and sources.

[4] A similar feature, although not so strikingly obvious, is observed in US data. Also, note that the literature has documented larger cross-sectional variation in inflation expectations among households and among firms than among professional forecasters (see, e.g., Coibion and Gorodnichenko, 2015; Coibion et al., 2018b, 2020a).

which suggests that, when exploring the relationship between expectations and inflation, the state of the macroeconomy may need to be controlled for.

Panel C in Figure 1 displays the long-term inflation expectations of professional forecasters (the 6-to-10-year forecasts from Consensus and the 5-year from the SPF) and financial markets participants (the 5-year inflation-linked swap).[5] The establishment of the monetary union brought about a decline and subsequent stabilization in long-term inflation expectations, which remained mostly below but close to the ECB's 2% inflation target over the next twenty years or so. Among the measures depicted, inflation expectations from financial markets are the ones that exhibited higher volatility.

Looking across agents, when time horizons and measures are more readily comparable, Figure 1 shows that the quantitative short-term inflation expectations of households systematically deviate from the expectations of professional forecasters and financial markets participants. With regard to firms expectations, there is no long-spanning quantitative series available in the euro area, however, the literature has shed light on their characteristics in advanced economies, placing them closer to households' than to professional forecasters' (see, e.g., **?**Coibion and Gorodnichenko, 2015; Coibion et al., 2018b, 2020a; Candia et al., 2024). The discrepancy in beliefs between these two sets of agents (households and firms vis-à-vis professional forecasters and financial markets participants) may help capture the distinctive pass-through channel that may operate via households' and firms' own inflation expectations. When updating their beliefs, households and firms reoptimize and influence the path of macroeconomic aggregates, including inflation. Furthermore, having access to both qualitative and quantitative measures of inflation expectations (at least for households) would help uncover which type of the available measures, if any, conveys a better signal of these agents' behaviors, better in the sense that it is more relevant to the evolution of inflation.

Next, we outline the models that are estimated for euro area core inflation and the empirical strategy that is pursued in an attempt to explore the influence of agents' inflation expectations on aggregate inflation.

[5] For our methodological approach to be meaningful, a sufficiently long series of inflation expectations is necessary and, for the euro area, there is no available survey data long enough on households' or firms' long-term inflation expectations. The ECB Consumer Expectations Survey (CES) asks households about inflation expectations 3 years ahead, but this survey is only available from 2020. Likewise, the Survey on the Access to Finance of Enterprises (SAFE), conducted by the ECB and the European Commission, asks questions related to long-term inflation expectations, but this survey is not included in our analysis as it starts in the first semester of 2009 and was run biannually until 2024, when it became quarterly.

3 Econometric strategy

We simulate, as closely as possible, the experience of an exogenous observer who estimates empirical models of euro area inflation using the HICP excluding food and energy. Annualized quarterly inflation rates are computed from seasonally adjusted price data as: $\pi_t = 100 * ((p_t/p_{t-1})^4 - 1)$, where subscript t stands for the quarter. Inflation data runs from 1995:Q1 to 2023:Q4. Inflation models are evaluated and compared in a real-time fashion, in that we work with vintages of data that introduce, when relevant, data revisions and take into account delays in publication. Within each vintage, the exogenous observer, standing at a given quarter t, conducts model estimation and forecasting in a pseudo-real-time manner using only the data available at that date. In our database, vintages of real-time data span over the period 2009:Q1-2023:Q4. For each vintage, we produce estimates of each inflation model in rolling windows of 40-quarters length with the first end-date at 2005:Q4, a window shift of one quarter at a time, and a final end-date at the end of each vintage. For each model estimation in each rolling window of each vintage, we perform (pseudo) out-of-sample conditional forecasts over consecutive horizons h, namely, from 1-quarter to 8-quarters ahead, albeit our main results are focused on the 4-quarter-ahead and the 8-quarter-ahead horizons.

As it is explained in detail later, we carry out forecast evaluation along the way. That is, the observer continually assess whose updates of inflation beliefs may consistently matter for inflation dynamics, and updating involves both incorporating new information and removing past one. The real time dimension and the underlying process of expectations are critical here in that, if the update of inflation expectations contains incoming information about the perceived future and if agents consistently reoptimize responding to new beliefs (and less so to past ones) by altering the intertemporal path of their choices, we might consistently observe aggregate (price) effects of agents' responses. If, compared to models with no beliefs, firms' or households' expectational updates continuously deliver a more accurate forecast and do so in a stable way, it may be argued that firms' or households' beliefs and behavior influence inflation in the aggregate.[6] Our benchmark model for comparison is a simple univariate framework since a common message in the literature emphasizes that, when it comes to inflation, it is difficult to beat, in a stable way, the forecasting performance of a univariate model. Further, in order to reduce

[6]The econometric approach applied in our paper is close in some aspects to previous work in Álvarez and Correa-López (2020) but departs from it in that we add vintages of real-time data and multiple specifications in a stepwise approach to point out both, how key it is to identify and explicitly account for the most informative measure of inflation expectations, and how the relative performance of each measure may change over time as varying shocks hit the economy.

observer's biases (cognitive, confirmation), specification uncertainty, and spurious correlations, we carry out a systematic analysis that combines, over a relatively long time-span, the real-time dimension and a thick-modeling approach (Granger and Jeon, 2004). That is, we use a large suite of specifications to explore, in a stepwise manner, the connection between agents' inflation beliefs and inflation while controlling for factors that may mediate this connection, such as the underlying state of the economy and cost-push shocks. We start with simple specifications and transition to the expectations-augmented Phillips Curve that is nowadays a key element of the macroeconomic modeling toolkit in central banks (Eser et al., 2020). Since we are interested in real-time expectations, we consider inflation expectations and other macroeconomic factors as observable, and produce the main estimates by OLS (see, e.g., Coibion and Gorodnichenko, 2025). We also carry out exercises to address endogeneity concerns related to our main results by adopting a GMM estimation approach.[7] All in all, the real-time thick-modeling systematic strategy followed by the exogenous observer intends both, to reduce specification uncertainty and sensitivity of parameter estimates to data revisions, and to improve the identification of the relationship between inflation and inflation expectations.

To begin with, inflation is assumed to follow a random walk (RW) data generation process (DGP) in the spirit of Atkeson and Ohanian (2001), as given by:

$$\pi_{v,t} \ = \pi_{v,t-4} + u_{v,t}, \tag{1}$$

where subscript v refers to the vintage, t denotes the quarter, and $u_{v,t}$ is an idiosyncratic disturbance. The Atkeson-Ohanian (AO) model constitutes a popular univariate benchmark specification in inflation studies.[8] With euro area data, Bańbura and Bobeica (2023) show that the AO model yields very similar inflation forecasts to those produced by the unobserved components stochastic volatility (UCSV) model of Stock and Watson (2007). Thus, the AO RW model is a reasonable and flexible benchmark to build the observer's strategy on.

Then, inflation is assumed to be influenced by economic agents' current beliefs about future inflation, as follows:

$$\pi_{v,t} \ = c + \beta \ E_{v,t}\,(\pi_{t+j}) + \epsilon_{v,t}, \tag{2}$$

where $E_{v,t}(\pi_{t+j})$ captures the agents' beliefs about inflation at a future date conditional on

[7]For a revision of the potential sources of endogeneity in this class of models, see, e.g., Mavroeidis et al. (2014); Barnichon and Mesters (2020).

[8]See the discussion in Dotsey et al. (2018) for the US.

the information available currently, and $\epsilon_{v,t}$ is a random disturbance. We estimate Eq. (2) using, one at a time, alternative measures of agents' inflation expectations as available in surveys and market sources. Motivated by the evidence emerging from randomized controlled studies, Eq. (2) takes inflation expectations as observable and the relationship between expectations and inflation as causal. When estimating Eq. (2) within a vintage, the observer evaluates whose updates of inflation beliefs consistently matter for inflation dynamics, and updating involves both, incorporating new information and removing past information through each rolling window. If expectational updates help deliver more accurate forecasts, one may argue that agents' updated beliefs and behavior influence aggregate inflation dynamics. This manner of exploring causality hinges on the departure from the full information rational expectations (FIRE) assumption on the part of economic agents.[9] If FIRE were in place, agents' inflation expectations would be superior -or at least as good as- the benchmark model in predicting inflation, regardless of whether the true DGP for inflation depends on expectations or not.

Next, we consider several variants of a model specification that describes the inflation process as:

$$\pi_{v,t} \; = c + \beta \, E_{v,t} \left(\pi_{t+j} \right) + \alpha \, \pi_{v,t-1} + \sum_{l=0}^{l_{max}} \left[\gamma_l \, s_{v,t-l} + \delta_l \, p_{v,t-l}^{input} \right] + \eta_{v,t}, \tag{3}$$

where $s_{v,t-l}$ is a macroeconomic measure of the cyclical position or forcing variable, $p_{v,t-l}^{input}$ is a vector of regressors capturing the evolution of input costs (import prices, unit labor costs, the nominal effective exchange rate), and $\eta_{v,t}$ is an idiosyncratic disturbance. Theories underpinning this sort of reduced-form structure are found in extended price-setting and wage-setting rules of the standard Phillips Curve tradition (e.g., Gordon, 2011) or within the NKPC framework when the FIRE assumption is relaxed (e.g., Paloviita, 2006; Adam and Padula, 2011; Mavroeidis et al., 2014; Coibion et al., 2018a). We shall refer to these specifications as the empirical NKPCs. In estimating variants of Eq. (3), inflation persistence may be explicitly allowed for (when $\alpha \neq 0$) or not (when $\alpha = 0$).[10] We also consider that the inflation process may be determined by a narrower set (only import prices) or a wider set (all input costs) of supply-side shocks. We keep the lag structure

[9] An extensive literature has gathered substantial empirical evidence supporting the departure from the FIRE assumption, especially on the part of households and firms (for a review, see Coibion et al., 2018a).

[10] Persistence mechanisms may be in operation when the prices that are more likely to be updated are those that have remained unchanged for longer (Sheedy, 2010) or when automatic indexation clauses in wage negotiations are in place, as it has been common in Europe.

of the empirical NKPCs explored in Álvarez and Correa-López (2020), where contemporaneous specifications or those including up to one lag, i.e. $l_{max} \in \{0, 1\}$, captured fairly well the results of more complex lag structures in euro area data. Recently, Bańbura and Bobeica (2023) provide a thorough evaluation of the forecasting performance of Phillips Curve models for the euro area, however, these authors only account for one explicit measure of (long-term) inflation expectations.

In essence, Eq. (3) extends Eq. (2) by letting inflation persistence, the business cycle, and supply shocks influence the inflation process. Thus, if OLS estimates of the parameter β in Eq. (2) are biased, the regressors introduced in Eq. (3) would help correct that bias. For example, parameter β may be biased because the state of the macroeconomy influences agents' inflation expectations, thus mediating the relationship between expectations and inflation, or because there are cost-push shocks affecting expectations that are not controlled for and show up in the random disturbance.[11] Treating inflation expectations as observable and replacing them by a survey measure also helps alleviate endogeneity concerns of OLS estimates. In fact, there is recent evidence of the latter, Beaudry et al. (2024a) empirically estimate US Phillips Curves using structural monetary shocks as instruments and find that the use of survey data on expectations helps to identify the Phillips Curve parameters more stably. To further address endogeneity concerns, we later present an exercise that estimates the NKPC models in Eq. (3) by GMM (see, e.g., Mavroeidis et al., 2014).

In a last step, we abstract from the expectations term and model inflation as follows:

$$\pi_{v,t} \ = c + \alpha \, \pi_{v,t-1} + \sum_{l=0}^{l_{max}} [\gamma_l \, s_{v,t-l} + \delta_l \, p^{input}_{v,t-l}] + \xi_{v,t}, \tag{4}$$

where $\xi_{v,t}$ is the random shock, and we consider the lag structures, persistence, and variants of the other controls specified just above.

The variables that may influence inflation dynamics are summarized below.[12] Importantly, in estimating Eq. (3), we consider all possible combinations of inflation expectations and activity measures to address sensitivity issues related to the slack measure used (see the discussion in, e.g., Coibion et al., 2018a). As it shall become clear next, this implies that, for each expectations measure, a rolling window involves 32 estimated

[11] There is an extensive literature exploring identification issues in the context of the price Phillips Curve (see, e.g., Mavroeidis et al., 2014; Barnichon and Mesters, 2020; del Negro et al., 2020; McLeay and Tenreyro, 2020; Beaudry et al., 2024b), primarily focused on recovering its slope coefficient when the relationship between economic slack and inflation may be masked by monetary policy conduct.

[12] See Appendix A for a detailed description of the database.

variants of Eq. (3).

1. Inflation expectations (k=13 measures) derived from:

    - Households. *EC consumer-based survey: (i) qualitative response on inflation over the next 12 months, and (ii) expected value of inflation over the next 12 months.*

    - Firms. *Output prices from the composite PMI*; *EC expected prices over the next 3 months in: (i) manufacturing, (ii) retail, and (iii) other services sectors.*

    - Professional Forecasters. *Consensus: (i) 1-year, and (ii) 6-to-10-year*; *SPF: (i) 1-year, and (ii) 5-year.*

    - Financial markets participants. *Inflation-linked swaps at horizons: (i) 1-year, (ii) 2-year, and (iii) 5-year.*

2. Economic activity (4 measures): *output gap*; *unemployment gap*; *GDP growth*; *unemployment rate.*

3. Input costs: Domestic ones, from *unit labor costs*, and external ones, from *import prices* and *the nominal effective exchange rate.*

As already noted, for each model estimation in each rolling window of each vintage, the exogeneous observer obtains (pseudo) out-of-sample conditional forecasts over horizons h one to eight quarters ahead. This implies that the observer needs to produce forecasts of the inflation expectations measures and of the exogenous regressors in each rolling window of each vintage at these horizons. The observer does so by fitting autoregressive processes, typically of order four, in a systematic way. Systematicity on the part of the observer is relevant here in order to eliminate the effect of changes in the forecasting process of inflation beliefs driven by observer's biases.

Note that the first 40-quarters length rolling window that the observer estimates has an end-date at 2005:Q4, however, for some inflation expectations series -namely, those that start in the 2000s- the initial rolling windows are effectively expanding windows until sufficient data become available to produce the 40-quarters rolling. This implies that the estimates of specifications that use expectations measures with a later starting date will lack reliability in the first estimated vintages.[13]

To explore forecast accuracy among the inflation structures bundled above, i.e. Eqs. (1) to (4), we compute the Root Mean Squared Forecast Error (RMSFE). Keeping in

[13]See the appendix for further details on data availability.

mind the real time dimension of the exercise leads us to adopt a within-vintage forecast evaluation strategy. In addition, the thick-modeling approach (Granger and Jeon, 2004) requires calculating the median forecast across all specifications considered. For example, in the within-vintage exploration of Eq. (3), we first compute for each horizon h and each expectations measure k, the median forecast for, say, rolling window rw produced across all specifications in the vintage υ.[14] Then, we obtain the squared forecast error for the said rolling window and, once a squared error is extracted for every rolling window within vintage υ, we compute the RMSFE of that vintage, as follows:

$$RMSFE_{\upsilon}^{h,k} = \sqrt{\frac{\sum_{rw=1}^{n} e_{rw}^2}{n}} \tag{5}$$

where the sum of squared errors is over the number n of rolling windows rw that produce the h-step-ahead forecasts in vintage υ. We follow the same within procedure for all vintages. Likewise, we derive the corresponding RMSFE of each vintage in the RW model of Eq. (1), in the expectations model of Eq. (2), and in the persistence model of Eq. (4).

We synthesize the information contained in RMSFEs, and seek evidence on the role of inflation expectations, by means of graphical representations of relative RMSFEs and of meta-regressions. Graphically, we first compare the RMSFEs produced by the RW process to the RMSFEs produced by models that only incorporate inflation expectations measures. As the latter specifications may produce biased estimates due to omitted variables, we then compare the RMSFEs produced by the RW process to those produced by the extended NKPC models featured in Eq. (3). Finally, we try to help identify the inflation expectations pass-through channel by comparing the latter with the RMSFEs produced by the class of models that exclude the expectations term, i.e. those bundled in Eq. (4). We hypothesize that if the information gathered in expectations measures is lost (not accounted for), one might systematically observe reduced forecast accuracy. We shall name these stepwise comparisons as: (A) expectations versus RW models, (B) empirical NKPC versus RW models, and (C) empirical NKPC versus persistence models.

We further explore the role of inflation expectations by means of meta-regressions (Stanley, 2001) in a stepwise manner as well. We estimate specifications of the form:

$$RMSFE_{\upsilon}^{h,k} = \phi_0 + \sum_{k=1}^{13} [\phi_k \, expectations_k] + \theta \, h + \vartheta \, \upsilon + \eta_{\upsilon}^{h,k}, \tag{6}$$

where $\{expectations_k\}$, h, and υ are, respectively, expectations dummies, horizon and

[14] Median forecasts are known to help hedge against breaks in forecast performance due to the presence of outliers.

vintage vectors of dummies, and $\eta_v^{h,k}$ is the error term. The expectations measures enter Eq. (6) as $(0,1)$ dummy variables, and we exclude model categories, namely, the RW model in comparisons (A) and (B), and the persistence model in comparison (C). We present the results for the entire period and for the ELB period.

In the last sections of the paper, we first introduce a complementary approach to the study of the inflation expectations pass-through channel by looking at the real-time distribution of the point estimates of the parameter of interest β over: (i) vintages and (ii) rolling windows. Then, we explore the configuration of the β-point estimates when the exogenous observer carries out the real-time inflation forecasting exercise assuming that inflation expectations and economic slack are endogenous and corrects for endogeneity by adopting a GMM approach. Subsequently, we validate the results of our recursive forecasting method by comparing it to an alternative direct forecasting approach. And, finally, we perform a horse race of a narrower and significant set of inflation expectations measures using the last vintage of the data. The latter exercise intends to gauge the quantitative relevance of the pass-through channel.

We do extensive robustness tests to the above by: (i) estimating the models using rolling windows of alternative window sizes, (ii) using the output gap as the only activity measure considered in Eqs. (3)-(4), and (iii) computing the Mean Absolute Forecast Error (MAFE) as an alternative metric of forecast accuracy.

4 Inflation expectations and real-time inflation forecasting

We begin by analyzing the role of inflation expectations via the graphical representation of relative RMSFEs. Figures 2 and 3 present the relative RMSFEs of the 4-step-ahead inflation forecasts obtained from the estimated inflation models previously defined.[15] We first focus on the results over the 4-quarter forecasting horizon noting that, in prolonged periods of stable inflation, it is difficult to beat the forecasting performance of the univariate AO RW process, as it essentially forecasts the average 4-quarter-ahead inflation rate with the average rate over the previous four quarters (Stock and Watson, 2007).

Figure 2 displays the relative RMSFEs when models incorporate inflation expectations from households (first row of graphs) and from firms (second row of graphs). Regarding

[15] The micro evidence in, e.g., Coibion et al. (2020b) suggests that changes in inflation expectations on the part of Italian firms turn into actions with some delay, which lends support to the discussion of the 4-quarter horizon.

households, panel A shows that, for most of the sample period, the expectations models that use the qualitative survey response produce forecasts that are consistently more accurate than the RW. The quantitative measure of expectations extracted from the same survey does not produce such forecasting advantage in a systematic way. Our prior is that in prolonged periods of very stable inflation, such as the low inflation episode at the ELB, it would be difficult to beat the forecasting performance of the AO RW process, and panel A shows that even simple models accounting for qualitative expectations from households may do so. Furthermore, panel B shows that introducing other covariates into the simple expectations models does not alter these results. When comparing panel B and panel A, the forecasting ability of the empirical NKPC models tends to be superior, especially at the ELB episode. In the last step of our stepwise approach, panel C shows that, compared to persistence models that abstract from information on inflation expectations, the empirical NKPC models that include the households' qualitative survey response produce better forecasts in a stable manner, which reinforces the role of inflation expectations. All in all, taking the evidence together, the results suggest that models that are continually updated with households' qualitative beliefs about future inflation can predict core inflation more accurately, and do so in a stable way, than models that do not use this information.

Regarding firms, the results are quite similar to those from households in that there are systematic instances in which the exogenous observer could stably produce more accurate forecasts by taking into account updated information on firms' beliefs. In this case, the results suggest that those models that use information from retail and other services firms' qualitative response on expected changes in their own price appear to stably deliver better core inflation forecasts than models that do not.

All in all, qualitative price responses, as in the available surveys, appear to be informative signals of consumer and firm behavior. Macroeconomic theory suggests that households' and firms' own inflation expectations, through their role in the perceived real interest rate or in the relative price of reference, matter to inflation. If households and firms believe that inflation will increase in the future and that interest rates will not change to offset this increase, their perceptions of the real interest rate may fall, inducing them to increase current consumption and investment.[16] Similarly, firms may pre-emptively

[16] A positive relationship between households' inflation expectations and consumption has been empirically documented in, e.g., Ichiue and Nishiguchi (2015); D'Acunto et al. (2016); Vellekoop and Wiederholt (2019); Dräger and Nghiem (2021); Duca-Radu et al. (2021); Coibion et al. (2022). Note that a negative link is also theoretically possible, e.g., if the negative income effect from higher inflation expectations dominates the intertemporal substitution effect or if the increase in expected inflation signals an adverse macroeconomic outlook. Some micro data studies have indeed found a negative or a mixed link, particularly at the single country level (Bachmann et al., 2015; Burke and Ozdagli, 2023; Coibion et al., 2023).

respond to the expectation of a lower relative price by raising their own price, or workers and union representatives may bargain for higher nominal wages to hedge against a lower real wage. As a result of these current choices, inflation should increase and we would observe an effect of households' and firms' own inflation expectations on the aggregate inflation level. Our results thus lend support to these theoretical predictions and to the latest evidence from randomized controlled trials (Coibion et al., 2018b, 2020b) suggestive of a causal and relevant effect of households' and firms' own inflation expectations on these agents' decisions and, through general equilibrium effects, on inflation. Notably, these expectations are short-term as their reference period is, at most, 12 months.

Figure 3 depicts the relative RMSFEs at horizon 4 when models incorporate inflation expectations from professional forecasters (first row of graphs) and from financial markets participants (second row of graphs). Looking at the panels in the same stepwise manner as above, we observe that both, models that are informed by the SPF's long-term inflation expectations measure and from (all) swap-based expectations measures predict inflation better, and do so stably, than models that do not incorporate this information. Bahaj et al. (2025) show that at short maturities (3 years or less), the frictions from liquidity and other premia drive swap market prices, which makes them diverge substantially and persistently from expected inflation. However, at long maturities, the observed swap price appears to track expected inflation fairly well. Hence, we shall emphasize the long-term swap price as a reasonable -albeit imperfect- measure of financial markets' inflation expectations. Bearing this in mind, the results thus suggest that forecasters' and financial markets participants' long-term beliefs about inflation may contain information about households' and firms' decisions, hence anticipating core inflation dynamics. Theoretically, forecasters and financial markets participants appear attentive and best positioned to assess the news regarding inflation, monetary policy-making, and various other sources of (dis)inflationary shocks (Blinder, 2018). Managing their expectations through, for example, inflation targeting and forward-guidance, may have entailed a transmission channel of monetary policy to households' and firms' decisions through the contemporaneous long-term interest rate (even in the absence of immediate changes to short-term rates, see Coibion et al. (2020a)). In turn, households' and firms' decisions on consumption, savings, investment or hiring, may have influenced inflation in general equilibrium - hence the salient role ascribed, in terms of inflation stabilization, to professional forecasters' and financial markets participants' beliefs (Blinder et al., 2008). These theoretical

In the case of firms, the sign of the effect of inflation expectations on investment appears more context-specific depending on whether inflation is more demand-side or supply-side driven (see the evidence in Coibion et al., 2018b, and Coibion et al., 2020b, for New Zealand and Italy, respectively).

notions appear to be confirmed in our empirical exploration.

The outbreak of the Covid pandemic in early 2020 and, especially, the invasion of Ukraine's sovereign territory by Russia in early 2022 constituted such major disruptive supply-side shocks in Europe that inflation accelerated very markedly.[17] Looking at our results during this period across all agents represented in Figures 2 and 3 suggests that, at the 4-quarter horizon, an exogenous observer would have generally predicted core inflation better using the RW in the second half of the pandemic period. However, there are two clear exceptions to this observation. In particular, incorporating into the models the information from firms' own price expectations in manufacturing and, noticeably, in retail would have substantially improved core inflation forecasts. That is, firms' beliefs about the evolution of their own short-term pricing in manufacturing and, especially, in retail, two of the major sectors affected by the shocks via supply-side bottlenecks and lockdowns, may have better signaled firms' prospective behavior at the time, hence influencing inflation in the aggregate. This result lends support to the hypothesis explored in Beaudry et al. (2025) and Coibion and Gorodnichenko (2025) according to which the acceleration of short-run inflation expectations of US households and firms induced by the shocks drove inflation dynamics post COVID-19. Importantly, the pandemic era illustrates that the short-run own-price expectations of firms operating in those sectors more affected by the cost shocks may themselves be the most predictive of aggregate core inflation behavior.

Looking at the overall evidence in this manner, it appears that shifts in households' and firms' own inflation expectations at short-term horizons (of at most one year) influence their behavior such that aggregate inflation effects can be foreseen. Likewise, the evidence suggests that the long-term SPF and swap market rate contain information about the forthcoming evolution of aggregate price-setting dynamics. In the last section of the paper, we attempt to discern whether there are different transmission channels operating through the expectations of these two distinct set of agents.

Next, we explore the role of inflation expectations for the dynamics of inflation via meta-regressions. The corresponding results in the 4-quarter-ahead forecasting horizon are presented in Table 1. Columns (A), (B), (D) and (E) display the estimates when the excluded category corresponds to the RW model while in columns (C) and (F) the excluded category is the persistence model, for both the whole sample and the ELB

[17] An emerging literature is exploring the competing hypotheses behind the inflation acceleration of the early 2020s in advanced economies, from the strong nonlinearity of the Phillips Curve kicking-in when labor markets became exceptionally tight (e.g., Benigno and Eggertsson, 2023) to the driving role of short-run inflation expectations of households and firms in the aftermath of the shocks (e.g., Beaudry et al., 2024a, 2025; Coibion and Gorodnichenko, 2025)

period. The stepwise bilateral comparisons reinforce and expand the main conclusions derived from the graphical analysis. In particular, those models that use updated information from households' qualitative beliefs about future inflation, from firms' qualitative response on expected own price changes -especially in retail and other services-, from professional forecasters' long-term measures -especially the SPF-, and from the long-term financial markets swap rate, consistently deliver improved core inflation forecasts than benchmark models that are not informed by them. The coefficients in these models show the largest negative magnitudes with strong statistical significance. These results appear to be reinforced during the ELB period since the coefficients are still highly significant, often of a higher order of magnitude and with the corresponding negative sign. In a period of exceedingly stable inflation and bounded nominal interest rates, the real-time update of inflation expectations seems to have brought about aggregate price effects, and this mechanism appears relevant and statistically significant.

Since the 8-quarter horizon is more aligned with the medium-term target of monetary policy, we turn next to discuss the results of the 8-quarter-ahead forecasts. Figures 4 and 5 depict the relative RMSFEs at horizon 8 when models incorporate information on expectations from households and firms, and from professional forecasters and financial markets participants, respectively. Likewise, Table 2 presents the results of the meta-regressions.

Taking the stepwise evidence of the graphical analysis and the regressions together suggests that, for the whole sample, the exogenous observer's use of models that incorporate information either on households' beliefs about future inflation, firms' qualitative response of expected own price changes, or financial markets swap rates can stably produce better medium-term forecasts than models that abstract from this information. Likewise, in the ELB period, the exogenous observer could produce more accurate and stable forecasts by using a variety of measures of inflation expectations. Adding to the ones in the 4-quarter-ahead analysis, the quantitative measure of expectations from households in the EC survey and the output price from firms in the PMI survey do stably produce a forecasting advantage over the RW, while professional forecasters' measures do not.

Appendix B reports robustness analysis to the above by means of meta-regressions that use (i) the output gap as the only measure of economic activity, and (ii) the Mean Absolute Forecast Error (MAFE) as an alternative metric of forecasting accuracy. With the exception of some idiosyncrasies, our results are generally robust to these formulations.

4.1 The pass-through of short-term inflation expectations to core inflation

In the previous section, we found that households' and firms' own inflation expectations at short-term horizons systematically help the observer anticipate core inflation dynamics, which we take as evidence that updates in households' and firms' expectations influence their behavior, leading to aggregate price effects. Next, we explore how stable and significant is the relationship between core inflation and these measures of short-term inflation expectations. In doing so, we focus our attention on the pass-through parameter in expectations and empirical NKPC models.

Figure 6 presents the real-time distribution of the point estimates of the parameter of interest β in expectations and empirical NKPC models, that is, before and after controlling for observable economic slack and cost-push shocks with various lag structures. The figure shows that, after including these controls, the β estimates generally remain stable from vintage to vintage and significant. The pass-through estimate lies in the range between 0.1 and 0.2 whether expectations are formed by households or by firms, which implies that a one standard deviation increase in the standardized balance of inflation expectations responses is associated with a 0.1-0.2 percentage point increase in core inflation. The economic relevance of this pass-through estimate is explored in the last section of the paper, where we present estimates of parameter β using the last vintage of data.

The real-time configuration of the inflation expectations pass-through can be explored from a short-term perspective as well, in expectations models and NKPC models. Figure 7 displays, for each rolling window, the median value and distribution of parameter β across vintages, model specifications and slack measures (when applicable). This way of looking at the results focuses more on the short-term variation of the pass-through estimates. Before the early 2020s, the β estimates are stable and significant around a median value of 0.1 to 0.3 over the rolling windows. With the pandemic and, especially, the onset of Ukraine's invasion by Russia, the magnitude of the pass-through estimate at least doubles for each of the inflation expectations measures depicted in Figure 7. Noticeably, the increase in the pass-through estimate is significantly larger and more persistent in models that rely on firms' beliefs about their short-term pricing. In the literature, the cyclical surge in inflation that followed the supply-side shocks of the early 2020s has been explained by the global nature of the shocks creating supply-chain pressures (e.g., Ascari and Fosso, 2024) and by demand-side forces that rely on either alternative labor market measures of slack (e.g., Barnichon and Shapiro, 2024) or a strongly non-linear Phillips Curve in the face of a tight labor market (e.g., Benigno and Eggertsson, 2023). Alternative explanations based on the de-anchoring of households' and firms' inflation expectations or, more generally, on the interaction between supply-side pressures, households' and firms' inflation expectations, and pricing behavior have recently gained momentum (e.g., Beaudry et al., 2024a; Acharya et al., 2025; Beaudry et al., 2025; Coibion and Gorodnichenko, 2025). The results summarized in Figure 7 lend support to the latter view in that the short-run inflation expectations of households and, especially, firms may have played a major role in euro area core inflation dynamics through the first half of the 2020s.

4.2 Endogeneity of pass-through estimates

Our empirical approach, albeit flexible, may be faced with specification and sampling uncertainty due to weak identification (see the discussion in, e.g., Mavroeidis et al., 2014; Barnichon and Mesters, 2020), potentially producing biased estimates of our pass-through parameter β. In this section, we explore the configuration of the β point estimates when the exogenous observer carries out the real-time inflation forecasting exercise assuming that inflation expectations and economic slack are endogenous and corrects for endogeneity by adopting a GMM approach. The observer uses the last vintage of the data to estimate the rolling windows of all the variants of Eq. (3) described above. As instruments of survey beliefs and economic slack, we use their own two lags in contemporaneous specifications and up to lag 4 in those specifications that include the first lag of the slack variable; in specifications that include a persistence term, we use as instruments 4 lags of lagged core inflation. In estimating Eq. (3), we generate iterated GMM estimates (see, e.g., Mavroeidis et al., 2014) using, alternatively, the four survey measures of inflation expectations that stood out as most informative for the evolution of inflation (households, retail firms, other services firms, PMI managers). For each survey measure, we perform Hansen's J-test for instrument validity of all specifications and subsets of specifications.

For each inflation expectations measure, specification and rolling window, Figure 8 presents the β point estimates obtained by OLS versus the corresponding β point estimates obtained by GMM once the 2.5% of the distribution at each tail is removed to deal with outliers. Table 3 reports the main summary statistics.

A number of results follow from the configuration of the estimated β points. First, mean values are in between 0.1 to 0.5 and the means produced by GMM are larger than those produced by OLS. Median values are in between 0.1 and 0.4, such that GMM still produces larger median coefficients than OLS although the differences are not so pronounced. Second, a substantial majority of the estimated β parameters are simultaneously positive across estimation methods. Specifications that use beliefs information from retail firms produce the largest share of simultaneous positives at 90.8%, closely followed by those specifications that use households' inflation beliefs (83.6%). The other two inflation expectations measures deliver positive coefficients in a simultaneous way with less frequency, however this frequency is still above 70%. Narrowing down to intervals, values of pass-through OLS and GMM estimates simultaneously in the range of $0 < \beta \leq 0.5$ are the most common, as outlined in the corresponding quadrant of Figure 8. For example, 77.4% of estimates that use households' inflation beliefs lie in the interval $\beta \in (0, 0.5]$ while for retail firms' beliefs this figure is close to 50%.

Third, a cursory inspection of the point estimates around the 45 degree line in Figure 8 indicates how close the OLS and GMM estimates actually are. It stands out the reduced dispersion of estimates produced by specifications that are based on households' inflation beliefs, while the point estimates from specifications that incorporate survey expectations information from retailers, other services firms and PMI managers are noticeably more dispersed. This is also summarized in the standard deviations of Table 3. Likewise, this information is presented in the estimated kernel densities of Figure 9, showing that households' inflation beliefs can produce less dispersed pass-through estimates either using OLS or GMM estimation methods. For models that incorporate firms' beliefs, OLS estimates are noticeably less dispersed than GMM estimates. This result suggests that, across estimation methods, NKPC models that incorporate information on inflation expectations from households appear more efficient in their estimation of the parameter β than those models that use information from retailers, other services firms and PMI managers.

Finally, the last row of Table 3 reports the rejection frequencies of Hansen's J-test of overidentifying restrictions of the GMM estimation (Hansen, 1982). The rejection frequencies are in between 3% and 6% at the 5% level, hence there is no systematic evidence against the validity of overidentifying restrictions. We also performed Hansen's J-tests on the GMM estimates from subsets of specifications and found that specifications including lagged inflation have a higher fraction of cases with valid instruments, and that specifications that include the complete set of cost-push variables or that include lags of the cost-push variables improve the rejection frequencies.[18]

Overall, once we address concerns about endogeneity, the results suggest that the median estimates of the pass-through parameter β generated by GMM are slightly larger in magnitude than those generated by OLS. As a result, it could be argued that the OLS estimates obtained by the exogenous observer constitute a lower bound of the extent of

[18]The results from these tests are available from the authors upon request.

the pass-through of inflation expectations to core inflation.

4.3 Recursive versus direct forecasting

As noted earlier, generating forecasts from either the expectations model of Eq. (2) or the empirical NKPC model of Eq. (3) requires producing forecasts of the expectations term included in both specifications and, in the case of the NKPC model, the exogenous regressors as well. We have done so by estimating fourth-order autoregressive processes in a recursive manner: each multi-step-ahead prediction is obtained by substituting previously forecasted values back into the estimated equation. This recursive approach mirrors standard practice in professional forecasting.[19] Nevertheless, a direct (non-iterated) method, which avoids the need for forecasting expectations and exogenous regressors, represents a natural alternative. In this section, we present a validation exercise in which we compare the forecast accuracy obtained under the recursive and the direct forecasting methods, focusing on the four expectations measures that emerged as most relevant for explaining inflation in the preceding analysis, i.e. the qualitative measures on households' and firms' inflation beliefs.[20]

The direct forecasts are computed based on adjusted versions of the expectations model of Eq. (7) and the empirical NKPC model of Eq. (8), connecting directly inflation in time t with expectations and exogenous regressors in time $(t-h)$, in the manner of local projections models (Jordà, 2005):

$$\pi_{v,t} \; = c + \beta \, E_{v,t-h} \left(\pi_{t+j} \right) + \epsilon_{v,t}, \tag{7}$$

$$\pi_{v,t} \; = c + \beta \, E_{v,t-h} \left(\pi_{t+j} \right) + \alpha \, \pi_{v,t-h-1} + \sum_{l=0}^{l_{max}} \left[\gamma_l \, s_{v,t-h-l} + \delta_l \, p^{input}_{v,t-h-l} \right] + \eta_{v,t}. \tag{8}$$

In order to compare the forecast accuracy delivered by the recursive and the direct

[19] The preference for recursive forecasting stems primarily from its substantially lower computational cost: unlike the direct approach, which requires estimating a separate model for each forecast horizon, the recursive method relies on a single estimated model whose outputs are iteratively reused to generate longer-horizon predictions. Additional differences between the two methods include: (i) recursive forecasting implicitly assumes that the underlying relationship among the variables remains stable across all forecast horizons, and (ii) it promotes a greater internal consistency in the sequence of forecasts, since each longer-horizon prediction is conditioned on the model's own earlier predictions rather than independent estimates.

[20] The results for the rest of the expectations measures are available from the authors upon request.

approaches, we compute the relative RMSFEs in the 4-quarter-ahead horizon of each model. The results of these comparisons are presented in Figure 10 for the four inflation expectations measures outlined above.

The results appear to confirm that the recursive approach, as adopted in our baseline analysis, consistently delivers more precise inflation forecasts than the direct approach. This holds across all four expectations measures and for both, the expectations model and the empirical NKPC model. Accordingly, we conclude that the recursive forecasting procedure used throughout the paper is reasonably well-supported from a methodological standpoint and on the basis of the superior predictive accuracy that shows consistently.

4.4 A horse race of inflation expectations measures

Having shown the relevance for inflation of the available qualitative information on households' and firms' beliefs, we next explore which one matters more in the empirical determination of inflation. The theory predicts that the short-run inflation expectations of (sticky) price-setting firms are those that matter for inflation, hence, the empirical relevance attributed to households' beliefs would stem from their high correlation with firms' ones. In Table 4, we explore this hypothesis by reporting estimates of variants of the empirical NKPC model of Eq. (3) using the last vintage of the data. In the first three columns, the model estimates control for the inflation beliefs of households and retail firms (individually and simultaneously), while the last three columns expand the latter by allowing for an inflation persistence term. The results show that the retailers' short-term qualitative beliefs on expected changes in their own price are more important in accounting for inflation. Whether one controls for past inflation or not, the coefficient on firms' inflation expectations is correctly signed, retains significance across specifications and registers the largest R^2.[21] These specifications explain a large fraction of the movements in core inflation with an adjusted R^2 of up to 0.73. More particularly, Figure 11 depicts the evolution of observed inflation and of its fitted value using the model of column (E). The figure shows that both series move reasonably close to each other with the fitted model picking up turning points fairly well. Overall, we view the results in Table 4 as supportive of the central prediction of the NKPC framework regarding firms' inflation expectations as the ones that matter the most for euro area inflation dynamics. With US data, Coibion and Gorodnichenko (2025) ascribe this empirical role to households; however, the authors acknowledge the lack of sufficient data on firms' beliefs to reach a final

[21] Likewise, this result is robust across measures of economic slack; all the estimates are available from the authors upon request.

conclusion and, in any event, we need to concede that both agents' expectations (retailers and consumers) may be more interconnected than what the available survey measures reflect. Appendix C confirms our result using, as an alternative measure to retail firms' beliefs, those of other services firms.

Once we condition on firms' short-term inflation expectations, Table 5 explores the role to be ascribed to professional forecasters' and financial markets participants' long-term inflation beliefs in accounting for inflation dynamics. As already noted above, long-horizon financial prices are more suitable to quantify expected inflation since the frictional component of the financial price drives rates at shorter maturities (3 years or less); see the discussion in Bahaj et al. (2025). Professionals' and financial markets participants' inflation expectations thus appear especially relevant for pricing long-term assets, plausibly influencing households' and firms' long-horizon spending decisions and, potentially, inflation. The results reported in Table 5 appear to confirm this notion. When we run models that include firms' short-run inflation beliefs simultaneously with either professional forecasters' or financial markets participants' long-run inflation expectations, the coefficients of the former retain strong significance while the coefficients of the latter are generally significant, especially for the long-horizon swap rate. This evidence may be suggestive of different pass-through channels of inflation beliefs to inflation, one that may operate via price-setters' short-run beliefs and another one via financial actors' long-run beliefs. Appendix C shows, once again, that this result is robust to the use of a measure of firms' beliefs that is based on information from other services firms.

Our final exploration is concerned with the empirical magnitude of the estimated coefficient on firms' inflation beliefs. The previous sections have consistently shown a pass-through estimate of short-run inflation expectations to inflation in the range 0.1-0.3. In the last two columns of Table 4, we report a baseline β point estimate of about 0.5 when we control for lagged inflation and use the last vintage of the data for estimation. This figure implies that a one standard deviation increase in the standardized balance of inflation expectations responses is associated with a 0.5 pp increase in core inflation. For the expectations of retailers regarding their own price, the original balance of responses across the three categorical answers to the survey's question has a historical standard deviation of +11.6 points.[22] That is, a one standard deviation increase involves a net 11.6 pp increase in the proportion of respondents expecting a higher price outlook. As an illustration, from 2020:Q2 to 2022:Q2, when our measure of core inflation accelerated

[22] The specific categorical answers to the question asked in the survey are: "How do you expect the prices you charge to change over the next 3 months? They will increase, remain unchanged or decrease". See Appendix A for more details.

by 4 pp, there was an accumulated increase of about five standard deviations in retailers' inflationary sentiment, explaining close to 66% of the core inflation acceleration. Albeit this figure is to be taken as orientative, the evidence nonetheless suggests that firms' short-run inflation expectations were an important driver of inflation in the surge after the shocks of the early 2020s. On the other hand, and not surprisingly, our estimates for the whole sample indicate that the Phillips Curve is rather flat, that is, the slope of the Phillips Curve is, in general, not significant.[23]

5 Concluding remarks

Several theoretical mechanisms suggest that households' and firms' inflation expectations affect very saliently these agents' choices and decisions with the potentiality to determine inflation in the aggregate. The existence of an economically meaningful pass-through channel connecting inflation expectations and inflation could be key to monetary policymakers in their pursuit of inflation stabilization. In this paper, we have explored this connection through the lens of a macroeconomic forecasting exercise carried out by an exogenous observer in real time. The stepwise and systematic inclusion of real-time expectations from surveys and markets in estimated vintages of inflation models may provide some useful insights to inform the policy debate and contribute to the literature.

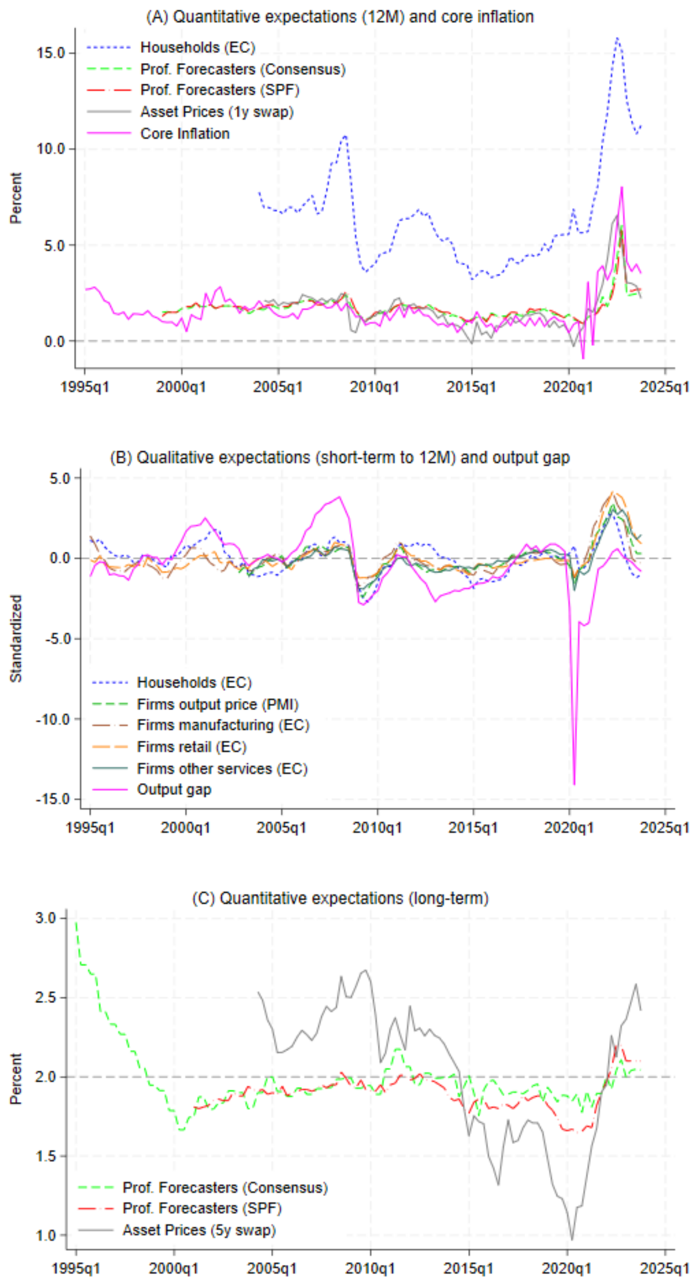
This paper has argued that households' and firms' expectational updates can help an exogenous observer predict core inflation. More particularly, models that are informed by households', retailers', and other services firms' own inflation expectations at short-term horizons systematically anticipate core inflation more accurately, and do so in a stable way, than models that do not use this information. This result appears reinforced in two recent episodes of very distinct inflation dynamics: the effective lower bound (ELB) period and the post-COVID-19 period. A horse race of expectations measures confirms a central prediction of the New Keynesian Phillips Curve (NKPC) theoretical framework regarding the relevance of firms' short-run inflation expectations to inflation dynamics. Finally,

[23]This result is robust across model specifications and variants of slack variables; the estimates are available from the authors upon request. The flat(tening) of the Phillips Curve is a common result in the empirical literature that applies macroeconomic data to the analysis of inflation (e.g., Ball and Mazumder, 2011; Blanchard, 2016), see the survey and discussion in Hooper et al. (2020). Under an inflation targeting regime, a successful monetary policy would tackle any trade-off between inflation and output thus masking the underlying correlation in the Phillips Curve (e.g., McLeay and Tenreyro, 2020). More particularly, McLeay and Tenreyro (2020) argue that a Phillips Curve relationship should appear stronger in disaggregated panel than in aggregate data, as shown in studies that use city-level, state-level or metropolitan areas data (e.g., Fitzgerald and Nicolini, 2014; McLeay and Tenreyro, 2020; Hazell et al., 2022; Fitzgerald et al., 2024).

conditioned models suggest the existence of different pass-through channels of inflation expectations to inflation, one that may operate via price-setters' short-run beliefs about their own pricing and another one via financial actors' long-run beliefs.

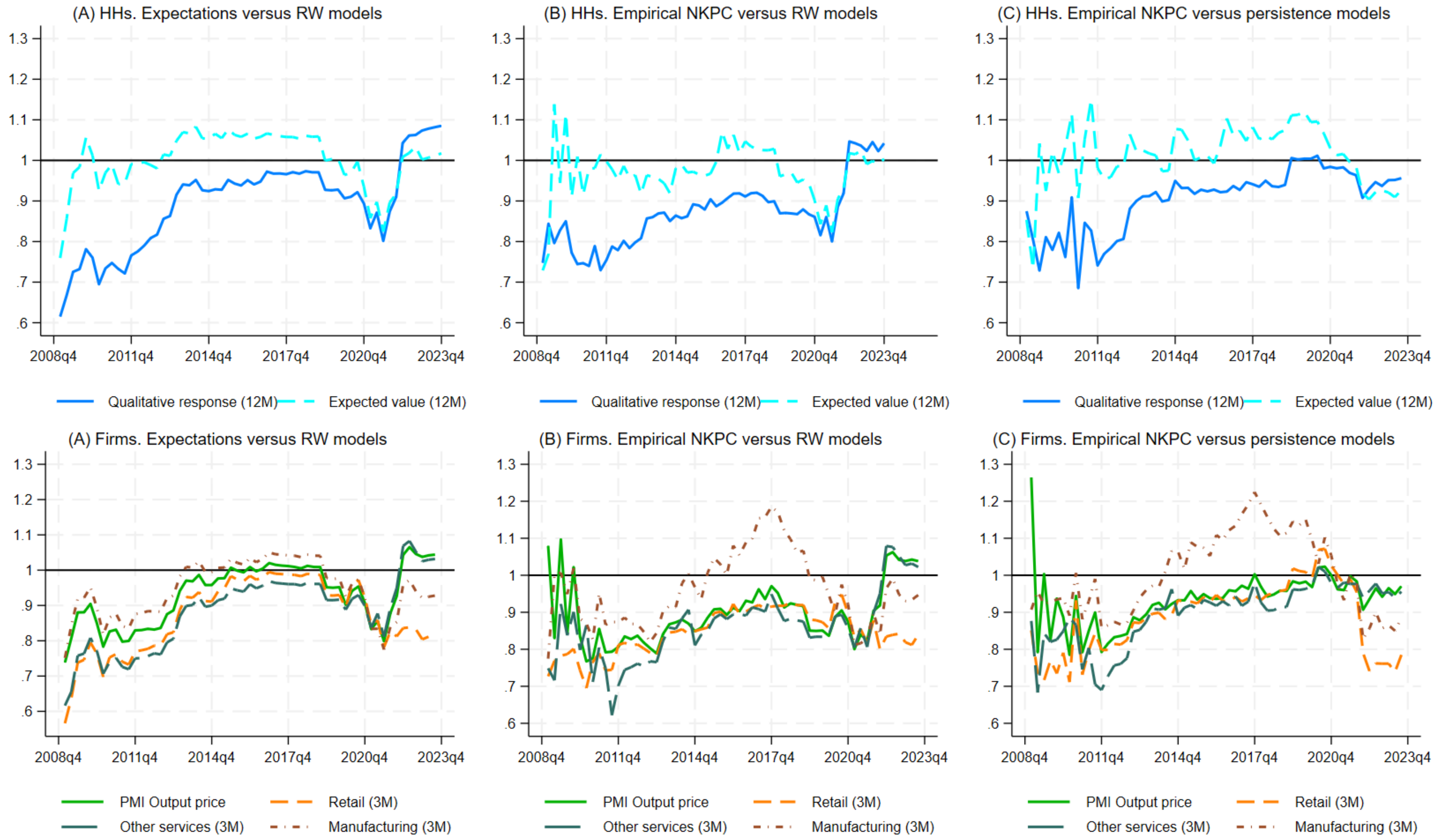
6 Figures and Tables

Figure 1: Measures of expectations, inflation and business cycle position in the euro area.



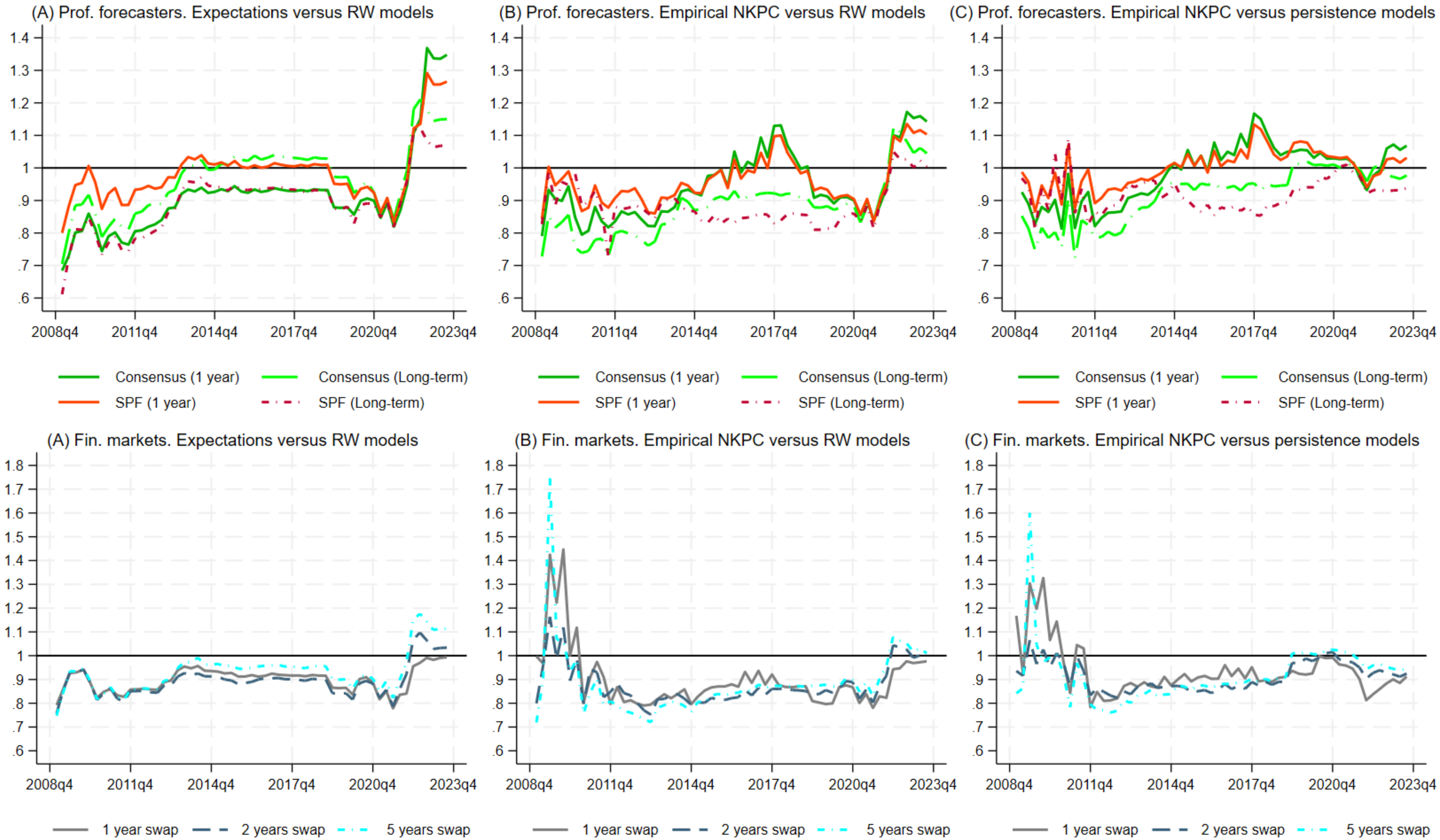
Note: This figure shows the evolution of expectations measures, core inflation and a measure of the state of the economy. Appendix A provides a detailed account of data definitions, measures and sources.

Figure 2: Relative RMSFEs of core inflation models by expectations measures (households and firms), h=4.



Note: This figure shows the RMSFEs at horizon 4 of models that include expectations measures (in panel (A) the expectations model; in panels (B,C) the empirical NKPC model) computed for each vintage in real time, relative to the corresponding RMSFEs of benchmark models (in panels (A,B) the random walk (Atkeson-Ohanian) model; in panel (C) the persistence model).

Figure 3: Relative RMSFEs of core inflation models by expectations measures (professional forecasters and financial markets participants), h=4.



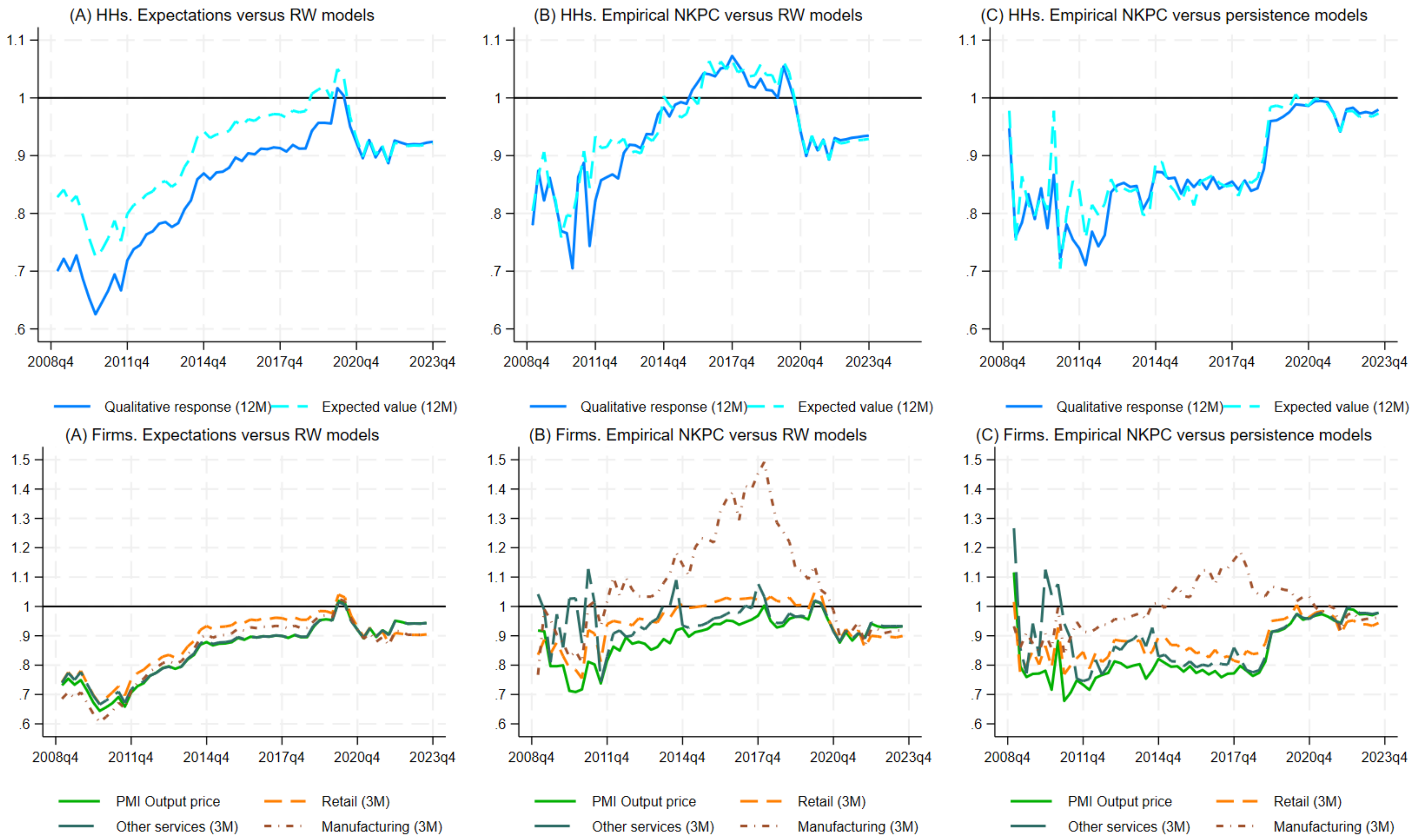
Note: This figure shows the RMSFEs at horizon 4 of models that include expectations measures (in panel (A) the expectations model; in panels (B,C) the empirical NKPC model) computed for each vintage in real time, relative to the corresponding RMSFEs of benchmark models (in panels (A,B) the random walk (Atkeson-Ohanian) model; in panel (C) the persistence model).

Table 1: RMSFEs meta-regressions for EA core inflation, h=4.

	(A) ALL Expectations vs. RW	(B) ALL NKPC vs. RW	(C) ALL NKPC vs. Persistence	(D) ELB Expectations vs. RW	(E) ELB NKPC vs. RW	(F) ELB NKPC vs. Persistence
Households						
Expected value (12M)	-0.020 ***	-0.018 ***	-0.014 ***	-0.011 ***	-0.017 ***	-0.010 ***
	(0.005)	(0.005)	(0.005)	(0.003)	(0.003)	(0.004)
Qualitative response (12M)	-0.072 ***	-0.067 ***	-0.063 ***	-0.064 ***	-0.069 ***	-0.062 ***
	(0.005)	(0.005)	(0.005)	(0.003)	(0.002)	(0.003)
Firms						
PMI Output price	-0.053 ***	-0.051 ***	-0.047 ***	-0.045 ***	-0.064 ***	-0.057 ***
	(0.004)	(0.005)	(0.005)	(0.003)	(0.002)	(0.003)
Manufacturing (3M)	-0.058 ***	-0.031 ***	-0.027 ***	-0.030 ***	-0.001	0.006
	(0.008)	(0.007)	(0.007)	(0.003)	(0.006)	(0.006)
Retail (3M)	-0.109 ***	-0.099 ***	-0.095 ***	-0.060 ***	-0.069 ***	-0.062 ***
	(0.012)	(0.010)	(0.010)	(0.004)	(0.003)	(0.003)
Other services (3M)	-0.078 ***	-0.069 ***	-0.065 ***	-0.071 ***	-0.075 ***	-0.068 ***
	(0.005)	(0.005)	(0.005)	(0.004)	(0.003)	(0.003)
Prof. Forecasters						
Consensus (1Y)	-0.036 **	-0.018 **	-0.014 *	-0.073 ***	-0.027 ***	-0.020 ***
	(0.016)	(0.008)	(0.008)	(0.002)	(0.005)	(0.005)
Consensus (long-term)	-0.022 ***	-0.056 ***	-0.052 ***	-0.031 ***	-0.066 ***	-0.059 ***
	(0.007)	(0.006)	(0.006)	(0.003)	(0.003)	(0.003)
SPF (1Y)	-0.005	-0.012 **	-0.009	-0.034 ***	-0.027 ***	-0.020 ***
	(0.010)	(0.006)	(0.005)	(0.003)	(0.003)	(0.003)
SPF (long-term)	-0.067 ***	-0.059 ***	-0.056 ***	-0.070 ***	-0.082 ***	-0.075 ***
	(0.005)	(0.005)	(0.005)	(0.003)	(0.005)	(0.005)
Financial Markets						
1 year swap	-0.077 ***	-0.058 ***	-0.054 ***	-0.075 ***	-0.082 ***	-0.075 ***
	(0.005)	(0.009)	(0.009)	(0.003)	(0.003)	(0.003)
2 years swap	-0.071 ***	-0.064 ***	-0.060 ***	-0.085 ***	-0.093 ***	-0.087 ***
	(0.004)	(0.005)	(0.005)	(0.003)	(0.003)	(0.003)
5 years swap	-0.042 ***	-0.056 ***	-0.052 ***	-0.060 ***	-0.092 ***	-0.086 ***
	(0.006)	(0.009)	(0.009)	(0.003)	(0.003)	(0.004)
Number of observations	1020	1020	1020	476	476	476
Adjusted R-squared	0.97	0.97	0.98	0.85	0.82	0.78

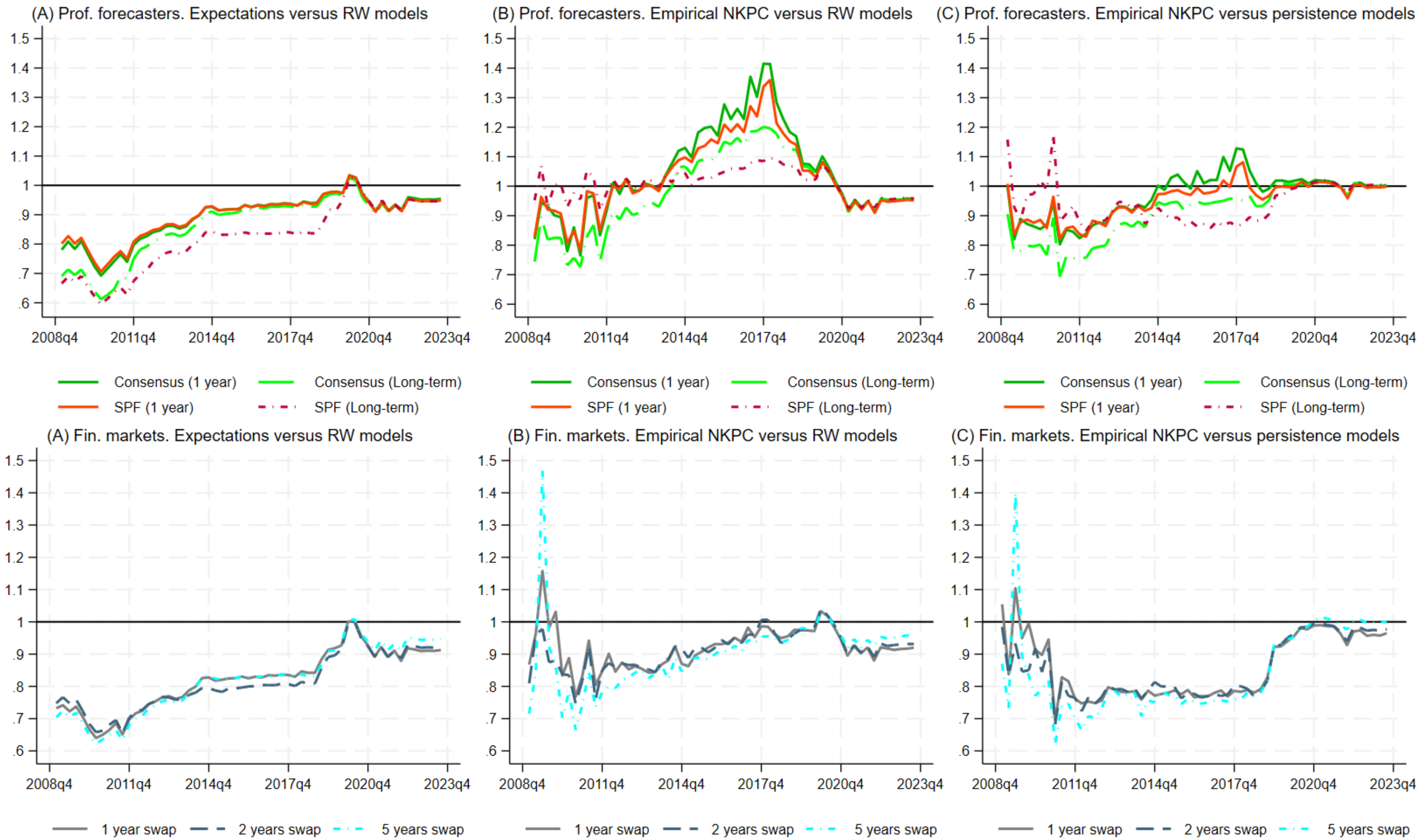
Notes: *** p-value<.01, ** p-value<.05, * p-value<.1. In the case of NKPC models, RMSFEs based on median forecasts across specifications and slack measures. ALL stands for all sample period and ELB for the effective lower bound period. Regressions include a constant term and vintage dummies. Excluded categories: in regressions (A,B,D,E), the random walk (Atkeson-Ohanian) model; in regressions (C,F), the persistence model. Robust standard errors in parentheses. See the text for more details.

Figure 4: Relative RMSFEs of core inflation models and expectations measures (households and firms), h=8.



Note: This figure shows the RMSFEs at horizon 8 of models that include expectations measures (in panel (A) the expectations model; in panels (B,C) the empirical NKPC model) computed for each vintage in real time, relative to the corresponding RMSFEs of benchmark models (in panels (A,B) the random walk (Atkeson-Ohanian) model; in panel (C) the persistence model).

Figure 5: Relative RMSFEs of core inflation models and expectations measures (professional forecasters and financial markets participants), h=8.



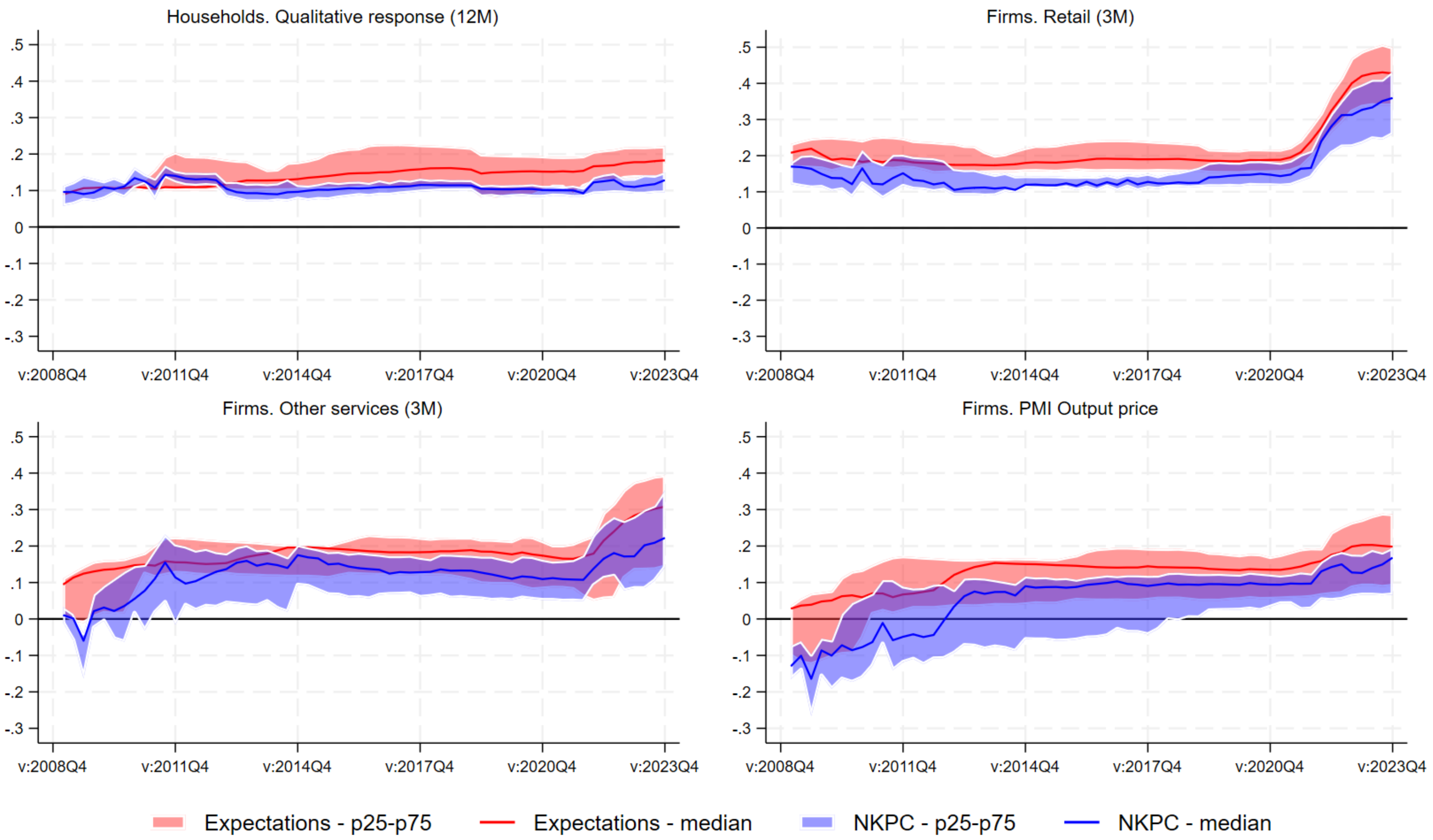
Note: This figure shows the RMSFEs at horizon 8 of models that include expectations measures (in panel (A) the expectations model; in panels (B,C) the empirical NKPC model) computed for each vintage in real time, relative to the corresponding RMSFEs of benchmark models (in panels (A,B) the random walk (Atkeson-Ohanian) model; in panel (C) the persistence model).

Table 2: RMSFEs meta-regressions for EA core inflation, h=8.

	(A) ALL Expectations vs. RW	(B) ALL NKPC vs. RW	(C) ALL NKPC vs. Persistence	(D) ELB Expectations vs. RW	(E) ELB NKPC vs. RW	(F) ELB NKPC vs. Persistence
Households						
Expected value (12M)	-0.041 ***	-0.033 ***	-0.042 ***	-0.025 ***	-0.021 ***	-0.044 ***
	(0.004)	(0.004)	(0.004)	(0.003)	(0.005)	(0.006)
Qualitative response (12M)	-0.077 ***	-0.040 ***	-0.049 ***	-0.063 ***	-0.022 ***	-0.045 ***
	(0.004)	(0.004)	(0.004)	(0.003)	(0.004)	(0.005)
Firms						
PMI Output price	-0.071 ***	-0.064 ***	-0.073 ***	-0.064 ***	-0.063 ***	-0.087 ***
	(0.004)	(0.005)	(0.005)	(0.003)	(0.005)	(0.005)
Manufacturing (3M)	-0.077 ***	0.044 ***	0.035 ***	-0.049 ***	0.108 ***	0.085 ***
	(0.005)	(0.010)	(0.009)	(0.003)	(0.010)	(0.010)
Retail (3M)	-0.059 ***	-0.039 ***	-0.048 ***	-0.034 ***	-0.019 ***	-0.042 ***
	(0.005)	(0.005)	(0.005)	(0.003)	(0.005)	(0.006)
Other services (3M)	-0.068 ***	-0.030 ***	-0.038 ***	-0.063 ***	-0.037 ***	-0.060 ***
	(0.004)	(0.007)	(0.008)	(0.003)	(0.007)	(0.008)
Prof. Forecasters						
Consensus (1Y)	-0.041 ***	0.032 ***	0.023 ***	-0.037 ***	0.077 ***	0.054 ***
	(0.004)	(0.007)	(0.006)	(0.003)	(0.009)	(0.009)
Consensus (long-term)	-0.060 ***	-0.008	-0.017 ***	-0.046 ***	0.027 ***	0.004
	(0.005)	(0.006)	(0.006)	(0.003)	(0.006)	(0.006)
SPF (1Y)	-0.040 ***	0.021 ***	0.012 **	-0.037 ***	0.056 ***	0.033 ***
	(0.004)	(0.005)	(0.005)	(0.003)	(0.007)	(0.007)
SPF (long-term)	-0.085 ***	0.013 **	0.004	-0.088 ***	0.006	-0.017 ***
	(0.005)	(0.005)	(0.005)	(0.003)	(0.005)	(0.006)
Financial Markets						
1 year swap	-0.093 ***	-0.051 ***	-0.059 ***	-0.092 ***	-0.065 ***	-0.089 ***
	(0.004)	(0.006)	(0.006)	(0.003)	(0.005)	(0.006)
2 years swap	-0.096 ***	-0.053 ***	-0.062 ***	-0.106 ***	-0.063 ***	-0.086 ***
	(0.004)	(0.005)	(0.005)	(0.003)	(0.005)	(0.006)
5 years swap	-0.087 ***	-0.057 ***	-0.065 ***	-0.094 ***	-0.076 ***	-0.099 ***
	(0.005)	(0.009)	(0.010)	(0.003)	(0.006)	(0.006)
Number of observations	1020	1020	1020	476	476	476
Adjusted R-squared	0.99	0.99	0.99	0.94	0.80	0.78

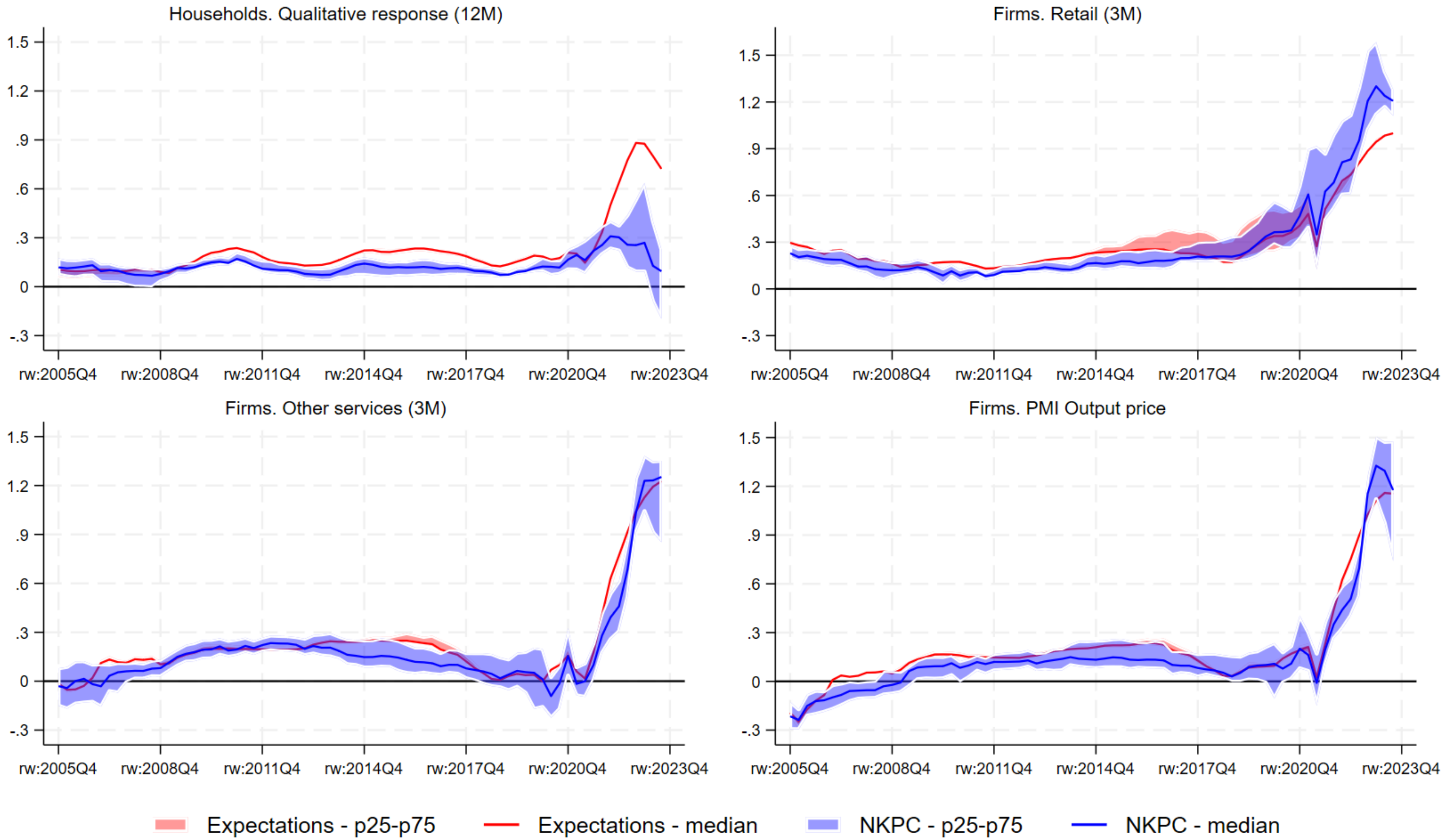
Notes: *** p-value<.01, ** p-value<.05, * p-value<.1. In the case of NKPC models, RMSFEs based on median forecasts across specifications and slack measures. ALL stands for all sample period and ELB for the effective lower bound period. Regressions include a constant term and vintage dummies. Excluded categories: in regressions (A,B,D,E), the random walk (Atkeson-Ohanian) model; in regressions (C,F), the persistence model. Robust standard errors in parentheses. See the text for more details.

Figure 6: Real time-varying distribution of the estimated relationship between core inflation and inflation expectations (households and firms): expectations vs. NKPC models, within-vintages.



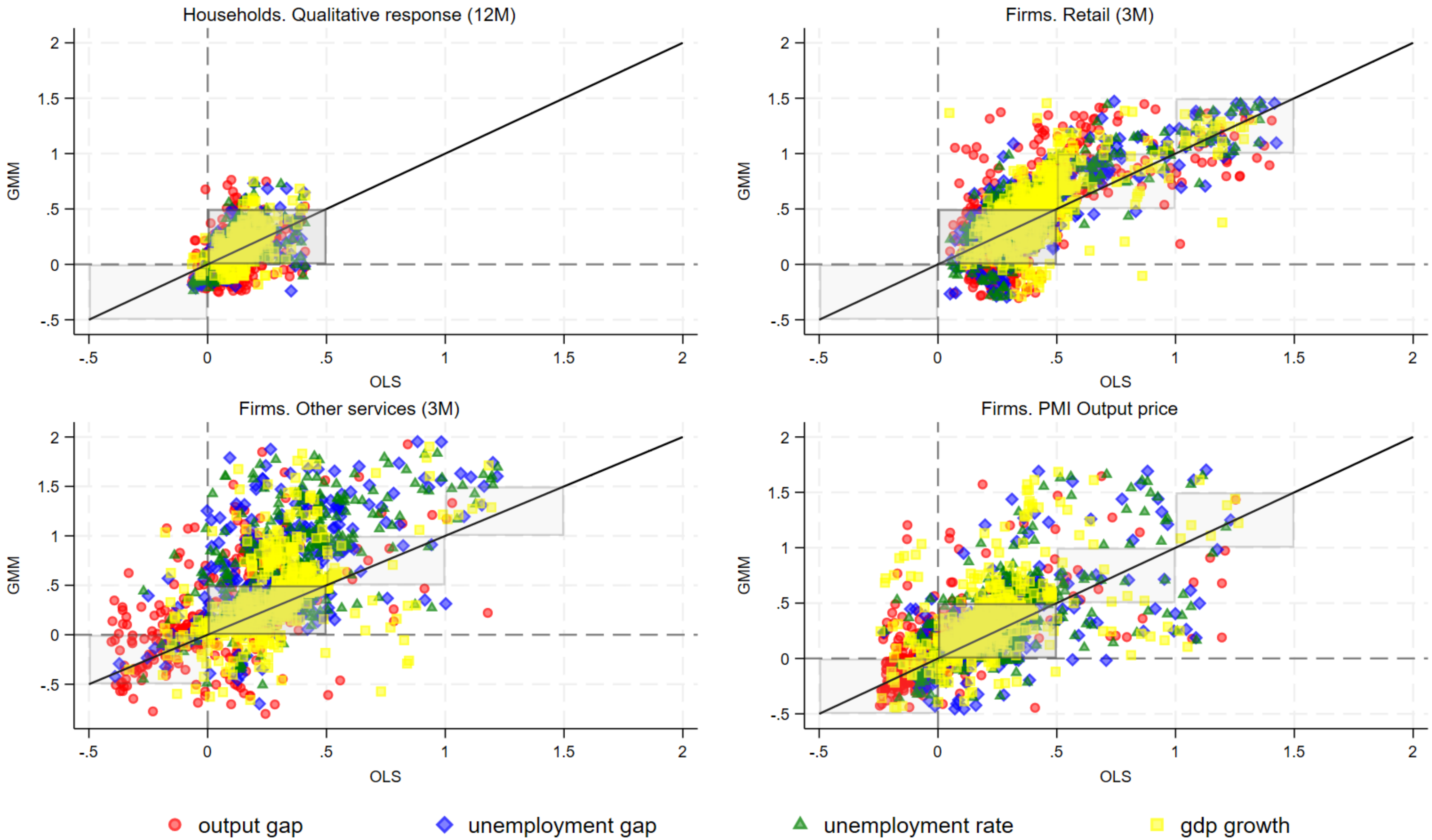
Note: This figure shows the real time-varying distribution of the estimated coefficient on inflation expectations in expectations models and NKPC models with core inflation as the dependent variable. Computation for each expectation measure is carried out in this manner: for each vintage, median value and percentiles are obtained over its corresponding rolling windows estimates. In the case of NKPC models, a previous computation is performed: for each vintage and rolling window, a median value is calculated over the different model specifications applied and slack measures considered. On the horizontal axis, v stands for vintage. Shaded areas in the figure show the 50% bands (percentiles 25-75), and solid lines show the median value.

Figure 7: Real time-varying distribution of the estimated relationship between core inflation and inflation expectations (households and firms): expectations vs. NKPC models, rolling windows.



Note: This figure shows the real time-varying distribution of the estimated coefficient on inflation expectations in expectations models and NKPC models with core inflation as the dependent variable. Computation for each expectation measure is carried out in this manner: for each sample rolling window, median value and percentiles are obtained across vintages and, in the case of NKPC models, also across the different model specifications applied and slack measures considered. On the horizontal axis, *rw* stands for rolling window such that the results are dated at the end of each sample rolling window. Shaded areas in the figure show the 50% bands (percentiles 25-75), and solid lines show the median value.

Figure 8: Point estimates of the pass-through parameter: OLS vs. GMM.



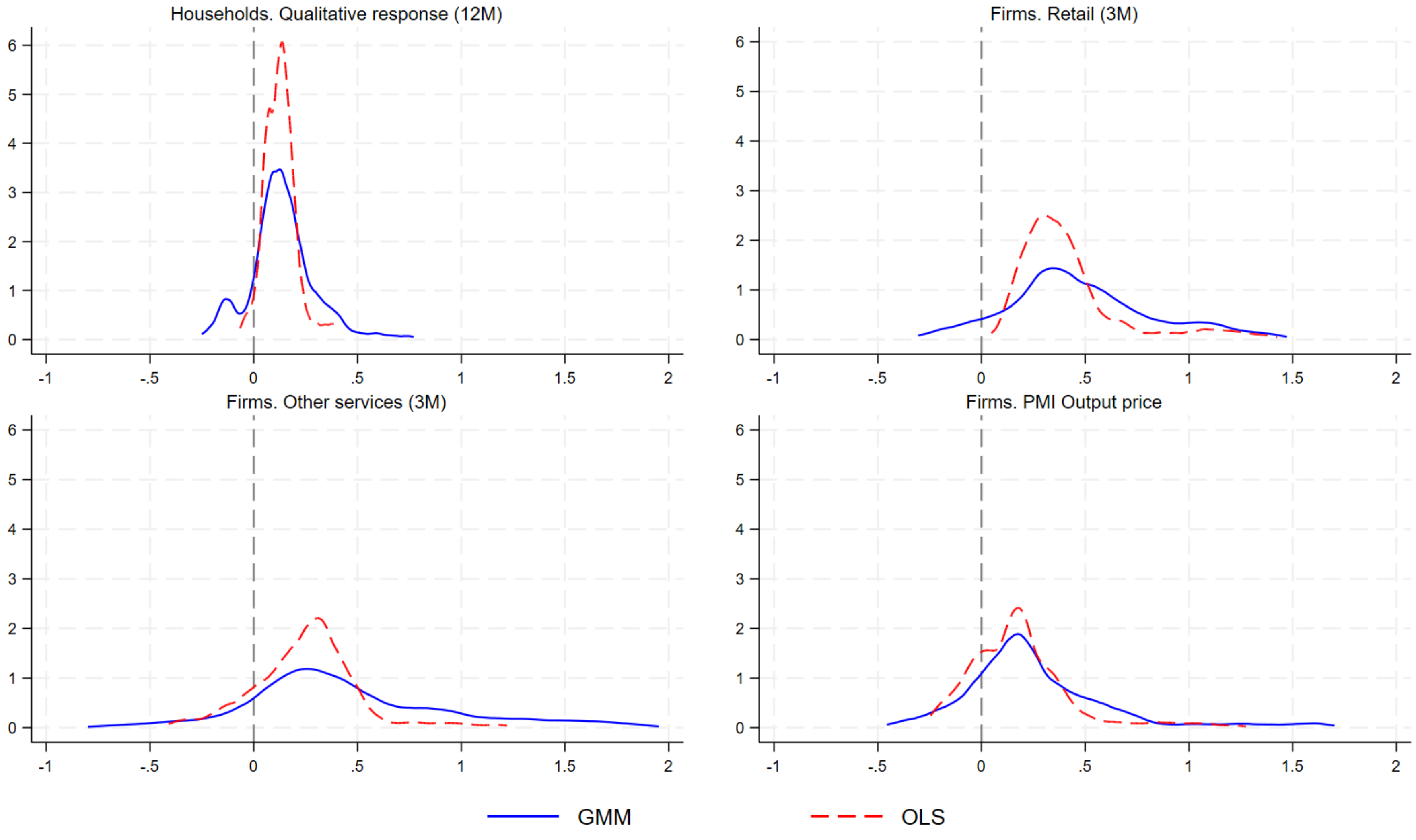
Note: This figure shows the point estimates of the coefficient on inflation expectations for different specifications of NKPC, based on rolling window samples of the last available vintage (2023Q4). The 2.5% more extreme estimates are excluded in both tails to avoid outliers. Each point in the scatter plot shows its OLS estimate on the horizontal axis and its GMM estimate on the vertical axis. Computation of GMM estimates was carried out applying an iterative method, which minimizes the usual GMM objective function in a recursive way until convergence is achieved. The instruments considered are 2 lags of the variable for expectations, 2 lags for slack measures in contemporaneous specifications and up to 4 in those specifications that include the first lag of the slack variable, and 4 lags of lagged core inflation in specifications that include a persistence term. Different symbols and colors represent the slack measure included in the model. The 45º line and shaded squares are included to facilitate the comparison between OLS and GMM estimates.

Table 3: Summary statistics for estimates of the coefficient on inflation expectations: OLS vs. GMM.

Survey expectation	Households Qualitative (12M)		Firms Retail (3M)		Firms Other services (3M)		Firms Output price (4-6M)	
Estimation method	OLS	GMM	OLS	GMM	OLS	GMM	OLS	GMM
Mean	0.129	0.144	0.431	0.481	0.256	0.457	0.192	0.276
Median	0.125	0.127	0.359	0.432	0.266	0.351	0.164	0.199
5th percentile	0.002	-0.149	0.139	-0.122	-0.193	-0.333	-0.174	-0.248
95th percentile	0.296	0.443	1.154	1.210	0.765	1.577	0.813	1.222
Standard deviation	0.092	0.196	0.292	0.393	0.291	0.566	0.288	0.417
Fraction both positive	0.836		0.908		0.793		0.717	
Fraction between 0 - 0.5	0.774		0.466		0.410		0.501	
Fraction between 0.5 - 1	0.002		0.097		0.027		0.015	
Fraction rejections by 5% Hansen J-test	0.028		0.060		0.040		0.047	

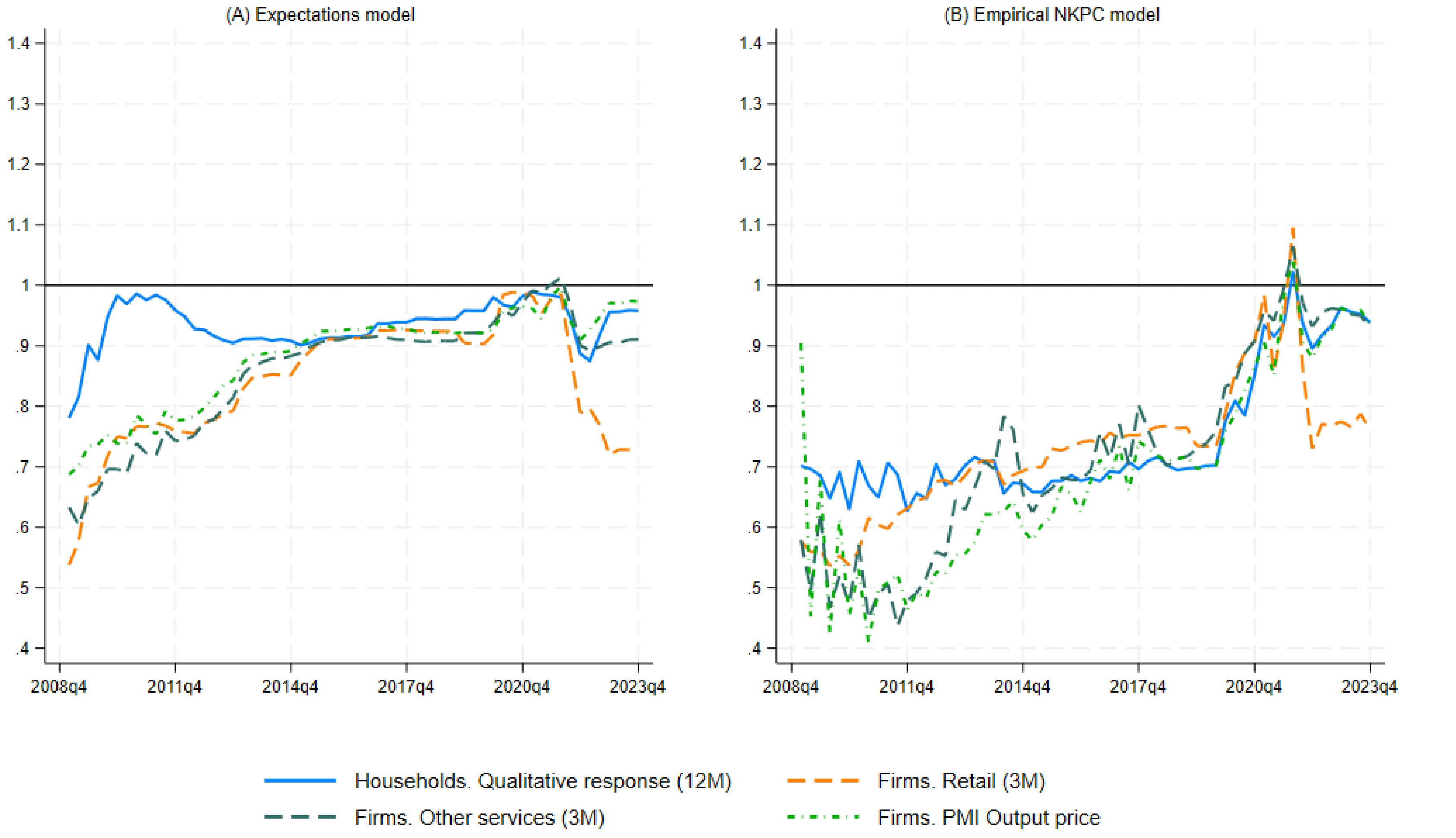
Note: This table shows the summary statistics for the estimates of the coefficient on inflation expectations obtained from rolling window samples of the last available vintage (2023Q4). The 2.5% more extreme estimates are excluded in both tails to avoid outliers. Computation of GMM estimates was carried out applying an iterative method, which minimizes the usual GMM objective function in a recursive way until convergence is achieved. The instruments considered are 2 lags of the variable for expectations, 2 lags for slack measures in contemporaneous specifications and up to 4 in those specifications that include the first lag of the slack variable, and 4 lags of lagged core inflation in specifications that include a persistence term.

Figure 9: Distribution of point estimates of the pass-through coefficient: OLS vs. GMM



Note: This figure shows the kernel-smoothed distribution of point estimates of the coefficient on inflation expectations for different specifications of NKPC, based on rolling window samples of the last available vintage (2023Q4). The 2.5% more extreme estimates are excluded in both tails to avoid outliers. Computation of GMM estimates was carried out applying an iterative method, which minimizes the usual GMM objective function in a recursive way until convergence is achieved. The instruments considered are 2 lags of the variable for expectations, 2 lags for slack measures in contemporaneous specifications and up to 4 in those specifications that include the first lag of the slack variable, and 4 lags of lagged core inflation in specifications that include a persistence term.

Figure 10: Relative RMSFEs of core inflation models with recursive versus direct forecasting approach



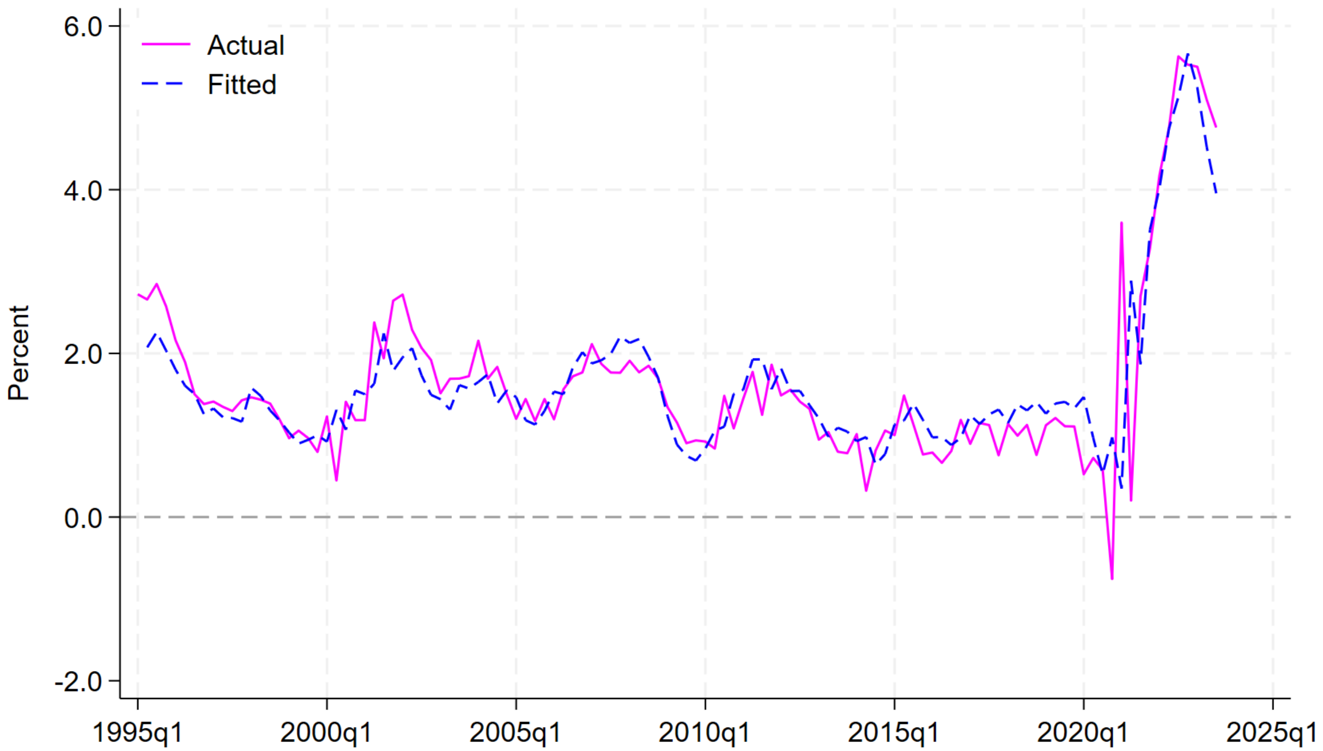
Note: This figure shows the RMSFEs at horizon 4 of models that include expectations measures (in panel (A) the expectations model; in panel (B) the empirical NKPC model) computed for each vintage in real time applying a recursive forecasting approach, relative to the corresponding RMSFEs when a direct forecasting method is applied.

Table 4: A horse race of inflation expectations measures in the NKPC model: Households vs. retail firms.

	(A)		(B)		(C)		(D)		(E)		(F)	
Households. Qualitative (12M)	0.240	**			-0.118		0.096	**			-0.049	
	(0.101)				(0.088)		(0.046)				(0.071)	
Firms. Retail (3M)			0.933	***	0.983	***			0.525	***	0.555	***
			(0.080)		(0.087)				(0.122)		(0.147)	
π_{t-1}							0.755	***	0.466	***	0.456	***
							(0.124)		(0.166)		(0.173)	
Number of observations	114		114		114		114		114		114	
Adjusted R-squared	0.21		0.65		0.65		0.66		0.73		0.73	

Notes: *** p-value<0.01, ** p-value<0.05, * p-value<0.1. The table reports regression results of core inflation on two measures -individually and simultaneously- of expected inflation (the first three columns), plus lagged core inflation (the last three columns). All regressions include a constant term, the unemployment gap as the measure of slack, and cost-push shocks. The estimation sample (1996-2023) corresponds to the last available vintage. Robust standard errors are reported in parentheses.

Figure 11: Core inflation: Actual vs. fitted values from a NKPC model with retailers' expectations.



Note: This figure depicts, for the last vintage of the data (2023Q4), the actual core inflation series versus the fitted inflation values from an empirical NKPC model that includes retail firms' inflation expectations, lagged core inflation, the unemployment gap and cost-push shocks.

Table 5: The pass-through channels of short-term and long-term inflation expectations.

	(A)	(B)	(C)	(D)
Firms. Retail (3M)	0.753 ***	0.976 ***	0.565 ***	0.827 ***
	(0.083)	(0.074)	(0.152)	(0.224)
SPF (long-term)	2.852 ***		1.954	
	(1.061)		(1.378)	
5 years swap		0.530 ***		0.420 *
		(0.195)		(0.230)
π_{t-1}			0.272	0.159
			(0.221)	(0.269)
Sample period	2001-2023	2004-2023	2001-2023	2004-2023
Number of observations	91	78	91	78
Adjusted R-squared	0.73	0.77	0.75	0.77

Notes: *** p-value<0.01, ** p-value<0.05, * p-value<0.1. The table reports regression results of core inflation on retailers' expectations combined with two alternate measures of long-term expected inflation (the first two columns) plus lagged core inflation (the last two columns). All regressions include a constant term, the unemployment gap as the measure of slack, and cost-push shocks. Robust standard errors are reported in parentheses.

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A Data definitions and sources

Inflation is computed from the Harmonized Index of Consumer Prices (HICP) excluding food and energy (Core). This price index series is seasonally adjusted.[24] The inflation rate is calculated as the annualized quarter-on-quarter growth rate of the seasonally adjusted index, in percentages. Data are available from 1995Q1.
Data source: Eurostat and our own calculations.

Inflation expectations

Households. Two measures based on the Consumer Survey, run by the Directorate General for Economic and Financial Affairs (DG-ECFIN) of the European Commission, that capture the price trends over the next 12 months. (a) Qualitative expectations: corresponds to the qualitative response to the question "By comparison with the past 12 months, how do you expect that consumer prices will develop in the next 12 months? They will... increase more rapidly, increase at the same rate, increase at a slower rate, stay about the same or fall". Data are provided as seasonally adjusted response balances and we proceed to standardize them. Data are available from 1995Q1. (b) Quantitative expectations ("Expected value"): corresponds to the quantitative response to the question "By how many percent do you expect consumer prices will go up / go down over the next 12 months?". Data are provided without seasonal adjustment as no seasonal pattern is detected. Data are available from 2004Q1.
Data source: DG-ECFIN (European Commission).

Firms. Four measures, as described below. (a) Output Price Index of the composite Purchasing Managers' Index (PMI). Data are provided as a diffusion index and we proceed to standardize them. Data are available from 2002Q4. Data source: S&P Global.
In addition, three measures obtained from surveys that are part of the European Commission's Business Surveys (respectively, the Retail Trade Survey, the Services Survey and the Manufacturing Industry Survey). The question asked in each case is qualitative and reads: "How do you expect the prices you charge to change over the next 3 months? They will... increase, remain unchanged or decrease". Data are provided as seasonally adjusted response balances and we proceed to standardize them. (b) Selling price expectations over the next 3 months of firms in the retail trade sector, which encompasses selling price expectations of firms in firm-to-consumer interactions. Data are available from 1995Q1. (c) Selling price expectations over the next 3 months of firms in the (other) services sector. The data cover services related to transportation, accommodation and food, information and communications, real estate, financial, professional, administrative and miscellaneous services. Data are available from 2003Q2. (d) Selling price expectations over the next 3 months of firms in the manufacturing sector, which encompasses selling price expecta-

[24] We seasonally adjust the price index series applying the TRAMO-SEATS method with JDemetra + 2.2.3 software.

tions of firms in firm-to-firm interactions. Data are available from 1995Q1. Data source: DG-ECFIN (European Commission).

Financial markets participants. Inflation-linked swaps at horizons of 1 year, 2 years, and 5 years. Data are available from 2004Q2. Data source: Reuters.

Professional Forecasters. Four measures, two with a short-term horizon and the other two with a long-term horizon, obtained from two different sources. (a) Consensus 1-year-ahead inflation forecast. Data are available from 1999Q1. (b) Consensus long-term: 6-to-10-year-ahead inflation forecast. Data are available from 1995Q1. (c) SPF 1-year-ahead inflation forecast. Data are available from 1999Q1. (d) SPF long-term: 5-year-ahead forecast. Data are available from 2001Q1.
Data sources: Consensus Forecast (from Consensus Economics), ECB Survey of Professional Forecasters (SPF).

Economic slack measures. Four measures, all based on seasonally adjusted data and available from 1995Q1, as described below. (a) Output gap: percentage difference between real GDP and the potential output. (b) Unemployment gap: percentage difference between the unemployment rate and the NAIRU. (c) Unemployment rate. (d) GDP growth: computed as the real GDP's annualized quarter-on-quarter growth rate.
Data sources: Eurostat, ECB.

Import price inflation: computed from the import price deflator index. The variable is expressed as annualized quarter-on-quarter growth rates, in percentages, adjusted by openness (the sum of exports and imports divided by GDP, all nominal). All data is provided seasonally adjusted. Data are available from 1995Q2. Data sources: Eurostat, ECB.

Unit labor costs: the variable is computed as annualized quarter-on-quarter growth rates, based on seasonally adjusted data, and it is expressed in percentages. Data are available from 1995Q1. Data source: Eurostat.

Nominal effective exchange rate of the euro against a currency basket of the euro area's main trading partners. The variable is computed as quarter-on-quarter growth rates, based on seasonally adjusted data, and it is expressed in percentages. Data are available from 1995Q2. Data source: ECB.

B Robustness Analysis

Table B.1. RMSFEs meta-regressions for EA core inflation, output gap models, h=4.

	(A) ALL NKPC vs. RW		(B) ALL NKPC vs. Persistence		(C) ELB NKPC vs. RW		(D) ELB NKPC vs. Persistence	
Households								
Expected (12M)	-0.040	***	-0.044	***	-0.044	***	-0.044	***
	(0.005)		(0.005)		(0.003)		(0.004)	
Qualitative (12M)	-0.073	***	-0.077	***	-0.069	***	-0.069	***
	(0.006)		(0.006)		(0.004)		(0.004)	
Firms								
PMI Output price	0.004		0.000		-0.029	***	-0.029	***
	(0.007)		(0.007)		(0.005)		(0.005)	
Manufacturing (3M)	0.061	***	0.056	***	0.115	***	0.115	***
	(0.013)		(0.013)		(0.011)		(0.011)	
Retail (3M)	-0.111	***	-0.115	***	-0.081	***	-0.081	***
	(0.009)		(0.010)		(0.004)		(0.004)	
Other services (3M)	-0.037	***	-0.041	***	-0.058	***	-0.059	***
	(0.008)		(0.008)		(0.005)		(0.005)	
Prof. Forecasters								
Consensus (1Y)	-0.001		-0.005		-0.011	*	-0.012	**
	(0.009)		(0.008)		(0.006)		(0.006)	
Consensus (long-term)	-0.045	***	-0.050	***	-0.059	***	-0.059	***
	(0.007)		(0.007)		(0.004)		(0.004)	
SPF (1Y)	-0.002		-0.007		-0.022	***	-0.023	***
	(0.006)		(0.006)		(0.004)		(0.004)	
SPF (long-term)	-0.051	***	-0.055	***	-0.070	***	-0.070	***
	(0.006)		(0.006)		(0.005)		(0.005)	
Financial Markets								
1 year swap	-0.022	**	-0.026	***	-0.037	***	-0.037	***
	(0.009)		(0.009)		(0.005)		(0.005)	
2 years swap	-0.030	***	-0.034	***	-0.067	***	-0.067	***
	(0.006)		(0.006)		(0.005)		(0.005)	
5 years swap	-0.029	***	-0.033	***	-0.087	***	-0.087	***
	(0.011)		(0.010)		(0.004)		(0.004)	
Number of observations	1020		1020		476		476	
Adjusted R-squared	0.96		0.96		0.79		0.79	

Notes: *** p-value<.01, ** p-value<.05, * p-value<.1. RMSFEs based on median forecasts across specifications with output gap as a measure of slack. ALL stands for all sample period and ELB for the effective lower bound period. Regressions include constant and vintage dummies. Excluded categories: in regressions (A,C), the random walk (Atkeson-Ohanian) model; in regressions (B,D), the persistence model. Robust standard errors in parentheses. See the text for more details.

Table B.2. MAFEs meta-regressions for EA core inflation, h=4.

	(A) ALL Expectations vs. RW	(B) ALL NKPC vs. RW	(C) ALL NKPC vs. Persistence	(D) ELB Expectations vs. RW	(E) ELB NKPC vs. RW	(F) ELB NKPC vs. Persistence
Households						
Expected value (12M)	0.005 *	0.008 **	0.012 ***	0.009 ***	0.007 **	0.012 ***
	(0.003)	(0.004)	(0.004)	(0.002)	(0.003)	(0.003)
Qualitative (12M)	-0.038 ***	-0.038 ***	-0.034 ***	-0.030 ***	-0.038 ***	-0.033 ***
	(0.004)	(0.003)	(0.003)	(0.003)	(0.002)	(0.003)
Firms						
PMI Output price	-0.026 ***	-0.036 ***	-0.031 ***	-0.018 ***	-0.042 ***	-0.036 ***
	(0.002)	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)
Manufacturing (3M)	-0.024 ***	-0.024 ***	-0.020 ***	-0.009 ***	-0.015 ***	-0.009 **
	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)
Retail (3M)	-0.065 ***	-0.059 ***	-0.054 ***	-0.039 ***	-0.048 ***	-0.042 ***
	(0.005)	(0.004)	(0.005)	(0.004)	(0.003)	(0.003)
Other services (3M)	-0.046 ***	-0.048 ***	-0.044 ***	-0.037 ***	-0.048 ***	-0.042 ***
	(0.003)	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)
Prof. Forecasters						
Consensus (1Y)	-0.043 ***	-0.013 ***	-0.009 *	-0.050 ***	-0.014 ***	-0.008 **
	(0.006)	(0.005)	(0.005)	(0.002)	(0.004)	(0.004)
Consensus (long-term)	-0.003	-0.034 ***	-0.029 ***	0.000	-0.035 ***	-0.029 ***
	(0.004)	(0.004)	(0.004)	(0.002)	(0.003)	(0.003)
SPF (1Y)	-0.017 ***	-0.012 ***	-0.007 **	-0.024 ***	-0.016 ***	-0.010 ***
	(0.004)	(0.003)	(0.003)	(0.002)	(0.003)	(0.003)
SPF (long-term)	-0.065 ***	-0.043 ***	-0.039 ***	-0.058 ***	-0.058 ***	-0.052 ***
	(0.003)	(0.004)	(0.004)	(0.002)	(0.004)	(0.005)
Financial Markets						
1 year swap	-0.042 ***	-0.035 ***	-0.031 ***	-0.046 ***	-0.056 ***	-0.051 ***
	(0.003)	(0.006)	(0.006)	(0.003)	(0.003)	(0.003)
2 years swap	-0.056 ***	-0.056 ***	-0.051 ***	-0.062 ***	-0.074 ***	-0.068 ***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
5 years swap	-0.032 ***	-0.050 ***	-0.046 ***	-0.038 ***	-0.067 ***	-0.062 ***
	(0.003)	(0.004)	(0.004)	(0.002)	(0.003)	(0.003)
Number of observations	1020	1020	1020	476	476	476
Adjusted R-squared	0.96	0.95	0.95	0.83	0.79	0.75

Notes: *** p-value<.01, ** p-value<.05, * p-value<.1. In the case of NKPC models, MAFEs based on median forecasts across specifications and slack measures. ALL stands for all sample period and ELB for the effective lower bound period. Regressions include constant and vintage dummies. Excluded categories: in regressions (A,B,D,E), the random walk (Atkeson-Ohanian) model; in regressions (C,F), the persistence model. Robust standard errors in parentheses. See the text for more details.

Table B.3. MAFEs meta-regressions for EA core inflation, h=8.

	(A) ALL Expectations vs. RW	(B) ALL NKPC vs. RW	(C) ALL NKPC vs. Persistence	(D) ELB Expectations vs. RW	(E) ELB NKPC vs. RW	(F) ELB NKPC vs. Persistence
Households						
Expected value (12M)	-0.014 ***	-0.003	-0.013 ***	-0.007 ***	-0.002	-0.017 ***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.005)	(0.005)
Qualitative (12M)	-0.047 ***	-0.021 ***	-0.031 ***	-0.037 ***	-0.011 ***	-0.027 ***
	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)
Firms						
PMI Output price	-0.050 ***	-0.045 ***	-0.055 ***	-0.046 ***	-0.048 ***	-0.063 ***
	(0.003)	(0.004)	(0.004)	(0.002)	(0.003)	(0.003)
Manufacturing (3M)	-0.051 ***	0.038 ***	0.028 ***	-0.033 ***	0.065 ***	0.049 ***
	(0.004)	(0.005)	(0.005)	(0.003)	(0.005)	(0.005)
Retail (3M)	-0.033 ***	-0.026 ***	-0.036 ***	-0.016 ***	-0.012 ***	-0.028 ***
	(0.004)	(0.004)	(0.003)	(0.003)	(0.004)	(0.004)
Other services (3M)	-0.052 ***	-0.037 ***	-0.047 ***	-0.050 ***	-0.047 ***	-0.063 ***
	(0.003)	(0.005)	(0.005)	(0.002)	(0.004)	(0.005)
Prof. Forecasters						
Consensus (1Y)	-0.023 ***	0.030 ***	0.020 ***	-0.022 ***	0.051 ***	0.035 ***
	(0.003)	(0.004)	(0.004)	(0.003)	(0.005)	(0.005)
Consensus (long-term)	-0.039 ***	0.004	-0.006	-0.030 ***	0.021 ***	0.006
	(0.004)	(0.005)	(0.004)	(0.002)	(0.004)	(0.004)
SPF (1Y)	-0.029 ***	0.022 ***	0.012 ***	-0.029 ***	0.038 ***	0.022 ***
	(0.003)	(0.004)	(0.003)	(0.003)	(0.004)	(0.004)
SPF (long-term)	-0.072 ***	0.013 ***	0.003	-0.070 ***	0.003	-0.013 **
	(0.003)	(0.005)	(0.005)	(0.002)	(0.005)	(0.005)
Financial Markets						
1 year swap	-0.064 ***	-0.029 ***	-0.039 ***	-0.064 ***	-0.044 ***	-0.060 ***
	(0.003)	(0.005)	(0.005)	(0.002)	(0.004)	(0.004)
2 years swap	-0.086 ***	-0.040 ***	-0.050 ***	-0.090 ***	-0.053 ***	-0.068 ***
	(0.003)	(0.004)	(0.004)	(0.003)	(0.004)	(0.004)
5 years swap	-0.074 ***	-0.048 ***	-0.058 ***	-0.075 ***	-0.058 ***	-0.074 ***
	(0.003)	(0.005)	(0.005)	(0.002)	(0.004)	(0.004)
Number of observations	1020	1020	1020	476	476	476
Adjusted R-squared	0.98	0.97	0.97	0.89	0.81	0.81

Notes: *** p-value<.01, ** p-value<.05, * p-value<.1. In the case of NKPC models, MAFEs based on median forecasts across specifications and slack measures. ALL stands for all sample period and ELB for the effective lower bound period. Regressions include constant and vintage dummies. Excluded categories: in regressions (A,B,D,E), the random walk (Atkeson-Ohanian) model; in regressions (C,F), the persistence model. Robust standard errors in parentheses. See the text for more details.

C Comparison of expectations measures

Table C.1: A race of inflation expectations measures in the NKPC model: Households versus other services firms.

	(A)	(B)	(C)	(D)	(E)	(F)
Households. Qualitative (12M)	0.240 **		-0.206 *	0.096 **		-0.095
	(0.101)		(0.108)	(0.046)		(0.085)
Firms. Other services (3M)		0.915 ***	1.003 ***		0.402 ***	0.460 **
		(0.156)	(0.157)		(0.147)	(0.178)
π_{t-1}				0.755 ***	0.554 ***	0.535 ***
				(0.124)	(0.182)	(0.190)
Sample period	1996-2023	2003-2023	2003-2023	1996-2023	2003-2023	2003-2023
Number of observations	114	82	82	114	82	82
Adjusted R-squared	0.21	0.58	0.59	0.66	0.69	0.69

Notes: *** p-value<0.01, ** p-value<0.05, * p-value<0.1. The table reports regression results of core inflation on two measures -individually and simultaneously- of expected inflation (the first three columns), plus lagged core inflation (the last three columns). All regressions include a constant term, the unemployment gap as the measure of slack, and cost-push shocks. Robust standard errors are reported in parentheses.

Table C.2: The pass-through channels of short- and long-term inflation expectations.

	(A)		(B)		(C)		(D)	
Firms. Other services (3M)	0.657	***	0.960	***	0.432	***	0.593	***
	(0.103)		(0.143)		(0.123)		(0.213)	
SPF (long-term)	4.409	***			2.936	**		
	(0.931)				(1.330)			
5 years swap			0.848	***			0.467	
			(0.243)				(0.316)	
π_{t-1}					0.335		0.382	*
					(0.203)		(0.223)	
Sample period	2003-2023		2004-2023		2003-2023		2004-2023	
Number of observations	82		78		82		78	
Adjusted R-squared	0.70		0.68		0.73		0.72	

Notes: *** p-value<0.01, ** p-value<0.05, * p-value<0.1. The table reports regression results of core inflation on other services firms' expectations combined with two alternate measures of long-term expected inflation (the first two columns) plus lagged core inflation (the last two columns). All regressions include a constant term, the unemployment gap as the measure of slack, and cost-push shocks. Robust standard errors are reported in parentheses.

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