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Do Household Expectations Help Predict Inflation?

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ABSTRACT:

We examine whether changes in the distribution of household inflation expectations contain information on future inflation. We first discuss recent shifts in micro data from the US, UK, Germany, and Canada. We then zoom in on the US to explore econometrically whether distributional characteristics help predict future inflation. We find that the shape of the distribution of household expectations does indeed help predict one-year-ahead CPI inflation. Variance and skewness of household expectations' distributions add predictive power beyond and above the median, especially in periods of high inflation. Remarkably, qualitatively, these results hold when including market-based measures and moments of the distribution of professional forecasts**.**

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WORKING PAPERS

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I. Introduction

The recent sharp rise in inflation around the world since 2021 has ignited academic and policy interest in measures of inflation expectations, including expectations of households and firms. Inflation expectations are likely to play a key role in driving inflation dynamics. However, in the full information rational expectations (FIRE) models dominating in the profession until recently, there are no differences in expectations across agents since everyone is supposed to know the “true” model of the economy. The academic literature has increasingly been recognizing that this assumption is far from reality (see e.g., Chen, Gornicka, and Zdarek, 2022, and D’Accunto and others, 2022). For example, there is considerable dispersion of inflation expectations across households and firms. Even professional forecasts display dispersions and deviation from full-information ration expectations (Coibion and Gorodnichenko, 2015). These different expectations influence consumption, saving, production, pricing decisions and wage bargaining, and thereby shape the overall inflation process. A better understanding of the drivers and economic significance of the inflation expectations of different groups is therefore high on the academic agenda. Moreover, closer monitoring of the expectations of different actors may also be important for forecasting purposes.

This paper focuses on household expectations. Household expectations have not been studied widely and are interesting as they often differ significantly from the expectations of professional forecasters and markets. In addition, they tend to be characterized by a relatively wide dispersion of expectations among households themselves. The diversity of views across households might be the result of different groups of households being exposed to different goods in their daily lives or having different sources of information than professional forecasters or market participants (D’Acunto and others, 2022). Possibly, differences in the thresholds across individuals for paying attention to price developments may also play a role, due to different cognitive resources or marginal values of obtaining accurate information about inflation (Bracha and Tang, 2022).

Recent studies also show that household inflation expectations matter for consumption and saving decisions, (D’Acunto and others, 2022; Andrade and others, 2020; Duca-Radu and others, 2021) and for households’ financing and home-ownership decisions (Botsch and Malmendier, 2021; Malmendier and Nagel, 2016; Malmendier and Wellsjo, 2020). It has further been shown that household expectations display similar characteristics as expectations of small- and medium-sized enterprises (Coibion and others, 2019; Candida and others, 2021). As such, they could be a proxy for inflation expectations that inform investment, hiring, and price-setting decisions of smaller firms.

While *median* household expectations have been often been found to have somewhat less predictive power than inflation expectations of other actors (e.g., Verbrugge and Zaman, 2021), recent research suggests that changes in the distributions of household expectations matter. Distributional changes are not only important drivers of current inflation (Meeks and Monti, 2022), but there is also reason to believe that they provide important signals about future inflation. For instance, discussing inflationary periods in different countries, Reis (2021) points out that changes in the variance and skewness of household inflation expectations have often been leading changes in inflation.

In our paper, we take a more systematic approach to examine whether changes in the distribution of household inflation expectations do indeed contain information about future inflation. For this purpose, we work with micro data from Canada, Germany the United Kingdom (UK) and the United States (US). We first document recent developments of distribution of one-year-ahead household inflation expectations in these four counties. We focus on one-year expectations, since these have been shown to matter for wage setting and Phillips Curve estimations (Glick, Leduc, and Pepper 2022; Werning, 2022; Faust and Weight, 2013; and Alvarez and others, 2022). Moreover, since expectations had been anchored for the last decades in advanced economies, there is not much variation over time in longer-term expectations.

We then zoom in on the US to explore econometrically whether distributional characteristics help predict inflation. Specifically, we test whether distributional characteristics of household inflation expectations add information beyond and above that contained in the medians of household expectations, market-based measures, and the distributions of professional forecasters' expectations. To this end, we estimate a simple inflation forecasting model, regressing one-year-ahead inflation on current inflation and moments of the distribution of one-year-ahead household inflation expectations, as well as moments of professional forecasts and market-based measures. As a robustness check, we use Functional Principal Component Analysis (FPCA) to capture the distribution of household inflation expectations in the forecasting exercise.

We find that the distributions of one-year expectations have shifted rightward in all four countries during the inflation surge, with more and more households expecting higher inflation outcomes. While most recently expectations have started to slowly come down, in each of the countries, the median household continues to expect higher inflation one year into the future, and a significant share of households are expecting inflation greater than 10 percent one year out.

In our regression analysis, we find that that the shape of the distribution of household expectations does indeed help predict one-year-ahead CPI inflation. Specifically, variance and skewness of household expectations' distributions add predictive power beyond and above the median. A decrease in the skewness is predictive of higher inflation one year out, while higher variance signals a change in inflationary regime. Remarkably, qualitatively, these results continue to hold when including market-based measures and moments of the distribution of professional forecasts. We also find that including the first three moments of the household inflation expectations distribution improves out-of-sample forecasts, relative to the median-only model, for the most recent inflationary period if the model is estimated on the 1970s/80s inflationary period.

II. Recent Shifts in the Distribution of Household Inflation Expectations in Four Countries

In the first part of this paper, we take a closer look at developments over the past four years in the distributions of one-year-ahead household inflation expectations for Canada, Germany, the UK, and the US. We construct distribution densities for the inflation expectations data for each of these countries and document how expectations distributions shifted as actual headline inflation rose and then fell.

A. Data Description

We use detailed microdata from the household inflation expectations surveys for the four countries of interest. For the US, Germany and the UK, this data is publicly available from the Michigan Survey, ECB Consumer Expectations Survey, and the Bank of England's Inflation Attitude Survey, respectively.[1] For Canada, we use data that we received directly from the Bank of Canada for the purposes of this study. For the US, UK, and

[1] For Germany, we also received data directly from the Bundesbank on its Survey of Consumer Expectations. We provide results from this data in Annex I.

Germany, we fit a kernel density to capture the distribution, using the Reis (2021) methodology. For the Canadian data this is not possible, as the Bank of Canada provides only data on the percentiles of inflation expectations, on which we fit a skewed-t distribution instead.

US Data

We use monthly data on one-year-ahead[2] household inflation expectations from the Survey of Consumers conducted by the University of Michigan. The survey is based on a rotating panel and every edition includes a minimum of 600 interviews. Monthly data is available from January 1978. The survey question consists of two parts. The first part asks: “During the next 12 months, do you think that prices in general will go up, or go down, or stay where they are now?” And the second part asks: “By about what percentage do you expect prices to go (up/down) on the average, during the next 12 months?” For the first question, responds can choose between “Higher”, “Stay the same”, “Lower”, and “Don’t Know (DK).” For the second question, respondents are expected to provide a percentage value, or answer “Don’t Know.” For the purpose of our study, we focus on answers to the second question.

For the construction of densities, we use the binned data published by the University of Michigan, and follow the method used by Reis (2021), which further assigns a lower bound of -5 and an upper bound of 20 to the bottom and uppermost bins respectively. Also following Reis (2021), we assign the frequencies to the mid-point of the inflation bins. Missing data points (“NA” and “DK whether up or down”) are excluded from the dataset. However, since the response “DK how much up” (code 96) has been relatively common over time, we assign the average of the positive inflation expectations to this last category. Thereafter, also following Reis, we fit a kernel density function of bandwidth 1.3.

UK Data

The quarterly Bank of England/Ipsos Inflation Attitudes Survey (previously known as Bank of England/Kantar Inflation Attitudes Survey)[3] has been conducted since 2001. Each quarter, a minimum of 2000 respondents are interviewed, chosen using a random location sample. The question for one-year ahead inflation expectations is: “How much would you expect prices in the shops generally to change over the next twelve months?” The respondents do not provide point estimates but are asked to choose from several ranges (e.g., up by 1 percent or less, up by 1 percent but less than 2 percent, etc.). In 2008 the survey changed an important aspect of this question. Prior to the change, the highest inflation expectations range respondents could choose from was “up by 5 percent or more”; since the change respondents get a follow-up question in that case, with the highest possible range being “up by 10 percent or more”. In 2022, a third follow-up question was included if a respondent chooses “up by 10 percent or more”, with the highest option being “up by 15 percent or more.”

The construction of densities for the UK data is adapted from the Reis method for the US. As the largest bucket in the UK dataset is “10 percent or more”, we assumed an upper bound of 15 percent and a mid-point of 12 percent for the last bucket. Further, we allocated deflation expectations in the category “down, i.e., smaller

[2] One-year-ahead expectations refer to the expectations formed in month t of a given year about the expected change in prices during the next 12 months.

[3] Prior to February 2022 Kantar conducted the survey, and since February 2022 Ipsos has been conducting the survey permanently switching to an online format.

or equal 0 percent" in a similar way as in the Michigan survey and used -2 percent as the mid-point. We fit a kernel density function of bandwidth 1.3.

German Data

The Consumer Expectations Survey (CES) is a relatively new online panel survey that has been conducted by the European Central Bank on a monthly basis since April 2020. Initially, the survey consisted of 2000 monthly respondents from Germany until June 2021, but as of July 2021, the target sample size has been increased to 3000. The survey enquires about one-year-ahead inflation expectations in two stages. Firstly, respondents are asked to provide qualitative responses on how they expect prices to change in 12 months from now. Secondly, it asks for point estimates for the rate of inflation within the range of -100% to 100%.[4]

We compose the German bins in the same way as the US bins using the answers to the second question on point forecasts. Again, Reis' method was used to construct the distributions by assigning the frequency to the mid-point of the bin and fitting a kernel density function of bandwidth 1.3.

Canadian Data

The Canadian Survey of Consumer Expectations has been conducted by the Bank of Canada as a quarterly survey since 2014 to measure expectations of Canadian consumers. It surveys about 2000 households in a rotating panel conducted online. As in the German, US, and UK surveys, it uses a two-part question set-up, whereby the first part of the question inquires whether the respondent expects inflation or deflation at the respective horizon and the second part asks for the percentage value ("What do you expect the rate of [inflation/deflation] to be over the next 12 months? Please give your best guess."

The Bank of Canada did not share individual responses with us but provided percentiles of point forecasts. Based on these percentiles we fit a skewed t-distribution following Azzalini and Capitanio (2003).

B. Recent Shifts in Distributions of Household Inflation Expectations

The data described in the previous section allows us to examine shifts in the distributions of household inflation expectations. Figure 1 shows the densities of households' point forecasts of one-year-ahead inflation for the four countries at four different points in time since 2019, with the most recent available 2023 observations graphed as red solid lines.

From the charts, it is clear that considerable shifts in household expectations have been underway. The distributions have shifted rightward in all four countries, with more and more households expecting higher inflation outcomes. In each of the countries, the median household expects higher inflation one year in the future than in 2019-20, and a significant share of households are expecting inflation greater than 10 percent one year out.

The most striking changes in the distribution are changes in variance and in the skewness of the distribution, with more disagreement among households and a significant fattening of the right tail. In the US, the UK, and in

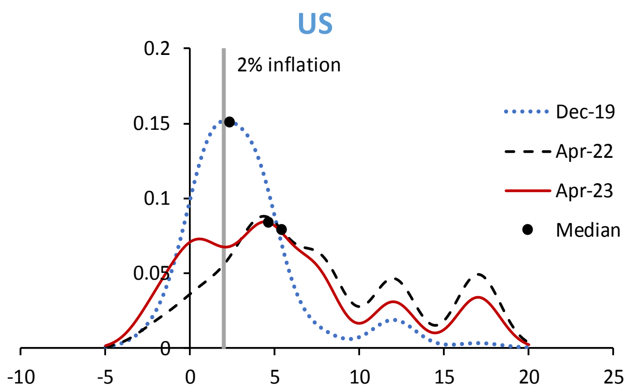
[4] There is a third question that asks respondents to choose the probability (between 0 and 100) of the inflation rate being in each of several categories (e.g., "Prices will increase by 0% or more but less than 2%", "Prices will increase by 2% or more, but less than 4%", etc.), such that the probabilities add up to 100, but this data is not used in this paper.

Germany, the distributions have also become more clearly bi- or trimodal, with the second highest mode situated at the 10-15 percent point in the UK and Germany, and even at the 15-20 percent point in the US, suggesting that an increasing share of households expects very high inflation outcomes. While the most recent surveys in each of the countries suggest that inflation expectations have slowly started to come down, median expectations remain substantially above target, except in Canada, and distributions continue to feature more variation and a fatter right tail than before the inflation surge.

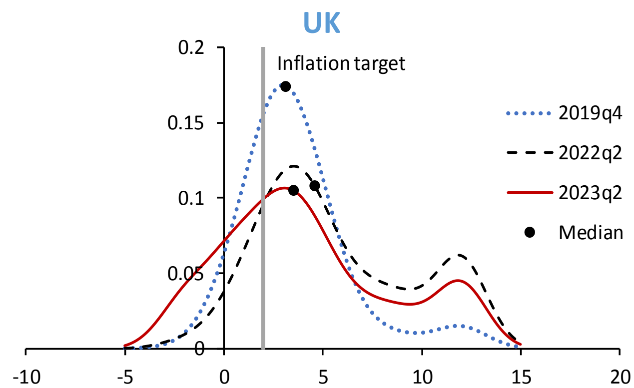
Given the short horizons of these expectations and the recent developments in actual inflation, these patterns may not be surprising. They simply indicate that households are aware of the trend in actual inflation, and that they do not expect it to (fully) reverse in a 12-month timespan. That would seem reasonable and is not necessarily indicative of a de-anchoring of longer-term expectations (indeed, expectations at the five-year horizon have shifted much less than one-year expectations).

However, one-year expectations have been shown to matter for wage negotiations and Phillips Curve estimation and it is plausible that they have an impact on shorter-term inflation dynamics and thereby influence future inflation outcomes. To test whether one-year household inflation expectations contain information about future inflation, in the next section we will explore the predictive power of short-term expectations.

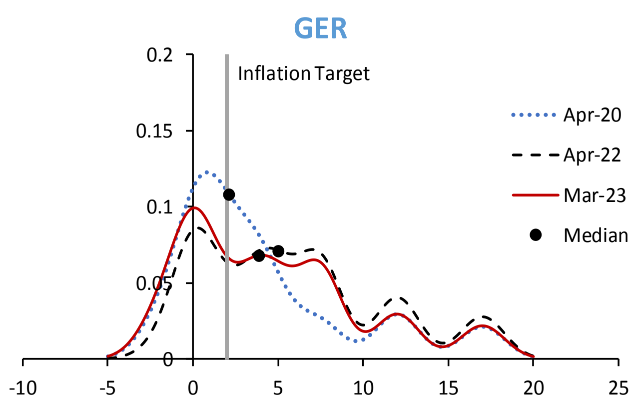
Figure 1. One-Year Expectations in the US, UK, Germany, and Canada



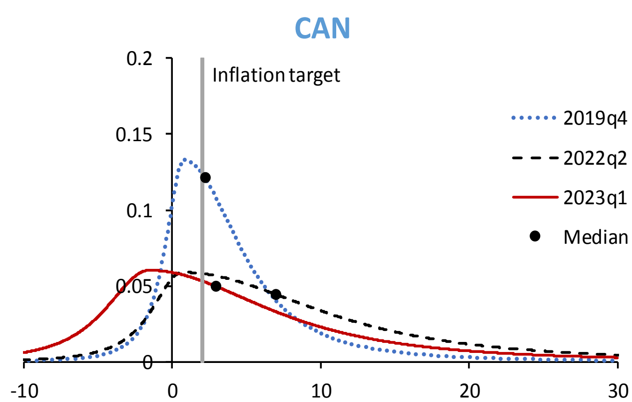
Sources: The University of Michigan's Survey of Consumers and authors' calculations.
Note: The charts fit kernel densities to households' inflation forecasts, using methodology similar to Reis (2021).



Sources: Bank of England Inflation Attitudes Survey and authors' calculations.
Note: The charts fit kernel densities to households' inflation forecasts, using methodology similar to Reis (2021).



Sources: European Central Bank Consumer Expectations Survey and authors' calculations.
Note: The charts fit kernel densities to households' inflation forecasts, using methodology similar to Reis (2021).



Sources: Canada Survey of Consumer Expectations and authors' calculations.
Note: The charts fit a skewed t-distribution based on percentiles of point forecasts.

III. The Predictive Power of Distributions of Household Inflation Expectations in the US

To test econometrically whether the distributions of one-year inflation expectations of households contain information about future inflation, we will focus on the US as it is the only country for which long time series are available. Specifically, we test whether distributions of household inflation expectations contain information about inflation over and above (i) the information that is contained in the medians of household expectations, and (ii) over market-based measures and the distributions of professional forecasters' expectations.

A. Methodology and Data

To this end, we specify a simple inflation forecasting model that regresses one-year-ahead inflation on current inflation and the first three moments of the distribution of household inflation expectations:

$$\pi_{t+12} = c + \alpha\pi_t + \sum_{k=1}^{K} \beta_k \, m_{k,t} + \varepsilon_t \quad (1)$$

where π_t is year-on-year US CPI inflation in period t, c is a constant, α and β_k are coefficients to be estimated, $m_{k,t}$ are moments, and ε_t is the error term.[5] In our baseline specifications, we use monthly data from January 1978-June 2023 in the models with only household expectations, and from October 1989-June 2023 in models including professionals' expectations (Table 1). We use quarterly data in a robustness exercise to be able to include household inflation expectations from 1966Q2 to 2023Q2.[6] In another robustness exercise, we use functional principal components, instead of moments, to describe the shape of the monthly distributions of household inflation expectations. Finally, we include several lags of inflation and several control variables to test for robustness.

Table 1. Characteristics of Different Data Sets

Data set	Sample period	Frequency	Number of respondents	Horizon of inflation forecast	Distribution?
Michigan Survey, monthly (Household expectations)	January 1978 – April 2023	Monthly	Minimum of 600 interviews	One year ahead	Yes
Michigan Survey, quarterly (Household expectations)	Q2 1966 – Q2 2023	Quarterly	Minimum of 600 interviews	One year ahead	Yes
Consensus Forecasts (Professionals' expectations)	October 1989 – June 2023	Monthly	Between 19 and 32 respondents	Current and next year	Yes
Cleveland Federal Reserve Bank (Market-implied expectations)	January 1982 – June 2023	Monthly	N.A.	One year ahead	No

For household inflation expectations, we use the monthly data on one-year-ahead expectations from the Michigan Survey. We compute the first three moments based on densities constructed as described in Section II.[7] We also compute the first three functional principal components to be used in a robustness exercise (for details, see Annex IV).

[5] Our baseline specification is in levels, even though for the whole period, the existence of a unit root in both inflation and moment series cannot be rejected. This is because individual subperiods that are identified by a breakpoint test (see Section III.B for details) appear to not feature a unit root. We provide results in first differences in Table A.6, Annex III.

[6] Mean and variance are available from 1960Q1 onwards, but the underlying micro data are not.

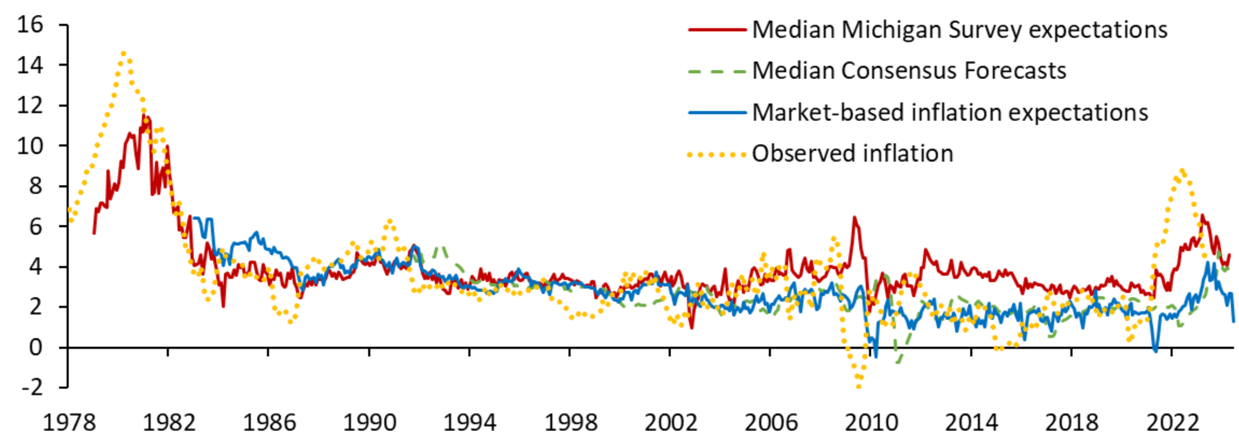
[7] A chart of the complete time series of the different moments of both households and professionals can be found in Annex II.

For the expectations of professional forecasters, we use monthly data based on surveys by Consensus Forecasts, available from October 1989. The number of respondents ranges from 19 to 32, with a typical number being in the high twenties. Consensus Forecasts does not provide one-year-ahead forecasts, but only forecasts for inflation in the current year and next year. We therefore construct a weighted average of the two with weights depending on the month of the year, which we use as proxy for the one-year-ahead forecast. Based on this data, we construct the first three moments of the distribution of professional forecasters.[8]

For market-implied expectations, we use monthly data on market-based inflation expectations provided by the Cleveland Federal Reserve Bank, available from January 1982. These estimates are derived from Treasury yields, inflation data, inflation swaps, and survey-based measures of inflation expectations.

Finally, we use year-on-year seasonally adjusted US CPI inflation. Monthly inflation data until June 2023 is used and quarterly data until Q2 2023. Control variables are the monthly unemployment rate, monthly producer price inflation (all commodities), and monthly capacity utilization, up until June 2023. Data on all variables is retrieved from the St. Louis Fed database.

Figure 2. Expectations of Households, Professional Forecasters, and Markets Compared



Sources: US Bureau of Labor Statistics, Survey of Consumers - University of Michigan, Consensus Forecasts, Federal Reserve Bank of Cleveland, Datastream, and authors' calculations.
Last observation: April 2023 for Michigan survey; June 2023 for observed inflation, Consensus Forecasts, and market-based inflation expectations.

Figure 2 plots the data on inflation and the medians over the full sample. From the chart it is immediately apparent that there is a high correlation between actual inflation and median household expectations, median professionals' expectations, and market-based expectations—as one might have expected. However, there are also some systematic differences. In particular, the median household tends to structurally expect higher inflation than professional forecaster and markets, a feature that has been well documented in the literature.

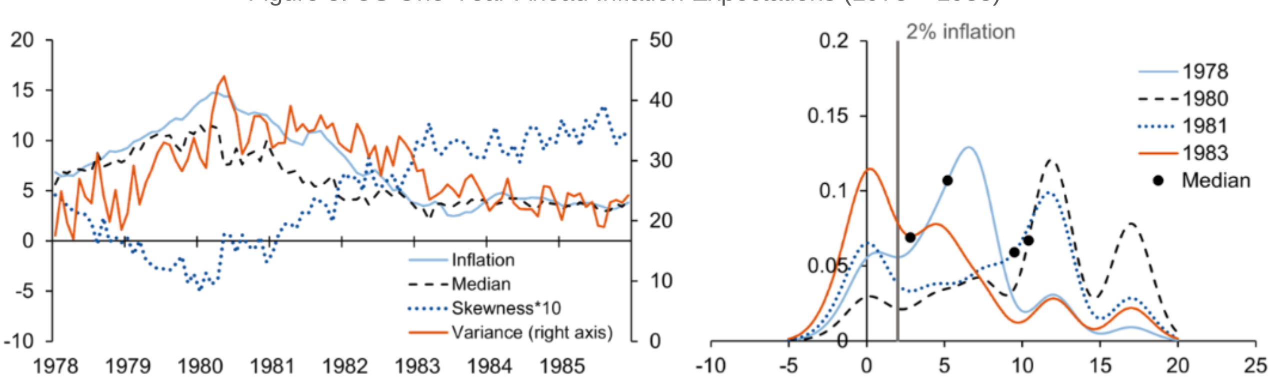
While such differences in and of themselves could contain complementary information about future inflation developments, in the remainder of the paper we seek to exploit the possible additional information that is contained in shifts in the whole *distribution* of household expectations. The moments of the distribution appear

[8] Time series of the moments of household and professionals' expectations for the whole period can be found in the appendix.

to shift in a systematic way during episodes of high inflation. Between 1978-1980, median and variance both rose as inflation rose, while skewness declined (Figure 3, left panel). These changes reflect the shift in the mass of the distribution to the right tail between 1978 and 1980, when the left and middle of the distribution thinned out and the mass of the distribution shifted to the right, increasing the median and variance and reducing skewness (Figure 3, right panel). Starting in 1980, inflation came down, with median expectations peaking before actual inflation. The variance, which measures the disagreement between households on future inflation, continued to stay high as inflation started declining, whereas skewness started to decline around the same time as the median peaked. The recent shifts in the distributions of household expectations in the US are consistent with the shifts observed during 1978-83. Starting in late 2020, through 2022, median and variance of the distribution increased, and skewness declined as the mass of the distribution shifted from the middle to the right (Figure 4). In the first few months of 2023, the mass of expectations has started to show the very first signs of shifting back to target. In comparison, during periods of relative stability in inflation, e.g., in 1996-2000 and 2012-2015, the distribution of inflation expectations remained stable (Figure 5).

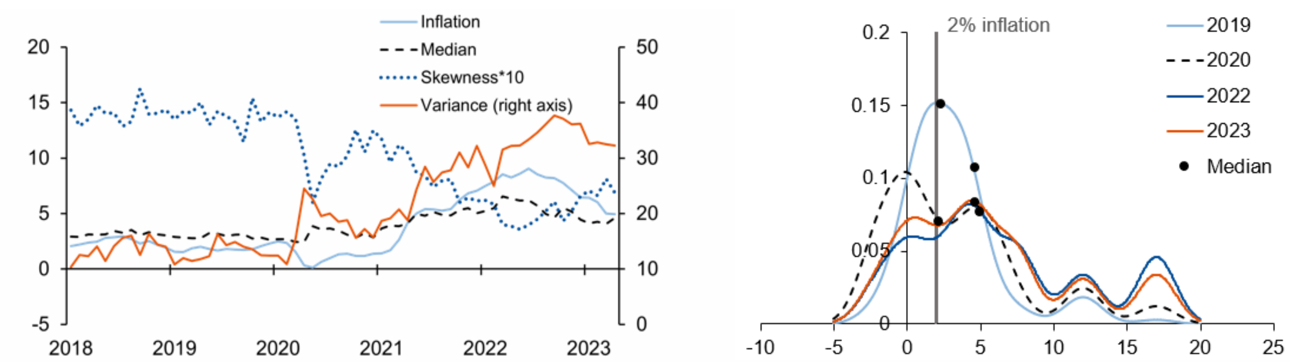
The observed patters in the change in moments of the distribution are consistent with the stylized facts established in Mankiw and others (2003), who show that disagreement about future inflation tends to rise with inflation and when inflation suddenly changes in either direction. These patterns are consistent with a theory of staggered adjustment of expectations, as explored, e.g., in Reis (2021). When there are reasons to expect inflation to rise, better informed households tend to move first to the right, increasing median and variance, while decreasing the skewness in tandem. On the other hand, better informed households are also the first ones to expect lower inflation, should inflation be likely to peak, decreasing the median and increasing the skewness, mirroring their pattern while rising inflation. However, the variance is expected to keep rising or stay elevated for longer with informed households moving to the middle ranges of inflation, only coming down when the mass of households begins to expect lower inflation. We therefore expect the sign of the coefficient of median to be positive, the one of skewness to be negative, and the one of variance to depend on inflation. In the following econometric analysis, we formally test this hypothesis.

Figure 3. US One-Year-Ahead Inflation Expectations (1978 – 1983)



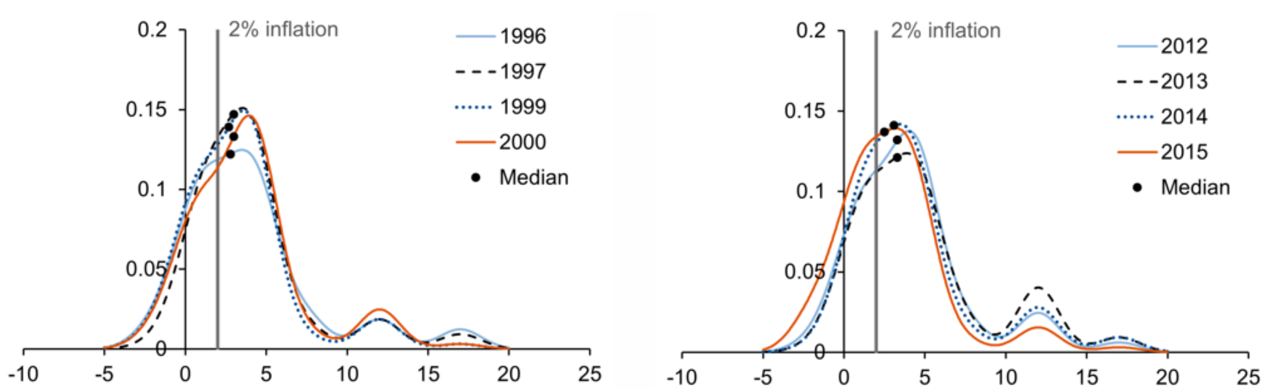
Sources: US Bureau of Labor Statistics, the University of Michigan's Survey of Consumers and authors' calculations.
Note: The LHS plot depicts inflation in month t and the moments in month t-12 to reflect the relationship analyzed in the regressions.

Figure 4. US One-Year-Ahead Inflation Expectations (2019 – 2023)



Sources: US Bureau of Labor Statistics, the University of Michigan's Survey of Consumers and authors' calculations.
Note: The LHS plot depicts inflation in month t and the moments in month t-12 to reflect the relationship analyzed in the regressions.

Figure 5. US One-Year-Ahead Inflation Expectations (1996 – 2000 and 2012 – 2015)



Sources: The University of Michigan's Survey of Consumers, IMF staff calculations.
Note: The charts fit kernel densities to households' inflation forecasts, using methodology similar to Reis (2021). The distributions plotted correspond to January of the respective years.

B. Baseline Results

We now examine if the shape of the distribution of households' inflation expectations has explanatory power for short-term inflation dynamics. Regression results of the baseline model using up to three moments of household inflation expectations are summarized in Table 2. The first three columns show coefficient estimates for the whole period, with specifications using one, two, and three moments, respectively. That is, the shape of the distribution of household inflation expectation is indeed informative about future inflation. Under the specification using three moments, all coefficients are statistically significant. As inflation shows substantial variability over the sample, with high-inflation periods at the beginning and the end, interspersed with a period of Great Moderation, we apply the global Bai and Perron (2003) breakpoint test to test for a maximum of two breakpoints. This partitions the sample into three different regimes, with two high-inflation regimes in 1978M1-

1990M7 and 2015M11-2022M6.[9] As shown in the remaining columns, the models perform best in the high-inflation periods, with adjusted R-squared being the highest during the first inflationary period, followed by the most recent inflationary period. The empirical models fitted on the subperiod in-between, roughly the great moderation period, are much less successful at explaining one-year-ahead inflation.

Table 2. Moments Model Based on Different Subsamples

	Inflation t+12											
Sample	**1978M1-2022M6**			**1978M1-1990M7**			**1990M8-2015M10**			**2015M11-2022M6**		
Constant	-1.28 **	-0.77 -	2.84 *	-1.16 *	1.94 ***	10.44 ***	4.45 ***	4.71 ***	3.95 ***	-4.71 ***	-3.22 **	-1.66 -
Inflation	0.18 -	0.24 *	0.24 **	-0.27 **	0.11 -	0.09 -	0.28 ***	0.29 ***	0.29 ***	-0.78 **	-0.62 **	-0.60 *
Median	1.07 ***	1.08 ***	0.78 ***	1.70 ***	1.48 ***	0.77 ***	-0.83 ***	-0.74 ***	-0.69 **	2.98 ***	0.91 -	0.77 -
Variance		-0.04 -	-0.07 **		-0.17 ***	-0.25 ***		-0.04 -	-0.03 -		0.31 ***	0.29 ***
Skewness			-1.72 **			-3.99 ***			0.40 -			-0.70 -
Adj. R-squared	0.61	0.61	0.62	0.81	0.85	0.87	0.13	0.14	0.14	0.46	0.55	0.54
N		534			151						80	

Sources: Survey of Consumers - University of Michigan and authors' calculations.
Notes: Subsamples are based on the Bai-Perron (2003) global breakpoint test based on the median model, with a significance level of 5 percent and a maximum number of breakpoints of 2. *** = significant at 0.01 level, **=significant at 0.05 level, *=significant at 0.1 level. Errors are Newey-West.

The signs of the coefficients are as expected in the two inflationary periods where the model can explain a large share of the variation. The sign of the median coefficient is always positive, while the sign of the skewness coefficient is always negative (although non-significant in some specifications in the most recent subsample). Interestingly, the sign of the variance coefficient is negative in the first subsample (although insignificant in one specification) and positive in the most recent subsample. This is in line with our prior that in periods with inflation peaks and their aftermath (as in the end 1970s/80s period), a larger variance is associated with decreasing inflation, as informed households move first less informed household catch up with a delay. Hence, the *negative* sign. On the other hand, in the most recent period, which covers the lead-up to an inflation peak, an increasing variance is associated with increasing inflation, hence the *positive* sign. In the low-inflation period in-between (which roughly covers the great moderation period), the variation in inflation and inflation expectations is low, resulting in a low explanatory power as well as insignificant coefficient for the latter.[10]

Robustness exercises included adding several lags of inflation to account for possible interdependencies between inflation and inflation expectations as well as controlling for several measures of slack in the economy. These exercises confirm our baseline results. The specification in first differences gives similar results with respect to the signs of coefficients, but estimation results are less significant, as expected.[11] Finally, we use FPCA to identify principal components of the distribution of inflation expectations, which are able to approximate distributions better than moments but are difficult to interpret (see Annex IV).

When does higher disagreement predict higher inflation?

The changing sign for variance raises the question of whether the relationships between higher moments of household expectations and inflation are robust and predictable, rather than dependent on the sample split. We

[9] We provide results allowing for three breakpoints in the appendix, which identifies the same two inflationary regimes as well as a pre- and a post-GFC low-inflation regime.

[10] In the middle sub-sample, the median has a negative sign and is significant. Looking at the time series charts in Annex II and the robustness check with three breakpoints, the negative sign seems to be driven by the global financial crisis period, which saw a large drop in inflation, while at the same time median inflation expectations rose sharply.

[11] All robustness exercises can be found in Annex III.

perform two exercises to test our hypotheses that higher variance of expectations, or disagreement among households, can be expected to predict higher future inflation when inflation has been increasing but lower inflation when inflation has been declining. First, we include regime dummies to capture the different regimes and second, we use quarterly time series of inflation expectations (available since the mid-sixties) to perform the same kind of analysis to see if the period leading up to the inflation peak (which is therefore most similar to the most recent period) will also yield a positive sign for the variance coefficient.

Table 3. Moments Model with Different Dummies

	Inflation t+12					
	No Dummy		Post minimum / maximum		Increasing / decreasing inflation	
	(1)	(2)	(3)	(4)	(5)	(6)
Constant	-0.77 -	2.84 *	-0.70 -	1.96 -	-0.93 **	2.47 **
Inflation	0.24 *	0.24 **	0.35 **	0.34 **	0.31 ***	0.31 ***
Median	1.08 ***	0.78 ***	1.00 ***	0.78 ***	0.57 **	0.27 -
Variance	-0.04 -	-0.07 **	-0.04 -	-0.07 *	0.05 -	0.02 -
Skewness		-1.72 **		-1.27 -		-1.65 ***
Variance*Dummy1			0.04 *	0.03 -	0.10 ***	0.10 ***
Variance*Dummy2			-0.07 ***	-0.07 ***	-0.04 ***	-0.05 ***
Adj. R-squared	0.61	0.62	0.64	0.64	0.75	0.76

Sources: Survey of Consumers - University of Michigan and authors' calculations.
Notes: Dummy 1 (2) in columns 3 and 4 is for pos- min (max), i.e. when in there was a 5-year minimum (maximum) of inflation in the previous 6 months. Dummy 1 (2) in columns 5 and 6 is for increasing (decreasing) inflation, defined as the 3-month-average 1-year-ahead being greater (less) than the 3-month average one year ago plus 1 percentage point. *** = significant at 0.01 level, **=significant at 0.05 level, *=significant at 0.1 level. Standard errors are Newey-West.

Table 3 displays regression results for the baseline model (columns 1-2), a specification including dummies 1 and 2 for months after a minimum and maximum, respectively (columns 3-4), and a specification including dummies 1 and 2 for months in periods with substantial increases and decreases in inflation respectively (columns 5-6). The idea behind including these dummies is to account for the apparent systematic differences in the sign of the variance coefficient, depending on the medium-term inflation regime. We find that the variance coefficient is significantly higher after inflation has reached a minimum and/or when inflation i has substantially increased over the past year. The variance coefficient is significantly lower after inflation has reached a maximum and/or when inflation has substantially decreased over the past year. Generally, the results are more significant and feature higher adjusted R-squares for the model including “increasing / decreasing inflation” dummies.[12]

We then perform the baseline analysis but using quarterly data which is available since 1966Q2 and hence allows us to test whether the period leading up to the inflation peak in the 1970s indeed produces a positive sign for the coefficient of the variance, as it does during the most recent period of inflation surge. Table 4 displays baseline results for the whole period, starting in 1966Q2, in column 1. For the longer quarterly full-

[12] We provide several exercises testing the robustness of this finding in the appendix. First, we use moments based on the micro data (i.e., the raw data) and the published moments. Results largely carry over, except that for the latest subsample, using the published moments the coefficient of the variance is insignificant (the same is true when we use the interquartile range instead of the variance). However, when using dummy variables instead of different subsamples, we get the same qualitative and significant results as in Table 3, regardless of whether using moments based on micro data, the published moments, or the interquartile range.

sample, the results are consistent with the shorter monthly full-sample in Table 2: the coefficient of median is positive and those of variance and skewness are negative, and all are highly significant.

Table 4. Moments Model Based on Different Subsamples, Quarterly Data

	Inflation t+4														
Sample	**1966Q2-2022Q2**			**1966Q2-1974Q3**			**1974Q4-1990Q2**			**1990Q3-2014Q1**			**2014Q2-2022Q2**		
Constant	-1.22 ***	-0.42 -	3.76 **	-4.10 -	-4.95 *	-2.19 -	-1.35 **	-0.30 -	-1.92 -	4.64 ***	5.05 ***	3.36 -	-3.31 -	0.86 -	6.59 *
Inflation	0.24 ***	0.25 ***	0.17 *	-0.12 -	-0.19 -	-0.20 -	-0.34 ***	-0.27 ***	-0.22 -	0.25 **	0.25 *	0.23 -	-0.10 -	0.19 -	0.14 -
Median	1.06 ***	1.27 ***	0.91 ***	2.55 **	0.07 -	-0.29 -	1.81 ***	1.82 ***	1.95 ***	-0.84 **	-0.70 *	-0.57 -	1.89 -	-2.55 -	-2.31 -
Variance		-0.09 ***	-0.11 ***		1.08 **	1.07 ***		-0.07 ***	-0.07 ***		-0.05 -	-0.03 -		0.62 ***	0.46 *
Skewness			-2.16 ***			-1.16 -			0.90 -			0.86 -			-3.02 *
Adj. R-squared	0.61	0.64	0.65	0.53	0.57	0.56	0.84	0.86	0.86	0.12	0.14	0.14	0.33	0.53	0.53
N		225			34			63			95			33	

Sources: Survey of Consumers - University of Michigan and authors' calculations.
Notes: Subsamples are based on the Bai-Perron (2003) global breakpoint test based on the median model, with a significance level of 5 percent and a maximum number of breakpoints of 3. *** = significant at 0.01 level, **=significant at 0.05 level, *=significant at 0.1 level. Errors are Newey-West.

We test for breakpoints in the quarterly data, this time allowing for three breakpoints to capture another possible break in the 1970s. The resulting subsamples are very close to the monthly subsamples, except for the fact that the first breakpoint doesn’t coincide with the start of the monthly sample, which is to be expected. The model estimated based first subsample (columns 4-6) indeed exhibits a positive and significant sign for the variance coefficient, as expected for this period of sharply rising inflation, albeit with insignificant coefficients for the median and skewness. The following subsample (columns 7-9), which comprises the peak inflation period and the following decline, features a negative and significant sign for the variance (in the respective specifications, 8 and 9), as in the corresponding monthly subsample, but an insignificant sign for the skewness coefficient (column 9). The latest subsample (columns 13-15), covering the recent increase in inflation, produces positive and significant coefficients for the variance and a negative and significant sign of skewness, consistent with our baseline results with monthly data. Finally, we report estimates with dummies accounting for periods of substantial increases and decreases in inflation, which confirm our results in Table 3: the variance coefficient is positive in times of substantially increasing inflation and negative in times of substantially decreasing inflation.[13]

Does the distribution of household expectations add information beyond forecasts by other agents?

We proceed to analyze whether changes in the distribution of household inflation expectations can add informational value on next year’s inflation *beyond* information contained in expectations by professional forecasters and financial markets. Since the survey data from Consensus Forecasts are only available since October 1989, we have to restrict our sample for this ‘horse race’ exercise to this shorter time period. We perform the horse race exercise using moments of the distribution of household expectations as well as moments of the distribution of professional forecasters and market-based expectations. Unfortunately, excluding the pre-1989 period generally implies the loss of a lot of variation over the sample, which leads to a significantly lower adjusted R-squared and significance of both the “households-only” moments model as well as the moments augmented by professionals’ and market expectations (Table 5). We therefore also include results for the horse race performed on the most recent period, as identified by previous breakpoint tests, excluding the low-variation intermediate period.

[13] Please see Table A.13 in Annex III.

The results show that changes in household expectation distribution do indeed add value beyond information contained in market-based and professional forecasts, especially when considering the most recent period. In particular, the sign of the median and variance coefficients of the household distribution are still positive and significant (except the coefficient of the median in the very last specification). Interestingly, the sign of the median of professional forecasters is significant but negative in this latest subsample. Hence, we conclude that moments of households' inflation expectations distributions do contain informational value additional to market expectations and the distribution of professional forecasters' expectations.

Table 5. Horse Race with Professional Forecasters and Market Expectations

	Inflation t+12								
Sample	**1990M10-2022M6**			**1990M10-2017M6**			**2017M7-2022M6**		
Constant	2.74 **	2.40 **	3.84 ***	3.57 ***	3.76 ***	3.42 **	4.75 ***	4.71 ***	7.50 -
Inflation	0.39 **	0.28 **	0.24 *	0.09 -	0.12 -	0.13 -	-0.54 -	-0.62 -	-0.65 *
Median HH	-0.18 -	-0.52 -	-0.62 *	-0.70 ***	-0.56 **	-0.54 **	2.58 ***	1.46 **	1.03 -
Variance HH		0.12 **	0.11 **		-0.06 -	-0.06 *		0.19 ***	0.17 **
Skewness HH			-0.73 -		-	0.17 -			-1.64 -
Market based	-0.19 -	0.10 -	0.20 -	0.37 **	0.25 -	0.23 -	-0.52 -	0.04 -	0.10 -
Median prof	-0.05 -	-0.33 -	-0.40 *	0.00 -	0.16 -	0.19 -	-3.67 ***	-3.70 ***	-3.44 ***
Variance prof		-1.65 -	-1.90 -		1.67 -	1.79 -		-1.51 -	0.38 -
Skewness prof			-0.28 -			0.12 -			-1.08 **
Adj. R-squared	0.06	0.10	0.11	0.17	0.19	0.19	0.73	0.76	0.80
N		381			321			60	

Sources: Survey of Consumers - University of Michigan, Consensus Forecasts, Cleveland Fed market-based expectations and authors' calculations.
Notes: Subsamples are based on the Bai-Perron (2003) global breakpoint test based on the median model, with a significance level of 5 percent and a maximum number of breakpoints of 2. *** = significant at 0.01 level, **=significant at 0.05 level, *=significant at 0.1 level. Errors are Newey-West.

Out-of-Sample RSMEs

We further test the robustness of the results by conducting an out-of-sample analysis. For the purpose of this exercise, the respective regression model is estimated based on a sample excluding the most recent data points. RMSEs are computed comparing these most recent data points with inflation predicted by the model based on the sample that excludes them.

Table 8 reports RMSEs for three and five year out-of-sample forecasting performance. That is, the regression models are estimated based on the sample excluding the last three (five) years. Predicted values are then computed based on these regression models and compared with actual inflation in the last three (five) years. We also conduct this exercise including a dummy for high inflation. Including distributional characteristics improves out-of-sample forecasting power for these periods only when also accounting for different inflation regimes.

Table 6. Out-of-Sample RMSEs, Full Sample

	Only constant	**…plus median**	**…plus variance**	**…plus skewness**	**…plus increasing / decreasing dummies**
3 years	3.35	3.02	3.17	3.12	2.13
5 years	2.66	2.41	2.57	2.52	1.69

Sources: Survey of Consumers - University of Michigan and authors' calculations.
Notes: The last column refers to the model containing interaction terms with variance*increasing inflation and variance*decreasing inflation.

The lack of predictive power of higher moments over the whole period, when not including dummies, is likely to stem from the fact that both the last three and last five years include the most recent high inflation episode, which might not be predicted well by models estimated largely based on a long low-inflation period. Instead, a model estimated on the previous inflationary episode might be better at predicting the current one. To test this hypothesis, we perform out-of-sample forecasting exercises for the last three years based on a model estimated on the 1978m1-1990m7 inflationary period. Indeed, including more moments consistently decreases RMSEs.

Table 7. Out-of-Sample RMSEs, Restricted Estimation and Evaluation Period

Only constant	**…plus median**	**…plus variance**	**…plus skewness**
7.27	5.74	3.17	2.19

Sources: Survey of Consumers - University of Michigan and authors' calculations.
Notes: The estimation period is 1978m1-1980m12 and the evaluation period is 2020m7-2022m6. The last column refers to the model containing interaction terms with variance*increasing inflation and variance*decreasing inflation.

IV. Conclusion

In this paper, we have presented novel evidence on how changes in the distribution of household expectations can help predict future inflation. Our findings suggest that household expectations contain information that is complementary to the information contained in professional forecasts and market-based indicators. The evidence strengthens the notion that it is important for policymakers to keep a close eye on household expectations.

However, we see our analysis as only a first step toward a deeper exploration of this issue. For example, while we focused in our quantitative examination on the United States, similar investigations could usefully be carried out for other countries where long time series of the micro data are available. Moreover, the role of household expectations around turning points (e.g., around changes from a low- to a high inflation regime) deserves further investigation given the results in the paper and the existing literature on attention/inattention by households.

Future research should also deepen our understanding about the role of household expectations in shaping the inflation process. How do different segments of the population react to changes in inflation expectations? What, if any, role do they play in wage negotiations? How are the consumption- and savings decisions of different parts of the population influenced by changes in inflation expectations? In sum, many important open questions remain, and it is our hope and expectation that future research efforts will help shed light on them.

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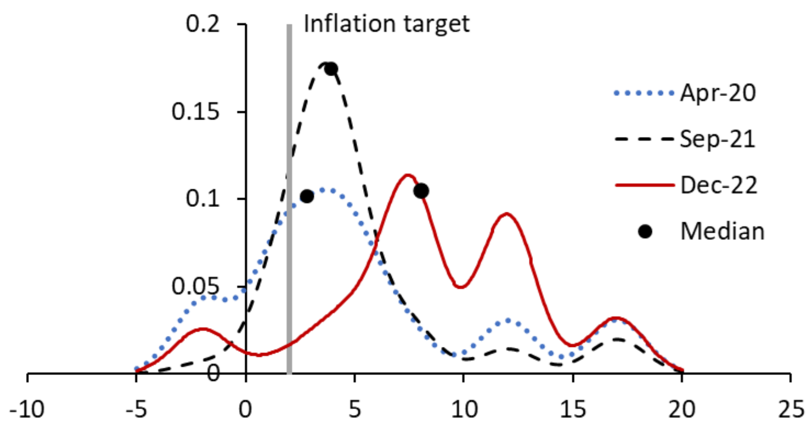
Annex I. Bundesbank Data

The relatively new Survey on Consumer Expectations of the Deutsche Bundesbank has been conducted monthly since April 2020, preceded by a brief pilot period from April to June 2019. Approximately 2000 households are asked to respond in each wave, with some respondents being asked to respond in multiple waves. The survey, inter alia, inquiries about one-year ahead inflation expectations. Similar to the US and UK setups, the survey enquires about inflation expectations in two stages. First, it asks whether respondents "think inflation or deflation is more likely over the next twelve months." Then, depending on the answer, the next question asks to assess the rate of inflation/deflation over the next twelve months. Again, we are interested in the answers to the second question. Bins are composed in the same way as the US bins and Reis' method was again used to construct the distributions.[14]

Figure A.2. One-Year Expectations in Germany

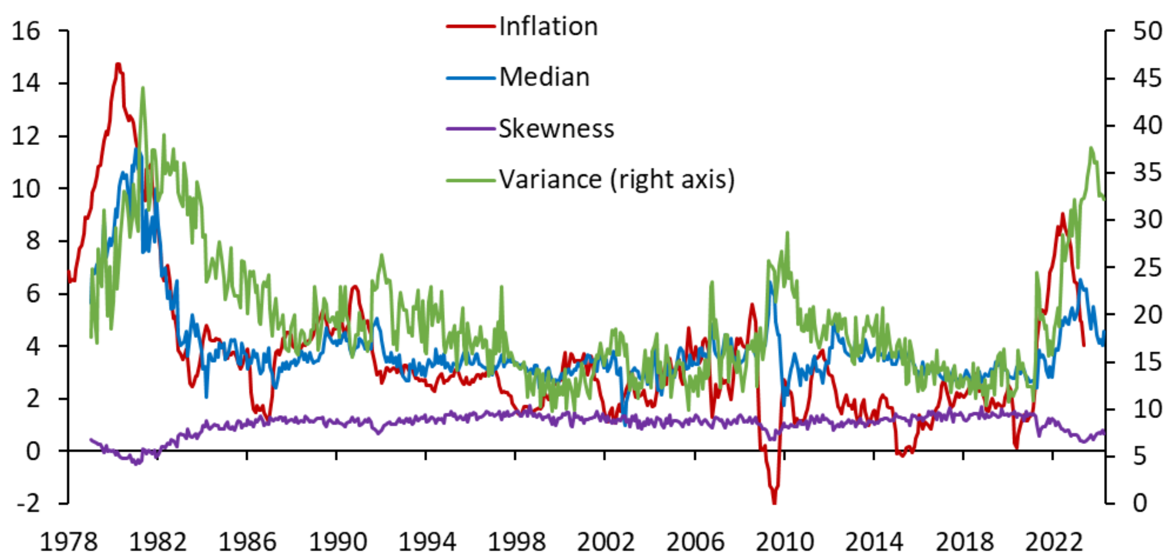


Sources: Bundesbank Survey on Consumer Expectations and authors' calculations.
Note: The charts fit kernel densities to households' inflation forecasts, using methodology similar to Reis (2021).

[14] Non-integer values that lie outside the Michigan Survey buckets (e.g., between 2-3 percent), are rounded up or down to the nearest integer.

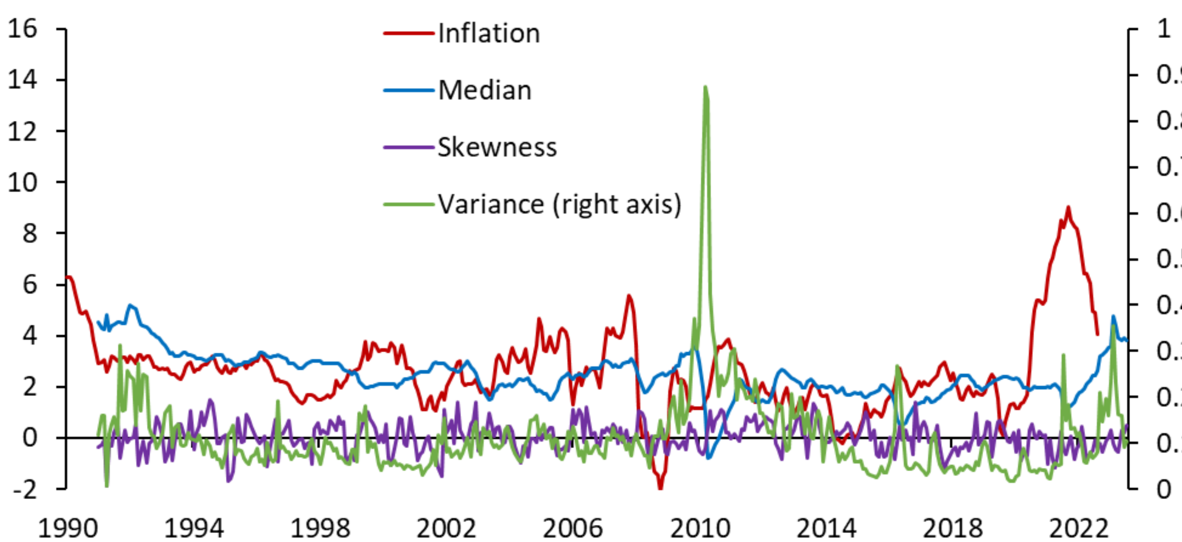
Annex II. Moments of Households' and Professionals' Expectations

Figure A.2. Moments of Households' Expectations



Sources: US Bureau of Labor Statistics, Survey of Consumers - University of Michigan, and authors' calculations.
Note: The plot depicts inflation in month t and the moments in month t-12 to reflect the relationship analyzed in the regressions.

Figure A.3. Moments of Professionals' Expectations



Sources: Consensus Forecasts, and authors' calculations.
Note: The plot depicts inflation in month t and the moments in month t-12 to reflect the relationship analyzed in the regressions.

Annex III. Moments Model Robustness

Table A.1. Moments Model Based on Different Subsamples, Three Breakpoints

	Inflation t+12														
Sample	**1978M1-2022M6**			**1978M1-1990M7**			**1990M8-2007M10**			**2007M11-2015M10**			**2015M11-2022M6**		
Constant	-1.28 **	-0.77 -	2.84 *	-1.16 *	1.94 ***	10.44 ***	1.70 ***	1.91 ***	3.03 ***	4.39 ***	3.79 ***	1.08 -	-4.71 ***	-3.22 **	-1.66 -
Inflation	0.18 -	0.24 *	0.24 **	-0.27 **	0.11 -	0.09 -	-0.14 -	-0.09 -	-0.12 -	-0.01 -	0.00 -	0.01 -	-0.78 **	-0.62 **	-0.60 *
Median	1.07 ***	1.08 ***	0.78 ***	1.70 ***	1.48 ***	0.77 ***	0.44 *	0.44 -	0.40 -	-0.84 ***	-0.91 ***	-0.76 **	2.98 ***	0.91 -	0.77 -
Variance		-0.04 -	-0.07 **		-0.17 ***	-0.25 ***		-0.02 -	-0.02 -		0.05 -	0.09 **		0.31 ***	0.29 ***
Skewness			-1.72 **			-3.99 ***			-0.71 -			1.25 -			-0.70 -
Adj. R-squared	0.61	0.61	0.62	0.81	0.85	0.87	0.04	0.04	0.05	0.26	0.27	0.29	0.46	0.55	0.54
N		534			151			207			96			80	

Sources: Survey of Consumers - University of Michigan and authors' calculations.
Notes: Subsamples are based on the Bai-Perron (2003) global breakpoint test based on the median model, with a significance level of 5 percent and a maximum number of breakpoints of 3. *** = significant at 0.01 level, **=significant at 0.05 level, *=significant at 0.1 level. Errors are Newey-West.

Table A.2. Moments Model Including Lags Based on Different Subsamples

	Inflation t+12											
Sample	**1981M1-2022M6**			**1981M1-1990M7**			**1990M10-2007M10**			**2016M5-2022M6**		
Constant	1.56 -	1.40 -	1.90 -	1.66 -	3.70 ***	0.57 -	3.90 ***	4.07 ***	3.32 ***	-4.61 ***	-3.71 ***	-5.12 -
Inflation	0.34 ***	0.33 ***	0.33 ***	0.02 -	0.09 -	0.09 -	0.24 **	0.21 **	0.21 **	-0.65 **	-0.63 **	-0.65 ***
Inflation(-12)	-0.03 -	-0.05 -	-0.05 -	-0.07 -	0.08 -	0.08 -	0.07 -	0.13 -	0.13 -	-0.54 -	-0.58 ***	-0.56 -
Inflation(-24)	0.04 -	0.02 -	0.02 -	0.08 -	0.13 -	0.15 -	0.03 -	0.08 -	0.08 -	0.19 -	0.08 -	0.09 -
Inflation(-36)	0.02 -	0.00 -	0.00 -	-0.13 -	-0.05 -	-0.05 -	0.06 -	0.12 *	0.11 *	1.10 ***	0.87 **	0.90 **
Median	0.07 -	-0.07 -	-0.10 -	0.78 **	0.87 ***	1.12 ***	-0.78 **	-0.55 *	-0.50 *	2.57 ***	1.65 **	1.78 *
Variance		0.05 -	0.04 -		-0.19 ***	-0.16 **		-0.08 **	-0.07 **		0.16 **	0.18 ***
Skewness			-0.24 -			1.42 -			0.40 -			0.61 -
Adj. R-squared	0.19	0.19	0.19	0.35	0.44	0.44	0.14	0.17	0.18	0.67	0.69	0.69
N		498			115			301			74	

Sources: Survey of Consumers - University of Michigan and authors' calculations.
Notes: Lag length based on smallest AIC for the median model. Subsamples are based on the Bai-Perron (2003) global breakpoint test based on the median model, with a significance level of 5 percent and a maximum number of breakpoints of 2. *** = significant at 0.01 level, **=significant at 0.05 level, *=significant at 0.1 level. Errors are Newey-West.

Table A.3. Moments Model, Controlling for Unemployment Rate

	Inflation t+12											
Sample	**1978M1-2022M6**			**1978M1-1990M7**			**1990M8-2015M10**			**2015M11-2022M6**		
Constant	-1.36 *	-1.10 *	2.13 -	1.70 -	1.57 -	13.71 ***	4.50 ***	4.58 ***	3.70 ***	-4.45 **	-3.74 **	-6.55 -
Inflation	0.18 -	0.30 **	0.29 *	-0.19 *	0.14 -	0.01 -	0.28 ***	0.31 ***	0.31 ***	-0.03 -	-0.21 -	-0.18 -
Unempl. rate	0.01 -	0.14 -	0.10 -	-0.37 **	0.11 -	-0.26 -	-0.02 -	0.04 -	0.05 -	0.51 **	0.33 -	0.39 -
Median	1.07 ***	1.07 ***	0.81 ***	1.54 ***	1.49 ***	0.54 -	-0.81 **	-0.74 **	-0.68 **	1.59 **	0.96 -	1.21 -
Variance		-0.08 -	-0.10 *		-0.20 ***	-0.21 ***		-0.05 -	-0.04 -		0.17 *	0.17 *
Skewness			-1.49 *			-5.11 ***			0.45 -			1.20 -
Adj. R-squared	0.61	0.61	0.62	0.83	0.85	0.87	0.13	0.14	0.14	0.56	0.57	0.56
N		534			151			303			80	

Sources: Survey of Consumers - University of Michigan and authors' calculations.
Notes: Subsamples are based on the Bai-Perron (2003) global breakpoint test based on the median model, with a significance level of 5 percent and a maximum number of breakpoints of 2. *** = significant at 0.01 level, **=significant at 0.05 level, *=significant at 0.1 level. Errors are Newey-West.

Table A.4. Moments Model, Controlling for Capacity Utilization

	Inflation t+12											
Sample	**1978M1-2022M6**			**1978M1-1990M7**			**1990M8-2015M10**			**2015M11-2022M6**		
Constant	-4.85 -	-3.11 -	-2.64 -	-15.82 ***	-2.17 -	0.61 -	0.34 -	1.03 -	0.98 -	18.78 **	6.83 -	7.40 -
Inflation	0.15 -	0.20 -	0.13 -	-0.15 -	0.08 -	0.01 -	0.20 -	0.21 *	0.21 *	-0.25 -	-0.43 -	-0.41 -
Capacity utilization	0.05 -	0.03 -	0.09 *	0.19 ***	0.05 -	0.14 -	0.05 -	0.04 -	0.05 -	-0.29 ***	-0.13 -	-0.15 -
Median	1.07 ***	1.08 **	0.62 ***	1.41 ***	1.44 ***	0.51 *	-0.77 ***	-0.74 **	-0.75 ***	2.24 ***	1.08 -	1.24 -
Variance		-0.03 -	-0.05 -		-0.15 ***	-0.19 ***		-0.02 -	-0.02 -		0.23 **	0.24 **
Skewness			-2.55 **			-4.89 ***			-0.10 -			0.63 -
Adj. R-squared	0.61	0.61	0.62	0.84	0.85	0.87	0.15	0.15	0.15	0.52	0.55	0.55
N		534			151			303			80	

Sources: Survey of Consumers - University of Michigan and authors' calculations.
Notes: Subsamples are based on the Bai-Perron (2003) global breakpoint test based on the median model, with a significance level of 5 percent and a maximum number of breakpoints of 2. *** = significant at 0.01 level, **=significant at 0.05 level, *=significant at 0.1 level. Errors are Newey-West.

Table A.5. Moments Model, Controlling for Commodity Inflation

	Inflation t+12											
Sample	**1978M1-2022M6**			**1978M1-1990M7**			**1990M8-2015M10**			**2015M11-2022M6**		
Constant	-1.34 **	-0.77 -	2.69 *	0.61 -	2.34 ***	12.23 ***	4.63 ***	4.82 ***	4.02 ***	-1.95 **	-0.20 -	6.60 **
Inflation	0.22 -	0.30 -	0.30 -	-0.64 ***	-0.22 *	-0.31 **	0.23 *	0.26 *	0.25 *	-2.03 ***	-1.91 ***	-1.87 ***
Commodity infl.	-0.03 -	-0.04 -	-0.03 -	0.40 ***	0.26 **	0.31 ***	0.02 -	0.01 -	0.02 -	0.36 ***	0.37 ***	0.40 ***
Median	1.07 ***	1.09 ***	0.80 ***	1.44 ***	1.36 ***	0.53 *	-0.86 ***	-0.77 ***	-0.72 ***	2.70 ***	0.42 -	-0.20 -
Variance		-0.05 -	-0.08 *		-0.13 ***	-0.21 ***		-0.03 -	-0.02 -		0.34 ***	0.26 ***
Skewness			-1.65 **			-4.61 ***			0.43 -			-2.94 **
Adj. R-squared	0.61	0.61	0.62	0.84	0.86	0.88	0.14	0.14	0.14	0.67	0.79	0.81
N		534			151			303			80	

Sources: Survey of Consumers - University of Michigan and authors' calculations.
Notes: Subsamples are based on the Bai-Perron (2003) global breakpoint test based on the median model, with a significance level of 5 percent and a maximum number of breakpoints of 2. *** = significant at 0.01 level, **=significant at 0.05 level, *=significant at 0.1 level. Errors are Newey-West.

Table A.6. Moments Model in First Differences

	Diff(Inflation t+12)											
Sample	**1978M2-2022M6**			**1978M2-1990M7**			**1990M8-2015M10**			**2015M11-2022M6**		
Diff(Inflation)	-0.45 ***	-0.45 ***	-0.45 ***	-0.28 **	-0.27 **	-0.27 **	-0.49 ***	-0.49 ***	-0.49 ***	-0.44 *	-0.41 *	-0.41 *
Diff(Median)	-0.03 -	-0.01 -	-0.03 -	0.07 -	0.10 **	0.11 *	-0.21 ***	-0.19 ***	-0.21 ***	0.05 -	0.00 -	-0.07 -
Diff(Variance)		-0.01 -	-0.01 -		-0.02 **	-0.02 **		-0.01 -	-0.01 -		0.02 -	0.02 -
Diff(Skewness)			-0.10 -			0.08 -			-0.10 -			-0.24 -
Adj. R-squared	0.20	0.20	0.20	0.07	0.08	0.08	0.34	0.34	0.34	0.13	0.14	0.13
N		533			150			303			80	

Sources: Survey of Consumers - University of Michigan and authors' calculations.
Notes: Subsamples are based on the model in levels for comparison. *** = significant at 0.01 level, **=significant at 0.05 level, *=significant at 0.1 level. Errors are Newey-West.

Table A.7. Moments Model, with Published Moments

	Inflation t+12											
Sample	**1978M1-2022M6**			**1978M1-1990M7**			**1990M8-2015M10**			**2015M11-2022M6**		
Constant	-0.96 *	-0.96 *	-0.73 -	-0.72 -	-0.25 -	-2.40 ***	4.34 ***	4.27 ***	4.25 ***	-5.82 ***	-6.20 ***	-6.13 ***
Inflation	0.08 -	0.03 -	0.03 -	-0.53 ***	-0.44 ***	-0.36 **	0.30 ***	0.28 ***	0.28 ***	-1.00 ***	-0.98 ***	-0.97 ***
Median	1.17 ***	1.12 ***	1.11 ***	1.99 ***	2.16 ***	2.27 ***	-0.92 **	-0.92 **	-0.94 **	3.91 ***	4.10 ***	4.10 ***
Variance		0.01 -	0.01 -		-0.03 ***	-0.05 ***		0.01 -	0.01 -		-0.01 -	-0.01 -
Pearson coeff			-0.44 -			3.81 ***			0.14 -			-0.17 -
Adj. R-squared	0.60	0.61	0.61	0.77	0.79	0.81	0.13	0.13	0.13	0.40	0.42	0.48
N		534			151			303			80	

Sources: Survey of Consumers - University of Michigan and authors' calculations.
Notes: As the skewness is not part of the published variables, we compute the Pearson coefficient of skewness from the published mean, median, and variance. Subsamples are based on the Bai-Perron (2003) global breakpoint test based on the median model, with a significance level of 5 percent and a maximum number of breakpoints of 2. *** = significant at 0.01 level, **=significant at 0.05 level, *=significant at 0.1 level. Errors are Newey-West.

Table A.8. Moments Model with Increasing / Decreasing Inflation Dummies, with Published Moments

	Inflation t+12					
	No Dummy		Increasing / decreasing inflation			
Constant	-0.96 *	-0.73 -	0.32 -	1.35 ***	0.30 -	1.47 ***
Inflation	0.03 -	0.03 -	0.21 **	0.24 ***	0.12 -	0.14 -
Median	1.12 ***	1.11 ***	0.42 **	0.34 *	0.53 ***	0.46 ***
Variance	0.01 -	0.01 -	0.02 **	0.03 ***	0.02 **	0.03 ***
Pearson coeff		-0.44 -		-1.92 ***		-2.18 ***
Variance*Dummy1			0.05 ***	0.05 ***	0.06 ***	0.06 ***
Variance*Dummy2			-0.01 **	-0.02 ***	-0.01 **	-0.02 ***
GFC					-1.32 *	-1.50 **
Adj. R-squared	0.61	0.61	0.75	0.77	0.77	0.78

Sources: Survey of Consumers - University of Michigan and authors' calculations.
Notes: Increasing (decreasing) inflation is defined as the 3-month-average 1-year ahead being greater than the 3-month average one year ago plus 1 percentage point. The GFC dummy takes a value of 1 in years 2008-2010. *** = significant at 0.01 level, **=significant at 0.05 level, *=significant at 0.1 level. Errors are Newey West.

Table A.9. Moments Model, with Moments Based on Micro Data

	Inflation t+12											
Sample	1978M1-2022M6			1978M1-1990M7			1990M8-2015M10			2015M11-2022M6		
Constant	-1.22 *	-1.24 *	-1.52 *	-1.81 **	-0.98 -	-2.50 **	4.16 ***	4.22 ***	4.04 ***	-3.94 ***	-1.76 -	1.19 -
Inflation	0.21 -	0.19 -	0.19 -	-0.24 *	-0.08 -	-0.02 -	0.30 ***	0.30 ***	0.29 ***	-0.82 ***	-0.82 ***	-0.50 -
Median	1.13 ***	1.11 ***	1.15 ***	1.98 ***	2.07 ***	2.06 ***	-0.84 ***	-0.82 ***	-0.78 ***	3.08 ***	1.79 *	1.25 -
Variance		0.01 -	0.00 -		-0.06 ***	-0.06 ***		-0.01 -	-0.02 -		0.10 -	0.10 -
Skewness			0.15 -			0.52 *			0.14 -			-1.67 *
Adj. R-squared	0.59	0.59	0.59	0.80	0.82	0.83	0.13	0.13	0.13	0.40	0.42	0.44
N		534			151			303			80	

Sources: Survey of Consumers - University of Michigan and authors' calculations.
Notes: Subsamples are based on the Bai-Perron (2003) global breakpoint test based on the median model, with a significance level of 5 percent and a maximum number of breakpoints of 2. *** = significant at 0.01 level, **=significant at 0.05 level, *=significant at 0.1 level. Errors are Newey-West.

Table A.10. Moments Model with Increasing / Decreasing Inflation Dummies, with Moments Based on Micro Data

	Inflation t+12					
	No Dummy		Increasing / decreasing inflation			
Constant	-1.24 *	-1.52 *	0.28 -	0.33 -	0.20 -	0.46 -
Inflation	0.19 -	0.19 -	0.37 ***	0.37 ***	0.27 ***	0.26 ***
Median	1.11 ***	1.15 ***	0.26 -	0.25 -	0.36 -	0.33 -
Variance	0.01 -	0.00 -	0.03 -	0.03 -	0.03 *	0.04 *
Skewness		0.15 -		-0.03 -		-0.14 -
Variance*Dummy1			0.08 ***	0.08 ***	0.08 ***	0.08 ***
Variance*Dummy2			-0.03 **	-0.03 ***	-0.02 **	-0.02 **
GFC					-1.30 *	-1.38 *
Adj. R-squared	0.59	0.59	0.74	0.74	0.76	0.76

Sources: Survey of Consumers - University of Michigan and authors' calculations.
Notes: Increasing (decreasing) inflation is defined as the 3-month-average 1-year ahead being greater than the 3-month average one year ago plus 1 percentage point. The GFC dummy takes a value of 1 in years 2008-2010. *** = significant at 0.01 level, **=significant at 0.05 level, *=significant at 0.1 level. Errors are Newey West.

Table A.11. Moments Model, with Interquartile Range instead of Variance

	Inflation t+12											
Sample	**1978M1-2022M6**			**1978M1-1990M7**			**1990M8-2015M10**			**2015M11-2022M6**		
Constant	-1.28 **	-0.76 -	5.13 **	-1.16 *	1.01 *	12.28 ***	4.40 ***	5.43 ***	6.23 ***	-4.71 ***	-4.69 ***	5.46 -
Inflation	0.18 -	0.24 *	0.29 **	-0.27 **	0.12 -	0.20 -	0.28 ***	0.28 ***	0.28 ***	-0.78 **	-0.75 **	-0.58 *
Median	1.07 ***	1.08 ***	0.60 ***	1.70 ***	1.47 ***	0.46 -	-0.82 ***	-0.73 ***	-0.78 ***	2.98 ***	2.45 **	1.79 *
IQR		-0.16 -	-0.46 ***		-0.53 ***	-0.98 ***		-0.31 *	-0.37 *		0.39 -	-0.35 -
Skewness			-2.65 ***			-5.30 ***			-0.35 -			-4.27 **
Adj. R-squared	0.61	0.61	0.62	0.81	0.84	0.86	0.13	0.14	0.16	0.46	0.46	0.48
N		534			151			303			80	

Sources: Survey of Consumers - University of Michigan and authors' calculations.
Notes: Subsamples are based on the Bai-Perron (2003) global breakpoint test based on the median model, with a significance level of 5 percent and a maximum number of breakpoints of 2. IQR=interquartile range. *** = significant at 0.01 level, **=significant at 0.05 level, *=significant at 0.1 level. Errors are Newey-West.

Table A.12. Moments Model with Increasing / Decreasing Inflation Dummies, with Interquartile Range instead of Variance

	Inflation t+12					
	No Dummy		**Increasing / decreasing inflation**			
Constant	-0.76 -	5.13 **	-1.33 ***	1.24 -	-1.76 ***	1.65 -
Inflation	0.24 *	0.29 **	0.28 ***	0.30 ***	0.14 -	0.16 -
Median	1.08 ***	0.60 ***	0.53 **	0.34 *	0.64 ***	0.38 **
IQR	-0.16 -	-0.46 ***	0.32 **	0.19 -	0.44 ***	0.27 -
Skewness		-2.65 ***		-1.16 -		-1.55 **
IQR*Dummy1			0.40 ***	0.38 ***	0.43 ***	0.41 ***
IQR*Dummy2			-0.20 ***	-0.20 ***	-0.17 ***	-0.17 ***
GFC					-1.67 ***	-1.77 **
Adj. R-squared	0.61	0.62	0.76	0.76	0.77	0.78

Sources: Survey of Consumers - University of Michigan and authors' calculations.
Notes: IQR=interquartile range. Post min (max) is when in there was a 5-year minimum (maximum) in the previous 6 months. Increasing (decreasing) inflation is defined as the 3-month-average 1-year-ahead being greater than the 3-month average one year ago plus 1 percentage point. The GFC dummy takes a value of 1 in years 2008-2010. *** = significant at 0.01 level, **=significant at 0.05 level, *=significant at 0.1 level. Errors are Newey-West.

Table A.13. Moments Model with Increasing / Decreasing Inflation Dummies, Quarterly Data

	Inflation t+4					
	No Dummy		**Increasing / decreasing inflation**			
Constant	-0.42 -	3.76 **	0.14 -	6.13 ***	0.04 -	7.66 ***
Inflation	0.25 ***	0.17 *	0.41 ***	0.31 ***	0.35 ***	0.19 *
Median	1.27 ***	0.91 ***	0.65 ***	0.10 -	0.70 ***	0.03 -
Variance	-0.09 ***	-0.11 ***	-0.04 -	-0.05 -	-0.04 -	-0.04 -
Skewness		-2.16 ***		-3.12 ***		-4.00 ***
Variance*Dummy1			0.11 ***	0.10 ***	0.12 ***	0.11 ***
Variance*Dummy2			-0.03 **	-0.05 ***	-0.03 **	-0.05 ***
GFC					-1.27 -	-2.00 **
Adj. R-squared	0.64	0.65	0.76	0.78	0.77	0.80

Sources: Survey of Consumers - University of Michigan and authors' calculations.
Notes: Post min (max) is when in there was a 5-year minimum (maximum) in the previous 2 quarters. Increasing (decreasing) inflation is defined as 1-year-ahead inflation being greater than the inflation one year ago plus 1 percentage point. The GFC dummy takes a value of 1 in years 2008-2010. *** = significant at 0.01 level, **=significant at 0.05 level, *=significant at 0.1 level. Errors are Newey-West.

Annex IV. Functional Principal Component Analysis (FPCA)

As a robustness check to our main results, we use functional principal components instead of moments to describe the shape of the monthly distributions of household inflation expectations. FPCA allows to describe highly complex functions by a minimal number of components.[15] Figure A.4 shows density functions fitted on US households' one-year ahead expectations data from January 1978 to April 2023, with each grey line representing one month, and the black line depicting the average across all months. In most months, the distributions depict a mode close to, but above the Fed's 2-percent inflation target. Note that FPCA can be based either on the original distributions or on the distributions after centering them around their cross-sectional mean. We first report results based on the uncentered distributions. Regression results based on the centered distributions are provided as a further robustness exercise.

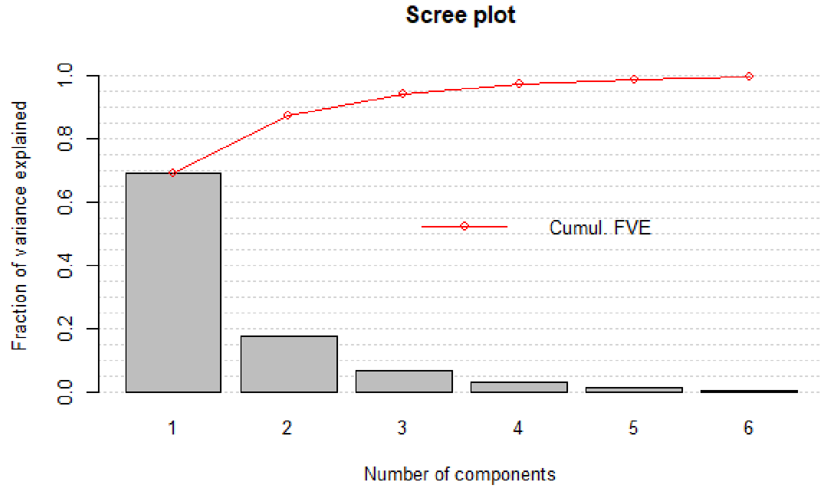
Figure A.4. Distributions of Households' One-year Expectations

Source: Survey of Consumers – University of Michigan, and authors' calculations.
Notes: Kernel densities based on US households' one-year expectations.

We find that three components explain around 94 percent of variation of the distribution. The scree plot depicted in Figure A.5 gives an idea of the goodness of the approximation over the whole sample. Since further components only add a marginal increase in the explained variation, we will report results for regressions that use three principal components as explanatory variables.

[15] See Meeks and Monti (2022) and Chang and others (2022) for a comprehensive mathematical exposition of FPCA in the context of household inflation expectations. Like Principal Component Analysis (PCA), FPCA is a technique to reduce the dimensionality of data while minimizing the loss of information contained in the data. While PCA deals with vectors, i.e., a multivariate set-up, FPCA is applied to functional data. The basic idea is to find the principal components that explain the largest part of variation in the data.

Figure A.5. Proportion of Variance Explained by FPCA



Source: Survey of Consumers – University of Michigan, and authors' calculations.
Notes: Left hand side: The scree plot depicts proportion of the variance which is explained for a given number of principal components. Right hand side: The eigenfunctions represent the principal components. Their shape is indicative about what part of the shape of the household expectation distribution they represent.

We again specify a simple inflation forecasting model that regresses inflation twelve months ahead on a constant, current inflation 'scores' describing the distribution:

$$\pi_{t+12} = c + \alpha\pi_t + \sum_{k=1}^{K} \beta_k s_{k,t}^{uncent} + \varepsilon_t \quad (A.1)$$

where π_t is inflation in period t, c is a constant, α and β_k are coefficients to be estimated, $s_{k,t}^{uncent}$ are scores[16] obtained from the FPCA based on uncentered distributions, and ε_t is the error term.

The shape of the distribution of expectations is informative of future inflation, independently of the number of scores we use (one, two or three). The regression results are summarized in Table A.14. The first three columns show coefficient estimates for the full sample period. For the specification including the first three scores, we find that coefficients of the first and the third score are statistically significant, while for the specifications including just one or two scores, only the first score is significant. As with our baseline results, the models perform best in the high-inflation periods at the beginning and end of the sample, respectively.

[16] The score measures to what extent a curve consists of the respective functional principal component.

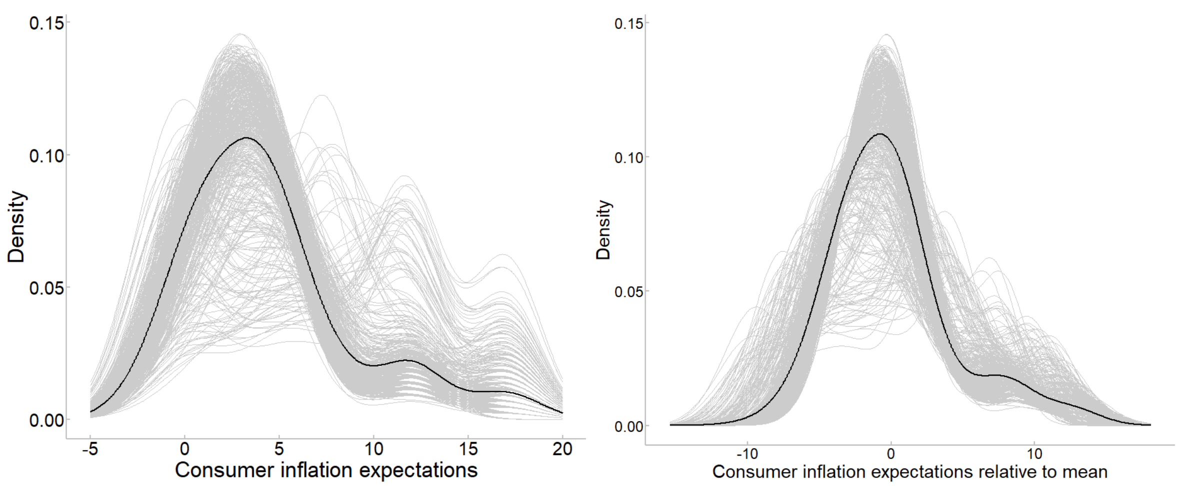
Table A.14. Scores Model Based on Different Subsamples, Uncentered Distributions

	Inflation t+12											
Sample	**1978M1-2022M6**			**1978M1-1990M7**			**1990M8-2015M10**			**2015M11-2022M6**		
Constant	2.25 ***	2.39 ***	2.83 ***	3.26 ***	3.55 ***	4.46 ***	1.68 ***	1.36 ***	1.19 ***	5.45 ***	6.49 ***	4.48 ***
Inflation	0.36 ***	0.32 ***	0.20 -	0.13 -	0.08 -	-0.09 -	0.14 -	0.26 **	0.25 **	-0.33 -	-0.68 **	0.02 -
Score 1	-16.86 ***	-18.14 ***	-22.28 ***	-28.96 ***	-31.55 ***	-34.05 ***	10.65 **	12.17 **	18.10 ***	-40.23 ***	-40.48 ***	3.72 -
Score 2		5.75 -	7.21 -		35.65 ***	37.18 ***		-8.48 **	-6.91 *		32.64 **	23.43 *
Score 3			-16.41 *			-19.04 **			17.14 *			93.46 ***
Adj. R-squared	0.58	0.58	0.59	0.67	0.83	0.84	0.09	0.14	0.16	0.54	0.59	0.68
N		534			151			303			80	

Sources: Survey of Consumers - University of Michigan and authors' calculations.
Notes: Subsamples are based on the moments model for comparison, with a significance level of 5 percent and a maximum number of breakpoints of 2. *** = significant at 0.01 level, **=significant at 0.05 level, *=significant at 0.1 level. Errors are Newey-West.

We next report results based on the FPCA performed on distributions centered their cross-sectional mean (see right-hand side of Figure A.6, while the left-hand side shows the original distributions). The mean curve of the centered distribution has a lower variance and a shorter right tail compared to its uncentered counterpart, so that the first two functional principal components are sufficient to capture the distribution.

Figure A.6. Uncentered and Centered Distributions of Households' One-year Expectations



The only difference for the forecasting model is that the mean should be included as an explanatory variable when using scores based on the centered distributions:

$$\pi_{t+12} = c + \alpha\pi_t + \sum_{k=1}^{K} \beta_k s_{k,t}^{cent} + \gamma\bar{\pi}_t^e + \varepsilon_t \quad (A.2)$$

where $s_{k,t}^{cent}$ are scores obtained from the FPCA based on centered distributions, $\bar{\pi}_t^e$ is mean expected inflation in period t and γ is the corresponding coefficient to be estimated.

Regression results are summarized in Table A.15. Empirical model (A.2), which includes the mean and scores based on the centered distributions, yields similar results as model (A.1) in the sense that coefficients of the

Source: Survey of Consumers – University of Michigan, and authors' calculations.
Notes: Left hand side: Kernel densities based on US households' one-year expectations. Right hand side: Kernel densities based on US households' one-year expectations *centered around the cross-sectional mean.* Grey lines indicate months January 1978 – April 2023, the black lines indicate the cross-months averages.

mean, and score 2 are highly significant when estimated for the full period, and score 1 is significant at a 10 percent level. Note that first principal component obtained from the uncentered FPCA is highly negatively correlated with the mean, so it is to be expected for the mean to have a positive significant coefficient. It also displays a similar pattern regarding the share of variation explained in the different sub-samples, with the highest R squared obtained for the earliest sub-sample, followed again by the most recent one and lower values for the intermediate period.

Table A.15. Scores Model Based on Different Subsamples, Centered Distributions

	Inflation t+12											
Sample	**1978M1-2022M6**			**1978M1-1990M7**			**1990M8-2015M10**			**2015M11-2022M6**		
Constant	-1.69 -	-1.91 -	-1.38 -	-4.66 ***	-5.17 ***	-1.69 -	4.52 ***	4.18 ***	5.18 ***	-5.48 ***	-0.42 -	5.80 *
Inflation	0.32 **	0.34 **	0.15 -	-0.20 -	0.12 -	-0.07 -	0.28 ***	0.27 **	0.29 ***	-0.95 ***	-0.70 **	-0.23 -
Mean	0.92 **	0.95 **	0.98 ***	2.13 ***	2.05 ***	1.56 ***	-0.73 ***	-0.66 ***	-0.95 ***	2.82 ***	1.54 *	-0.26 -
Score 1		1.94 -	-6.33 *		17.61 ***	7.58 *		3.58 -	8.63 -		-22.09 *	-16.44 -
Score 2			26.84 ***			33.55 ***			-16.49 *			-69.87 ***
Adj. R-squared	0.57	0.57	0.62	0.78	0.82	0.86	0.14	0.14	0.17	0.52	0.56	0.64
N		534			151			303			80	

Sources: Survey of Consumers - University of Michigan and authors' calculations.
Notes: Subsamples are based on the Bai-Perron (2003) global breakpoint test based on the mean model, with a significance level of 5 percent and a maximum number of breakpoints of 2. *** = significant at 0.01 level, **=significant at 0.05 level, *=significant at 0.1 level. Errors are Newey-West.

PUBLICATIONS

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