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Assessing the (de-)anchoring of households' long-term inflation expectations in the US

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ABSTRACT

Well-anchored inflation expectations play an important role in the achievement of price stability. The (de-)anchoring of long-term inflation expectations in the US has been under debate since the sub-prime crisis. This paper assesses and explains the evolution of the degree of (de-)anchorage of households' long-term inflation expectations in the US during the period of 1990 to 2019, in a time-varying framework. We find the long-term inflation expectations to be de-anchored during the entire study period. The de-anchorage was greater in the first half of the 1990s. Subsequently, it has declined but has not yet anchored. An increase in inflation perception reduces the degree of de-anchorage in a (persistently) low-inflation perception period, whereas it causes a rise in the degree of de-anchorage when inflation perception is around its long-term average or is persistently high. Further, a rise in economic policy uncertainty also increases the de-anchorage of households' long-term inflation expectations. This suggests that the Federal Reserve System (Fed) may find it beneficial to pay more attention to households' inflation perception.

1. Introduction

Well-anchored long-term inflation expectations are very important for the successful conduct of monetary policy in an inflation-targeting economy. Central banks often adopt an explicit numeral inflation target, partly to anchor long-term inflation expectations. If the central bank is credible, the target inflation should anchor the long-term inflation expectations. Accordingly, the long-term inflation expectations are expected to be determined only by target inflation, not by actual inflation, news, and/or short-term inflation expectations.

The (de-)anchoring of long-term inflation expectations in the US, the Euro area, and the emerging economies has been under debate since the sub-prime crisis. The empirical results are mixed, ranging from perfect anchoring to severe de-anchoring. For instance, in the context of the US, several studies have found the long-term inflation expectations to be perfectly anchored (Blanchard, 2016; Buono and Formai, 2018; Nautz et al., 2019; Strohsal et al., 2016), whereas a few studies have shown them to be de-anchored (Kumar et al., 2015; Nautz and Strohsal, 2015). Similarly, in the context of the Euro area, Scharnagl and Stapf (2015) have found that the medium- to long-term inflation expectations are well anchored, whereas Cruijsen and Demertzis (2011) have determined that inflation expectations are less well-anchored. Further, de Mendonça (2018) has shown that the inflation expectations in seven inflation-targeting emerging economies (Brazil, Chile, Colombia, Mexico, Poland, South Africa, and Turkey) are not perfectly anchored. This paper reexamines the debate by analyzing the evolution of (de-)anchorage of inflation expectations in the US from

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1990 to 2019.

Our study contributes to the literature on inflation expectations anchorage in two ways. First, we analyze the (de-)anchorage of survey-based measures of households' long-term inflation expectations. This is in contrast to most of the previous studies, which have analyzed either professional forecasters' inflation expectations (Buono and Formai, 2018; Cruijsen and Demertzis, 2011; Lyziak and Paloviita, 2018) or market-based break-even inflation rates (Jochmann et al., 2010; Nautz et al., 2017; Strohsal et al., 2016; Strohsal and Winkelmann, 2015)[1,2]. Our approach is justifiable on twofold grounds. First, as per the New Keynesian Phillips Curve, inflation expectations of firms are highly relevant to capture their pricing decisions. However, the quantitative measure of this information is unavailable for many countries, including the US. Binder (2015) and Coibion and Gorodnichenko (2015) have provided evidence that in the absence of firms' inflation expectations, households' inflation expectations are a better proxy than professional forecasters' inflation expectations in explaining actual inflation. Second, the market-based inflation rates are not very informative in forecasting inflation because they include not only the public's expectations of inflation but also the impact of other factors that affect prices. For instance, they are affected by liquidity risk, inflation risk, and animal spirits that are not related to expectations (Bauer and Rudebusch, 2015). Bauer and McCarthy (2015) have shown that the market-based measures do not provide useful forward-looking information about inflation. On the basis of the above two rationales, we deviate from the existing literature and ask whether households' inflation expectations are well anchored in the US.[3]

Our second contribution is identification of two different channels that may explain the evolution of (de-)anchorage of households' long-term inflation expectations. First, change in perception of inflation may alter the de-anchorage of households' long-term inflation expectations. The relevance of this argument can be seen in some recent surveys indicating that households are not well-informed about the objectives of the central bank, target inflation, and the official statistics of actual inflation (Kumar et al., 2015; Rowe, 2016).[4] Further, several studies have shown the importance of frequently purchased goods and services, such as food and gasoline, in forming economy-wide perceptions of inflation (Georganas et al., 2014; Giovane and Sabbatini, 2008; Jonung, 1981; Kumar et al., 2015; Nam and Go, 2018). Under such conditions, the (de)-anchorage of long-term inflation expectations may depend on what households *think* about current inflation. In this paper, we use current year-on-year food away from home (FAFH) inflation as a measure of perception of inflation. The FAFH inflation has fluctuated around its long-term average (i.e., 2.7%) in our study period, but it has been below its long-term average since the global financial crisis. We hypothesize that the effects of an increase in inflation perception on degree of de-anchorage would be different in the periods when the inflation perception is below its average as compared to the periods when it is above. This is because in the low inflation perceptions environment, an increase in inflation perception means moving toward the long-term average value (i.e., contributing to re-anchorage). By contrast, in the high inflation perceptions environment, an increase in its value indicates moving away from its long-term average value (i.e., contributing to de-anchorage). Therefore, we expect a U-shaped relationship between perception of inflation and change in degree of de-anchorage. We examine this relationship by comparing the effects of the rise in perception of inflation on degree of de-anchorage across periods when inflation perception is (persistently) below, near, and (persistently) above its long-term average.[5] Second, an increase in economic policy uncertainty may also increase the de-anchorage of households' long-term inflation expectations, and vice versa. As per this channel, an increase in economic policy uncertainty (i.e., a situation in which economic agents are unsure about the actions that policymakers are going to take and the consequences thereof) is expected to increase the degree of de-anchorage (Istrefi and Piloiu, 2014) because as policy uncertainty rises, households begin to doubt the policymakers' ability or willingness to keep promises. In the context of monetary authorities, this may mean questioning the credibility of the Fed regarding its ability to maintain price stability. As a result, the degree of de-anchorage of inflation expectations may increase.

In a nutshell, the main aim of this paper is to assess and explain the evolution of the degree of (de-)anchorage of long-term inflation expectations in the US from 1990 to 2019. We define long-term inflation expectations (measured by five-years-ahead households' inflation expectations) as perfectly anchored only if their deviations from the target inflation are not responsive to the respective deviations in short-term inflation expectations (measured by one-year-ahead households' inflation expectations), following Jochmann et al. (2010), Kumar et al. (2015), Strohsal et al. (2016).[6] If long-term inflation expectations are perfectly anchored, the pass-through from deviations of short-term inflation expectations to deviations of long-term inflation expectations is expected to be zero or near zero. We follow a two-step estimation procedure. In the first step, we apply a time-varying parameter approach to estimate the (de-)anchorage of inflation expectations, given by the coefficient of the pass-through, similar to that in Strohsal et al. (2016). We define this as the degree of (de-)anchorage of long-term inflation expectations. In the second step, we analyze the changes

[1] Some studies that analyze households' inflation expectations are Binder (2018), Kumar et al., (2015) and Nam and Go (2018).

[2] Market-based break-even inflation rate is also known as inflation compensation. It is calculated as the difference between the nominal yield on traditional Treasury Securities and Treasury Inflation Protected Securities (TIPS) with the same maturity. It reflects the inflation expectations among financial market participants.

[3] The need for a study of (de-)anchorage of households' inflation expectations has been suggested in a few studies. For instance, Binder (2017) stated that "there is less evidence regarding whether the announcement of an inflation target helps anchor households' expectations" (p. 245).

[4] The Pew Research Center for the People and the Press poll in the US asked consumers whether recent inflation was closer to 1%, 5%, 10%, or 20%. The mean response was found to be 7.4%, and 49% of the respondents either opted "refused to answer" or "did not know" (Kumar et al., 2015). By contrast, the actual rate of CPI inflation was approximately 1%. Similarly, in a February 2016 survey, households were asked about the current level of CPI inflation. Only 20% of the households could answer correctly while 45% answered "do not know" (Rowe, 2016).

[5] We define inflation perception to be persistently low (high) if it has been below (above) its long-term average for at least 12 consecutive months. The criteria are discussed in Section 4.2.3.

[6] It is expected that macroeconomic news can affect near-term inflation expectations, but not at longer horizons.

in the degree of (de-)anchorage of inflation expectations using two channels: (i) inflation perception and (ii) economic policy uncertainty.

The papers most closely related to our work are those of Binder (2018), Buono and Formai (2018), Kumar et al. (2015), Strohsal et al. (2016). Our approach differs from Buono and Formai (2018) and Strohsal et al. (2016) in the usage of the measures of inflation expectations. While the analyses of Buono and Formai (2018) and Strohsal et al. (2016) were based on professional forecasters' and a market-based measure of inflation expectations, respectively, we focus on households' inflation expectations. Our work also differs from Binder (2018) and Kumar et al. (2015) on two counts. First, while Binder (2018) and Kumar et al. (2015) have assessed the (de-) anchorage of households' inflation expectations in a constant parameter model, we do so in a time-varying framework. Second, we employ perceptions of inflation and economic policy uncertainty to explain the changes in the (de-)anchorage of long-term inflation expectations. To the best of our knowledge, this is the first paper that explains the (de-)anchorage of long-term inflation expectations using inflation perception and policy uncertainty channels.

We find four important results: (i) The long-term inflation expectations of households in the US responded to the short-term inflation expectations in a dynamic manner from 1990 to 2019. In other words, the de-anchorage of long-term inflation expectations has varied over time in the entire sample period. (ii) The de-anchorage was greater in the first half of the 1990s. Subsequently, it has declined but has not yet anchored. (iii) The relationship between inflation perception and the change in degree of de-anchorage is U-shaped if inflation perceptions are low and high persistently, and (iv) A rise in policy uncertainty increases the degree of de-anchorage of long-term inflation expectations.

The rest of the article is structured as follows: Section 2 discusses relationships between households' long-term and short-term inflation expectations in the US. Section 3 presents the empirical model to estimate the degree of (de-)anchorage of households' long-term inflation expectations. Section 4 presents the estimates of the degree of (de-)anchorage in the US and the channels which explain its evolution. The conclusions and policy implications are presented in Section 5.

2. Households' inflation expectations in the US

The Michigan Surveys of Consumers (MSC) provide information on households' inflation expectations in the US. These surveys collect data on about 500–600 households each month to gather information on various aspects of consumer sentiment, including two questions on inflation expectations:

Short-term expectations: During the next 12 months, do you think that prices in general will go up, go down, or stay where they are now? By about what percentage do you expect prices to go up/down, on average, during the next 12 months?

Long-term expectations: What about the outlook for prices over the next 5 to 10 years? Do you think that prices will be higher, about the same, or lower 5 to 10 years from now? By about what percentage per year do you expect prices to go up/down, on average, during the next 5 to 10 years?

Fig. 1 compares households' long-term inflation expectations, professional forecasters' inflation expectations, and market-based

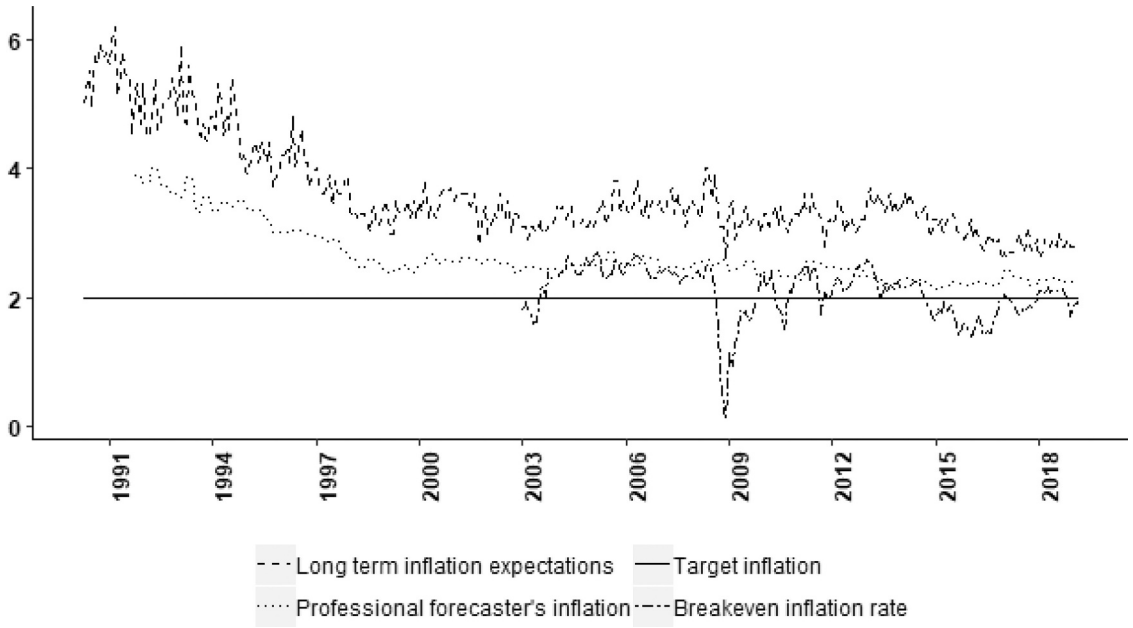

Fig. 1. Inflation expectations and target inflation in the US, 1990–2019. *Notes:* Long-term inflation expectations during the next 5 to 10 years come from the Michigan Surveys of Consumers (MSC). Professional forecasters inflation expectations of 10 year ahead CPI inflation come from the Philadelphia Federal Reserve's Survey of Professional Forecasters (SPF). Break-even inflation rate in the next 10 years come from the Federal Reserve Bank of St. Louis. Target inflation is 2% rate of Inflation.

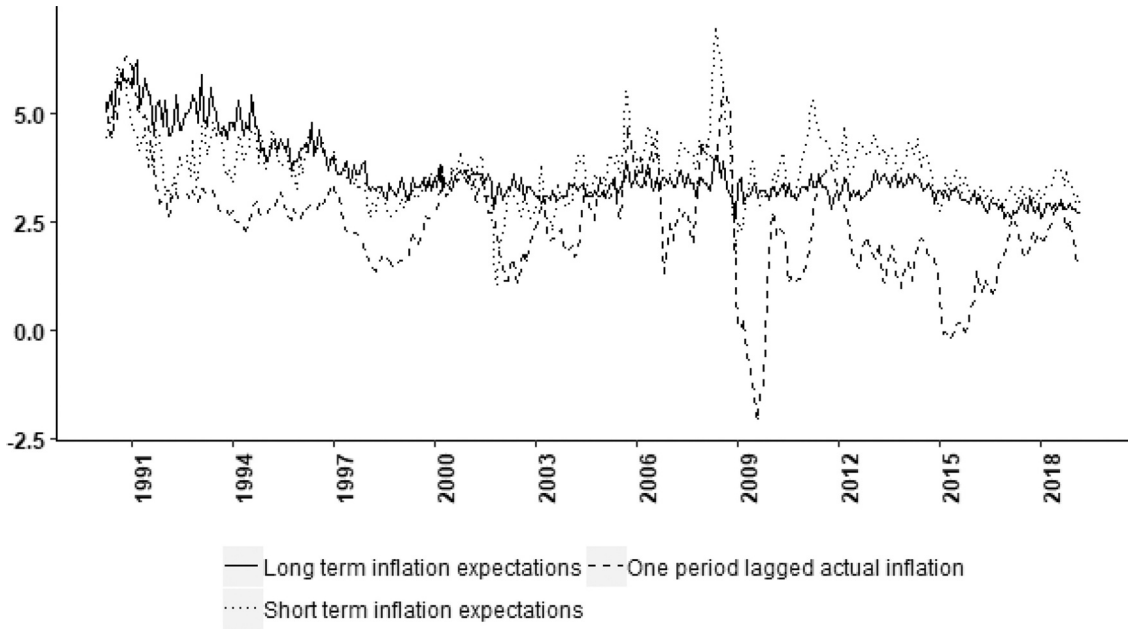

Fig. 2. Long-term inflation expectations, short-term inflation expectations, and actual inflation in the US, 1990–2019. *Notes:* Long-term inflation expectations (average) during the next 5 to 10 years and short-term inflation expectations (average) in the next 12 months come from the Michigan Surveys of Consumers (MSC). Actual inflation, measured by the year-on-year percentage change in consumer price index (CPI) for all urban consumers for all items, is obtained from the Federal Reserve Bank of St. Louis database.

break-even inflation rate. These variables exhibit comovement, however, their variations are very different from each other. Households' long-term inflation expectations vary more than professional forecasters' inflation expectations and less than the market-based break-even inflation rate. Further, households' long-term inflation expectations are higher than the Fed's target rate of inflation. For example, the average of households' long-term inflation expectations exceeded the target inflation by 1.5 percentage points (pp) from 1990 to 2019. They also exceeded professional forecasters' inflation expectations by 0.90 pp from 1991 to 2019 and market-based inflation expectations by 1.1 pp from 2003 to 2019. This finding indicates that the long-term inflation expectations may not be anchored at the 2-percent inflation target of the Fed and that the determinants of households' inflation expectations can be very different from professional forecasters' inflation expectations as well as the market-based break-even inflation rate.

Fig. 2 compares households' long-term inflation expectations, households' short-term inflation expectations, and one-period-lagged values of actual headline inflation. The long-term inflation expectations and actual inflation co-move in the same direction for the entire period. However, there were substantial gaps between them from March 1993 to March 2000, November 2008 to May 2011, and November 2014 to April 2019. By contrast, the relationship between the long-term and short-term inflation expectations was found to be extremely close for the entire period, including the above-mentioned time periods. This finding suggests that the current short-term inflation expectations might have played a more important role than the lagged actual inflation in determining long-term inflation expectations. The scatter plot of short-term and long-term inflation expectations also confirms this (see Fig. 3). Taken together, Figs. 2 and 3 offer a preliminary indication that long-term inflation expectations in the US might depend on short-term inflation expectations. The next section develops an empirical model to examine the impact of short-term inflation expectations on long-term inflation expectations.

3. Empirical model

In this section, we estimate the following time-varying regression equation:

$$(\pi^{e}_{t,\ hl} - \pi^{T}) = \alpha + \beta_t(\pi^{e}_{t,\ hs} - \pi^{T}) + \epsilon_t \quad \text{(i)}$$

where $\pi^{e}_{t,\ hl}$ is the households' long-term inflation expectations formed at time t for the forecast horizon l (where l = 5- to 10-years-ahead expectations), $\pi^{e}_{t,\ hs}$ is the households' short-term inflation expectations formed at time t for the forecast horizon s (where s = 12-months-ahead expectations), and π^{T} is the target rate of inflation, which is 2%. Accordingly, $(\pi^{e}_{t,\ hl} - \pi^{T})$ is the deviation of the households' long-term inflation expectations from the target rate of inflation at time t, $(\pi^{e}_{t,\ hs} - \pi^{T})$ is the deviation of the households' short-term inflation expectations from the target rate of inflation at time t, and ϵ_t is the error term at time t. It is assumed that the households form both long- and short-term inflation expectations at the same time, based on the same information set.

The (de-)anchoring parameter β_t is time-varying in our specification, wherein it is allowed to vary smoothly over the entire sample period. The choice of this approach over the other approaches, in which separate constant-parameter models are estimated for different sub-periods (Nautz and Strohsal, 2015), is justified because the transition of anchorage is expected to happen smoothly

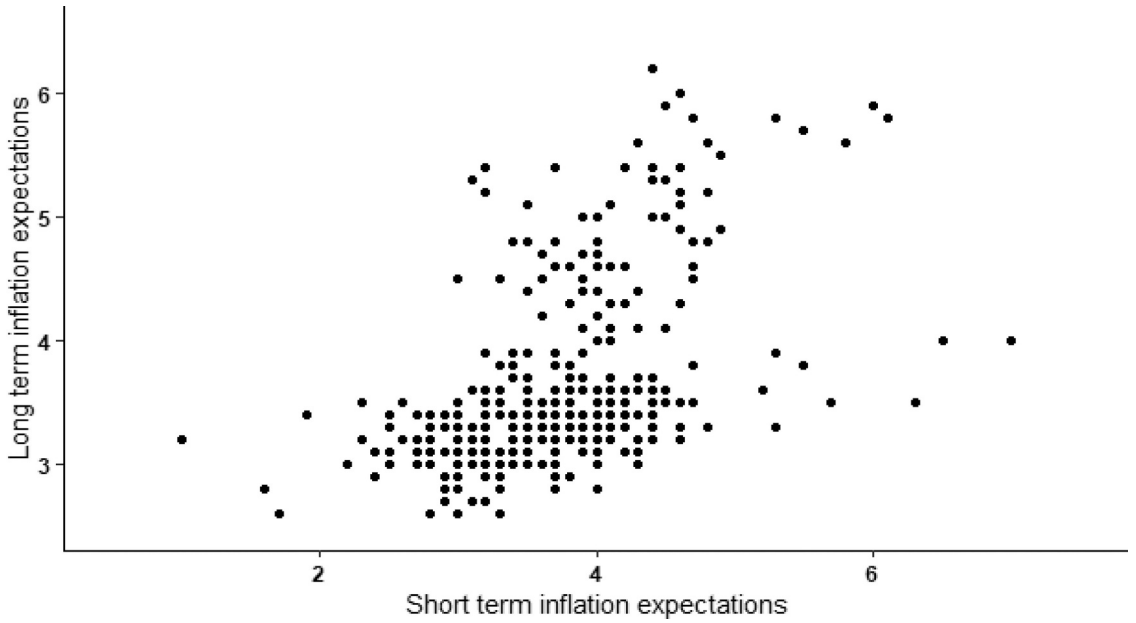

Fig. 3. Scatter plot of short-term and long-term inflation expectations in the US, 1990–2019. *Notes:* Long-term inflation expectations (average) during the next 5 to 10 years and short-term inflation expectations (average) in the next 12 months come from the Michigan Surveys of Consumers (MSC).

rather than abruptly and suddenly. Hence, we allow the parameter (β_t) to change smoothly in equation (i), following Strohsal et al. (2016).

We estimate equation (i) in a state space framework. The one-step-ahead smoothed estimates of the anchoring coefficient β_t are estimated using the Kalman filter. We use the optimization algorithm of Berndt et al. (1974) to estimate the following state space equations:

$$(\pi^e_{t,hl} - \pi^T) = \alpha + G_t\varphi_t \tag{ii}$$

$$\varphi_t = \varphi_{t-1} + V_t \tag{iii}$$

$$G_t = \begin{bmatrix} \pi^e_{t,\,hs} - \pi^T \\ 1 \end{bmatrix}' \quad \varphi_t = \begin{bmatrix} \beta_t \\ \epsilon_t \end{bmatrix} \quad V_t = \begin{bmatrix} \mu_t \\ \delta_t \end{bmatrix}$$

The variance-covariance matrix of the error terms in equations (ii) and (iii) takes the form

$$\aleph = diag\left(\exp\left(\sigma^2_{\mu_t}\right)\ \exp\left(\sigma^2_{\delta_t}\right)\right)$$

In this specification, the value of β_t captures the responsiveness of the deviation of long-term inflation expectations from the target inflation to the deviation of short-term inflation expectations from the target inflation.

If the long-term inflation expectations are perfectly anchored, they should not respond to the changes in deviation of short-term inflation expectations from the target rate of inflation, i.e., $\beta_t = 0$. The short-term inflation expectations are affected by economic news such as surprises in economic activity (i.e., release of unemployment rate, advance estimate of GDP, home sales, etc.) and can deviate temporarily from the target rate of inflation. However, this is not expected to affect the long-term inflation expectations. If they do have an effect, i.e., if β_t is not equal to 0, the long-term inflation expectations are not anchored or de-anchored.

The magnitude of β_t may capture the degree of de-anchorage of long-term inflation expectations. The larger the value of β_t, the greater the de-anchorage and the smaller the speed of adjustment of long-term inflation expectations to the target rate of inflation. Accordingly, the change in degree of de-anchorage at time t may be calculated as $(\beta_t - \beta_{t-1})$.

We use monthly data for the period of April 1990 to April 2019. Long-term and short-term inflation expectations are measured by the average inflation expectations of US households during the next 5 to 10 years and the next 12 months, respectively. Actual inflation is measured by the year-on-year percentage change in consumer price index (CPI) for all urban consumers for all items. Data on long-term and short-term inflation expectations are obtained from the Michigan Surveys of Consumers, and actual inflation is obtained from the Federal Reserve Bank of St. Louis database.

Table. 1
Parameter estimates of time-varying parameter model.

Dependent variable	$\sigma^2_{\mu_t}$	$\sigma^2_{\delta_t}$
$(\pi^e_{t,\ hl} - \pi^T)$	−1.91(0.05)***	−5.46(0.24)***

Note: The table shows the estimated parameters for Eq. (i) over the sample 1990M04 to 2019M04. The models are estimated using the Bernndt et al. (1974) algorithm. Standard errors are in parentheses. Other optimization algorithms provide similar results. The null hypothesis of no serial correlation has not been rejected by the Ljung-Box Q statistic. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

4. Results

4.1. Estimates of the time-varying degree of de-anchorage

Table 1 shows that the time variation of parameter β_t is statistically significant. Fig. 4 plots the estimated time-varying de-anchoring parameter (β_t) for the long-term inflation expectations, along with the 95-percent-confidence interval. The de-anchoring parameter (β_t) was statistically different from zero for our entire study period (i.e., from 1990 to 2019) and varied between 1.72 and 0.44. De-anchorage was higher at the beginning of the sample. Then it declined gradually until mid-2008. Afterward, the degree of de-anchorage increased in the second half of 2008 and 2009, and it picked up again from mid-2011 to mid-2015. On average, the value of the de-anchorage parameter (β_t) for the entire period is found to be 0.92, which is far above zero. Therefore, the null hypothesis that long-term inflation expectations are perfectly anchored for the entire period is rejected. Our findings are in line with the findings of (Kumar et al. (2015)), who have assessed the de-anchorage of households' inflation expectations in a constant-parameter model using a specification that includes short-term inflation expectations as an explanatory variable. They stated that "long-term forecasts are highly sensitive to movements in short-term forecasts for consumers in the US. … a 1-percentage point increase in short-term inflation forecast can be associated with as much as a 1-percentage point increase in long-term inflation forecasts" (Kumar et al., 2015, p. 197). They also reported a similar level of de-anchorage (i.e., slope is 0.70) for managers in New Zealand.

Robustness checks

Long-term inflation expectations are also believed to be well anchored if they do not respond to past actual inflation

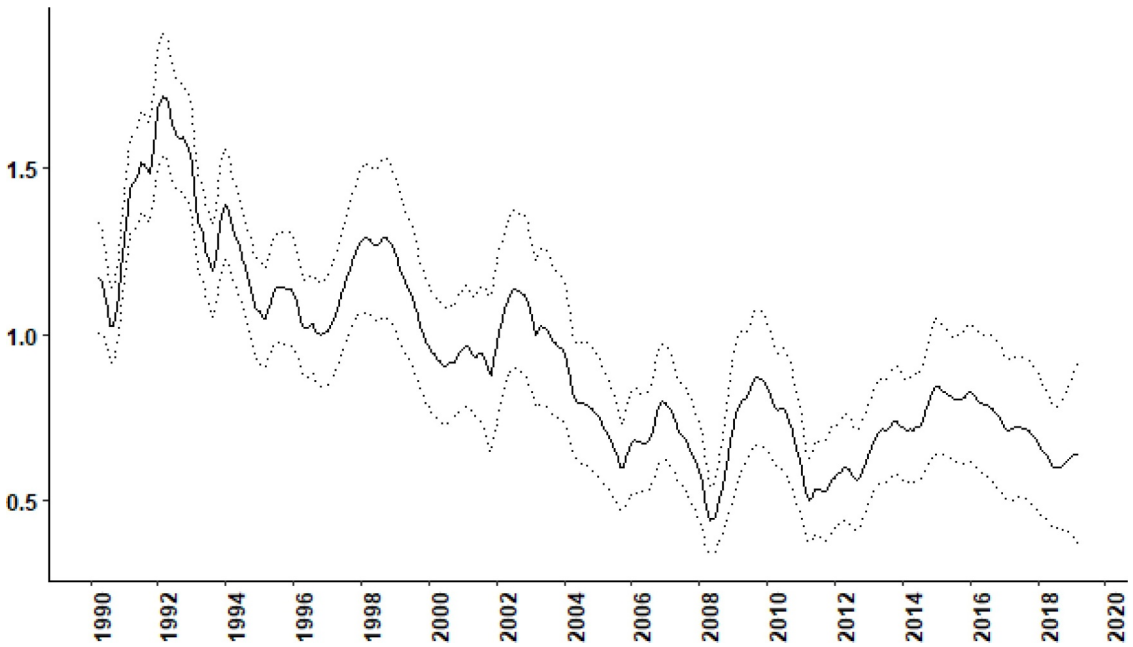

Fig. 4. Degree of de-anchorage in the US, April 1990 to April 2019. *Note:* We define degree of de-anchorage as the responsiveness of the deviations of long-term inflation expectations from the target rate of inflation to the respective deviations of the short-term inflation expectations. Long-term and short-term inflation expectations are measured by the average inflation expectations of US households during the next 5 to 10 years and the next 12 months, respectively. The dotted lines are the 95% confidence intervals.

(Bernanke, 2007; Blanchard, 2016; Cruijsen and Demertzis, 2011; Demertzis et al., 2012). If they are sensitive to past actual inflation, then they are de-anchored. Following Strohsal et al. (2016), we check whether non-inclusion of past actual inflation in equation (i) underestimates the degree of de-anchorage as a robustness check. For that purpose, we include the deviation of the lagged actual inflation from the target rate of inflation in equation (i), in addition to the deviation of short-term inflation expectations from the target, and calculate the degree of de-anchorage due to their combined effects.

We estimate the following equation:

$$\pi^{e}_{t,\ hl} - \pi^{T} = \alpha + \beta_t(\pi^{e}_{t,\ hs} - \pi^{T}) + \theta_t(\pi_{t-1,\ 12} - \pi^{T}) + \varepsilon_t \quad \text{(iv)}$$

where $\pi_{t-1,\ 12}$ is the average actual headline inflation over the last 12 months, lagged by one period. Accordingly, $(\pi_{t-1,\ 12} - \pi^{T})$ is the deviation of average actual headline inflation over the last 12 months, lagged by one period, from the target rate of inflation at time t. The overall degree of de-anchorage is the sum of $\beta_t + \theta_t$.We find that the sum of $\beta_t + \theta_t$ is not statistically different from β_t, especially after 1996. Results are not reported here. This suggests that our degree of de-anchorage measured by β_t is not underestimated.

4.2. What explains the time-varying degree of de-anchorage?

In the previous section, we show that the degree of de-anchorage of households' inflation expectations has varied over time and its magnitude has remained large even after robustness checks. The next concern is: What explains the time-varying degree of de-anchorage of long-term inflation expectations? One explanation could be the change in perceptions of inflation.

4.2.1. Perception of inflation channel

We hypothesize that an increase in perceptions of inflation may increase the degree of de-anchorage of long-term inflation expectations. However, long time series data on perceptions of inflation is unavailable in the US. It is available only after 2016.[7] If past actual inflation is perfectly and uniformly known to the public, the perceptions of inflation become identical to actual rates of inflation (Jonung, 1981). Thus, we first regress the change in degree of de-anchorage on past headline inflation. The headline inflation was insignificant in explaining the degree of de-anchorage (see column 1 of Table A2 in Online Appendix).

Recent surveys indicate that households are not well-informed about the objective of the central bank, target inflation, and the official statistics of actual inflation (Kumar et al., 2015; Rowe, 2016). Several studies show the importance of frequently purchased goods and services, such as food and gasoline, in forming economy-wide perceptions of inflation (Georganas et al., 2014; Giovane and Sabbatini, 2008; Jonung, 1981; Kumar et al., 2015; Nam and Go, 2018). Surveys also indicate that even among frequently purchased goods and services, economic agents give more weight to certain individual goods and services to form their inflation perceptions. For example, Kumar et al. (2015) found that 76% of managers rank gasoline as extremely important (rank of 4 or 5, with a mean response of 4.5) in forming their inflation perceptions. Similarly, Coibion and Gorodnichenko (2015) have argued that households place disproportionate weight on oil and gasoline prices in forming their inflation perceptions. It has also been found that households' personal experience of price changes for food, beverages, and household utilities were the most important factors influencing their perceptions of price changes (Rowe, 2016). Therefore, we consider the current actual inflation of a few individual commodities to test whether they explain the degree of de-anchorage of long-term inflation expectations. These commodities include: (i) Food Away From Home (FAFH) inflation; (ii) Food at Home (FAH) inflation; (iii) medical care inflation; (iv) tuition, other school fees, and childcare inflation; (v) rent of primary residence inflation; (vi) crude oil prices (West Texas Intermedia) dollars per barrel; and (vii) gasoline prices (dollars per gallon). Table A1 in the Online Appendix lists the data sources and variable definitions.

Each of these above-mentioned measures of inflation might have influenced the degree of de-anchorage in the US. We focus on the current FAFH inflation as a proxy for perception of inflation because of its three distinguishing features.[8] First, the share of FAFH in total food expenditure has increased since 1987, while the share of FAH spending has declined. Its share of total food expenditure increased and became approximately the same as FAH in 2007. By 2010, its share exceeded the market share of FAH. For example, total FAFH expenditure was $616.4 billion in 2010, i.e., 50.2% of total food expenditure in the US for that year (Saksena et al., 2018, p. 24).[9] Moreover, households encounter these prices more often, so they are among the most visible prices for most individuals.

[7] The University of Michigan has been collecting information on inflation perceptions, via the MCS, since 2016. The surveys ask respondents about their perceptions of inflation during the past 12 months and over the past 5 to 10 years. Axelrod, Lebow and Peneva (2018) examine these newly available data on US households' inflation perceptions. They find that the individuals who perceive higher inflation in the past tend to expect higher inflation in the future and those whose perceptions change tend to revise their expectations in the same direction.

[8] According to the United States Department of Agriculture's Food Expenditure Series, "FAFH expenditures comprise sales of food for on-premise consumption from eating and drinking places, hotels and motels, retail stores and direct sales establishments, recreational places, schools and colleges, and other places (such as military exchanges and institutions such as hospitals and prisons). For example, a deli sandwich purchased at a grocery store would be classified as an FAFH expenditure because such foods are typically consumed on the premises of the store" (Saksena et al., 2018, p. 23).

[9] Some factors that might have led to an increase in FAFH spending are: (i) rise in personal disposable income (PDI) and (ii) households' time constraints (Saksena, et al., 2018). First, PDI generally increased between 1987 and 2017, except during economic downturns. Several studies document a positive relation between PDI and FAFH expenditures. For instance, Kamakura and Yuxing Du (2012) have found that Engel curves for FAH are downward-sloping, while they are upward-sloping for FAFH. Further, the demand for FAFH is more sensitive to changes in income than is the demand for FAH (Okrent and Alston, 2012; Okrent and Kumcu, 2016; Seale, Jr., Regmi, and Bernstein, 2003). Second, there has been increase in

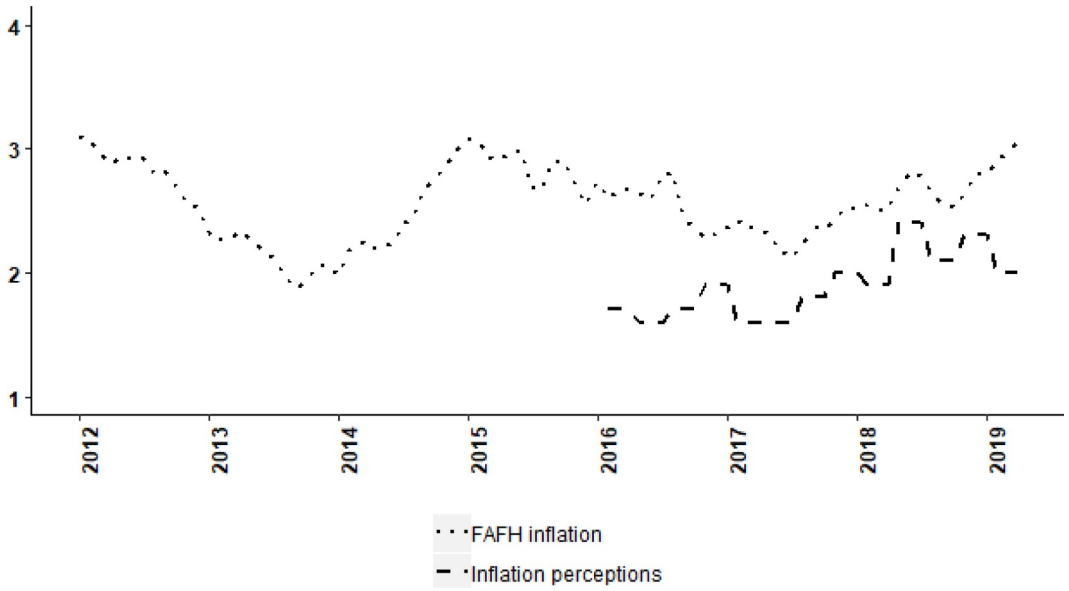

Fig. 5. Actual short-term perceptions of inflation and FAFH inflation, 2012–2019. *Notes:* Actual perception of inflation over the past 12 months is taken from Michigan Survey of Consumers (MSC) .[10] FAFH inflation (YoY) comes from the Federal Reserve Bank of St. Louis database.

Therefore, as per the frequency bias hypothesis, the changes in prices of FAFH might have played an important role in shaping people's perceptions of current inflation, which, in turn, might have changed the degree of de-anchorage of inflation expectations.

Second, the actual perception of inflation has closely tracked the FAFH inflation. Fig. 5 compares the actual perception of inflation during the past 12 months, collected by the University of Michigan, with the actual FAFH inflation during the past 12 months. For example, both co-move, and the correlation between them is 0.48. The mean perception of inflation is 1.9%, and the average FAFH inflation is 2.5%, between 2016 and 2019.

Thirdly, Fig. 6 compares the change in degree of de-anchorage at time period t relative to time period t-1, i.e., $(\beta_t - \beta_{t-1})$, along with the actual current FAFH inflation. We find that they are closely related. For example, the correlation between the change in degree of de-anchorage and FAFH inflation is 0.32 for the entire sample period. In the recent period, i.e., from August 2008 to April 2019, the correlation has increased to 0.69. On the basis of the above discussion, we believe that changes in FAFH inflation (hereafter, perceptions of inflation) might have led to a change in the degree of de-anchorage.

Furthermore, an investigation of trends in inflation perception reveals that inflation perception has been below average in the US since the global financial crisis. Fig. 7 illustrates this by showing the percentages of months in which inflation perception has been below its long-term average since September 2009, which is the case for 64% of the observations (i.e., 74 months out of 116 months). Furthermore, the average gap between inflation perception and its long-term average is -0.3 percentage points since September 2009.

Inflation perception has also been below average in a persistent manner since the crisis. We define inflation perceptions to be persistently low if it has been below its long-term average for at least 12 consecutive months, which is the case with 58% of the observations (see Fig. 7). The inflation perception is persistently below its long-term average for a total of 67 months out of 116 months (i.e., 25 months from September 2009 to September 2011, 22 months from November 2011 to August 2014, and 20 months from September 2016 to April 2018).

We hypothesize that in such periods of low inflation perception (as defined above), the direction of the relationship between inflation perception and the change in degree of de-anchorage may be different as compared to the periods when the inflation perception is above or around its long-term average value. This is because when inflation perception is below average, an increase in its value means moving toward its long-term average value (contributing to re-anchorage). When it is above its long-term average value, by contrast, an increase in its value indicates movement away from its long-term average value (contributing to de-anchorage). Therefore, we expect a U-shaped relationship between perception of inflation and the change in degree of de-anchorage. We examine this relationship in Section 4.2.3.

4.2.2. Policy uncertainty channel

We also investigate whether the change in degree of de-anchorage of households' long-term inflation expectations is explained by

(*footnote continued*)

women's education and labor-force participation in the US over the past several decades. This might have led to less time for cooking and higher FAFH expenditures (Saksena et al., 2018).

[10] We thank David E. Lebow and Ekaterina Peneva of the Federal Reserve System for providing this data.

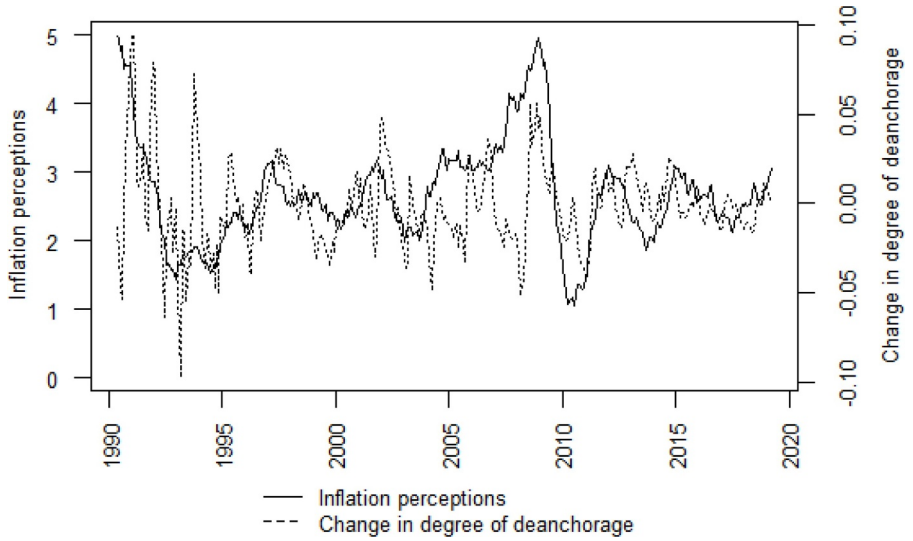

Fig. 6. Inflation perceptions (left axis) and change in the degree of De-anchorage (right axis) in the US, May 1990 to April 2019. *Notes:* Inflation perception, measured by YoY percentage change in FAFH inflation, is obtained from the Federal Reserve Bank of St. Louis database. Change in degree of de-anchorage is the change in the estimated time-varying coefficient β_t, calculated from in Eq. (1), in time t relative to t-1.

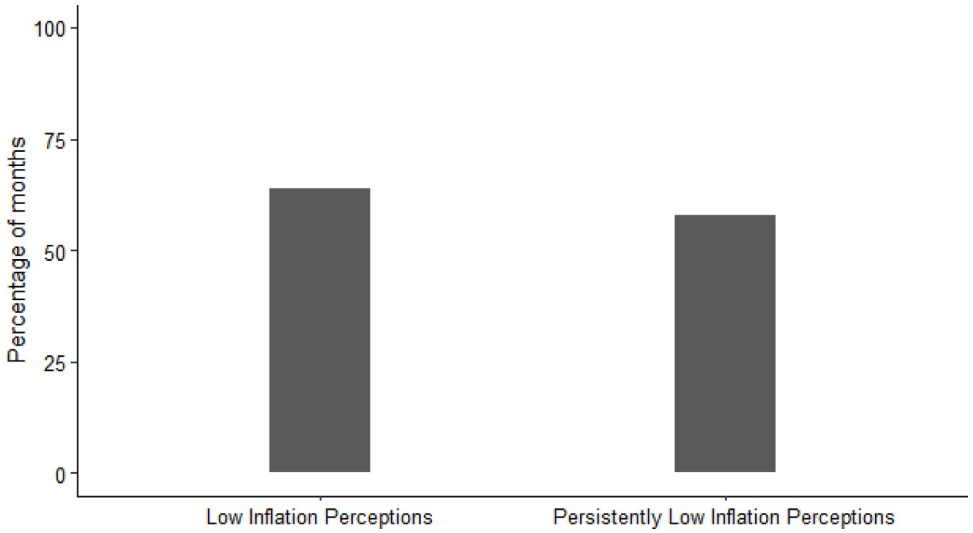

Fig. 7. Percentage of months with low and persistently low inflation perceptions in the US, September 2009 to April 2019. *Notes:* Inflation perception, measured by YoY percentage change in FAFH inflation, is obtained from the Federal Reserve Bank of St. Louis database. Low inflation perception refers to those periods when the inflation perceptions are below their long-term average. Persistently low inflation perception refers to those periods when the inflation perceptions are below their long-term average for at least 12 consecutive months.

the policy uncertainty channel. According to this channel, an increase in economic policy uncertainty (i.e., a situation in which economic agents are unsure about the actions that policymakers are going to take and the consequences thereof) is expected to increase the degree of de-anchorage (Istrefi and Piloiu, 2014). This is because when policy uncertainty rises, households begin to doubt the ability or willingness of policymakers to maintain their commitments. In the context of monetary authorities, this means questioning the credibility of the Fed to achieve price stability. As a result, the degree of de-anchorage of inflation expectations may increase.

Fig. 8 compares the changes in degree of de-anchorage of inflation expectations with economic policy uncertainty. We use the log of the economic policy uncertainty index (Baker et al., 2016) lagged by one period as a proxy for policy uncertainty. This index is supposed to capture the uncertainty about the actions that policymakers are going to take and the consequences thereof. The correlation between the change in degree of de-anchorage and one-period-lagged policy uncertainty is 0.14 for the entire period. This finding suggests that rising economic policy uncertainty might increase the degree of de-anchorage of long-term inflation expectations.

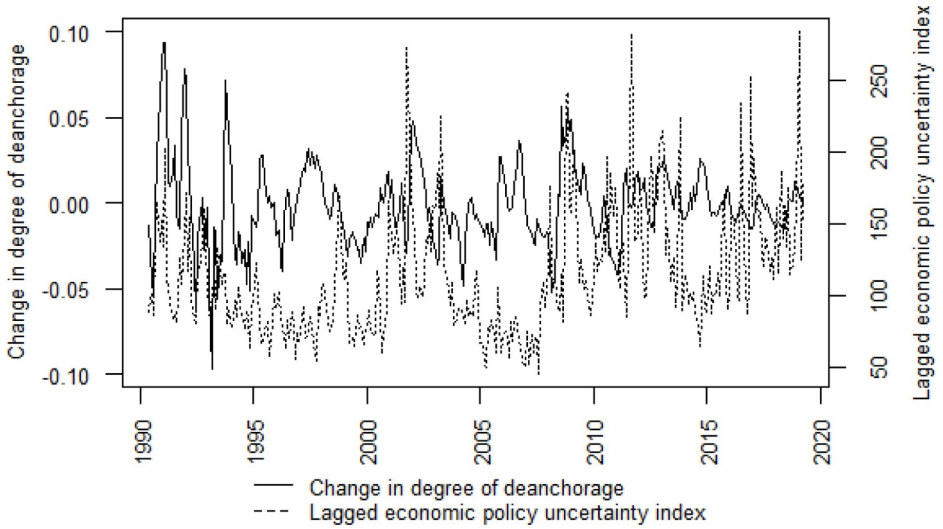

Fig. 8. Lagged economic policy uncertainty index (right axis) and percentage change in the degree of de-anchorage (left-axis) in the US, May 1990 to April 2019. *Notes:* Inflation perception, measured by YoY percentage change in FAFH inflation, is obtained from the Federal Reserve Bank of St. Louis database. Economic policy uncertainty index (lagged by one period) comes from (Baker et al., 2016).

4.2.3. Empirical model

In this section, our goal is to analyze the responsiveness of the change in degree of de-anchorage of households' long-term inflation expectations to changes in perception of inflation. In particular, we wish to investigate whether the changes in perception of inflation have a differential effect on the changes in degree of de-anchorage depending on its value, i.e., whether it is below, above, or around its long-term average value. To this end, we estimate the following regression equation:

$$\Delta\beta_t = \rho_0 + \rho_1\pi_{t,\,p} + \rho_2 D_t,^{low} + \rho_3 D_t,^{low}\,\pi_{t,\,p} + \rho_4 D_t,^{high} + \rho_5 D_t,^{high}\,\pi_{t,\,p} + \rho_6 PU_{t-1} + \varepsilon_t \quad \text{(v)}$$

where $\Delta\beta_t$ is the change in degree of de-anchorage parameter β_t (i.e., $\Delta\beta_t = \beta_t - \beta_{t-1}$), estimated in equation i. $\pi_{t,\,p}$ is the average year-on-year percentage change in perception of inflation at time t, measured by the percentage change in FAFH inflation, i.e., $[\frac{\text{FAFHindex}_t - \text{FAFHindex}_{t-12}}{\text{FAFHindex}_{t-12}}] \times 100$. We follow an approach similar to Ehrmann (2015) to examine the non-linear effects of inflation perception on the change in degree of de-anchorage. Accordingly, we divide inflation perception into three categories based on its long-term average value: (i) low inflation perception, (ii) high inflation perception, and (iii) around average inflation perception periods. The average inflation perception for the entire sample period is 2.7%. The low-inflation-perception category refers to the periods when inflation perception is less than 1 percentage point from its long-term average value (i.e., less than 1.7%). It is denoted by the dummy variable $D_t,^{\text{low}}$ and takes a value of 1 if inflation perception is low and zero otherwise. $D_b{}^{\text{low}}\pi_{t,\,p}$ is the interaction term between $D_b{}^{\text{low}}$ and $\pi_{t,\,p}$. By contrast, the high-inflation-perception category refers to the periods in which inflation perception is 1 percentage point higher than its long-term average value (i.e., more than 3.7%). It is denoted by the dummy variable $D_b{}^{\text{high}}$, which takes a value of 1 if inflation perception is high and zero otherwise. $D_b{}^{\text{high}}\pi_{t,\,p}$is the interaction term between $D_b{}^{\text{high}}$, and $\pi_{t,\,p}$. PU_{t-1} is policy uncertainty lagged by one period, which is measured by the log of the economic policy uncertainty index value of Baker et al. (2016).

Eq. (v) is also used to estimate the change in degree of de-anchorage when inflation perception is low or high persistently. We define inflation perception to be persistent if it stays low or high as per the above definition, for at least 12 consecutive months. As per this definition, the dummy variable $D_b{}^{\text{low}}$ ($D_b{}^{\text{high}}$) takes the value of 1 in Eq. (v) only if inflation perception is less (more) than 1 percentage point below (above) the long-run average value for at least 12 successive months.

In a model with only inflation perception as a regressor in Eq. (v), the coefficient of inflation perception (ρ_1) is expected to have a positive sign and be statistically significant, if the changes in degree of de-anchorage are influenced by the changes in inflation perception. On the other hand, an increase in inflation perception during a (persistently) low-inflation perception period is expected to decrease the change in degree of de-anchorage (contribute to re-anchoring), i.e., the sum of $\rho_{1+}\ \rho_3$ should be negative. By contrast, a rise in inflation perception during a (persistently) high-inflation perception period is expected to increase the change in degree of de-anchorage, i.e., the sum of $\rho_{1+}\ \rho_5$ should be positive.

4.2.4. Results

The regression results are reported in Table 2. Column 2.1 shows the responsiveness of the change in degree of de-anchorage to inflation perception only, for the whole sample period. As expected, the coefficient of inflation perception (ρ_1) has the correct sign (positive) and is statistically significant. A 1-percentage-point increase in inflation perception, on average, leads to an increase in

Table. 2
Determinants of degree of de-anchorage.

	Overall	Low/High Inflation	Low and High Inflation at least 12 months
	2.1	2.2	2.3
Inflation perception (ρ_1)	0.0102**	0.0105**	0.0119*
	(0.0041)	(0.0053)	(0.0066)
Low inflation perception (ρ_2)	–	0.0457	0.0681*
		(0.0315)	(0.0359)
Interaction inflation perception and low inflation perception (ρ_3)	–	−0.0412*	−0.0573**
		(0.0212)	(0.0265)
High inflation perception (ρ_4)	–	−0.0537	−0.2443***
		(0.1331)	(0.0598)
Interaction inflation perception and high inflation perception (ρ_5)	–	0.0098	0.0527***
		(0.0305)	(0.0143)
Lagged Policy Uncertainty (ρ_6)	–	0.0098*	0.0084*
		(0.0055)	(0.0051)
	−0.0291***	−0.0735**	−0.0717**
Constant (ρ_0)	(0.0105)	(0.0330)	(0.0328)
Observations	348	348	348
R^2	0.10	0.17	0.19

Notes: The table shows the estimation results for Eq. (v). The dependent variable is the change in the degree of de-anchorage parameter $\Delta\beta t$ estimated from Eq. (i). ***, **, and * denote significance at 1%, 5%, and 10% levels, respectively.
Newey-West standard errors are in parentheses.

degree of de-anchorage by 0.010 percentage points.[11]

The regression results for Eq. (v) are reported in Column 2.2 of Table 2. This non-linear specification of degree of de-anchorage improves R^2 from 0.10 to 0.17. Further, as expected, the effect of an increase inflation perception on the change in degree of de-anchorage is different depending on whether inflation perception is low, high, or near average. This is the case because the coefficient of the interaction term between inflation perception and low inflation perception (ρ_3) is negative and significant at the 10-percent level (see column 2.2 of Table 2). This implies that a 1-percentage-point increase in inflation perception during a period of low inflation perception decreases the change in degree of de-anchorage by 0.031 (i.e., $\rho_1 + \rho_3$) percentage points. However, if low inflation perception becomes persistent, i.e., if inflation perception remains low for at least 12 successive months, it reduces the change in degree of de-anchorage by 0.045 percentage points (see column 2.3 of Table 2). On the contrary, there is little evidence that the change in degree of de-anchorage is different when inflation perception is high, as the coefficient of ρ_5 is insignificant (see column 2.2). However, if inflation perception is persistently high, an increase in inflation perception of 1 percentage point, on average, increases the degree of de-anchorage by 0.065 (i.e., $\rho_1 + \rho_5$) percentage points (see column 2.3 of Table 2).[12]

This suggests that the relationship between inflation perceptions and the change in degree of de-anchorage is U-shaped if inflation perceptions are low and high persistently. To summarize, when inflation perceptions remain weak for a long time, an increase in inflation perception decreases the degree of de-anchorage by 0.045 percentage points, i.e., the degree of re-anchorage increases. At near-average inflation perception, it raises the degree of de-anchorage by only 0.012 percentage points (i.e., the change in degree of de-anchorage obtains its lowest value or the degree of de-anchorage is stable). By contrast, when inflation perception rises above its long-term average and becomes persistent for a long time, an increase in inflation perception raises the change in degree of de-anchorage by 0.065 percentage points, i.e., the degree of de-anchorage increases.[13]

As per our expectation, changes in policy uncertainty also affect the change in degree of de-anchorage significantly. The coefficient of lagged policy uncertainty has a positive sign, but it is statistically significant only at the 10% level, and its coefficients are small in magnitude. Its value ranges between 0.008 and 0.01 (see columns 2.2 and 2.3 of Table 2).

4.2.5. Discussion

The response of the change in degree of de-anchorage of inflation expectations to perceptions of inflation is consistent with the frequency bias hypothesis, i.e., the public pays more attention to the changes in prices of frequently purchased items such as FAFH.

[11] We also regress the degree of de-anchorage on some other frequently purchased goods and services in the place of FAFH inflation to see if they serve as measures of perception of inflation. Although their coefficients have positive signs, none of them are statistically significant except for the rent of primary residence inflation (see columns 2 to 7 of Table A2 in Online Appendix). However, it also becomes insignificant when FAFH inflation is included in the equation (see column 8 in of Table A2 in Online Appendix). This suggests that FAFH inflation plays a more important role than rent of primary residence inflation.

[12] An increase in inflation perception during a (persistently) low-inflation period reduces the degree of de-anchorage because inflation perception moves closer to its long-term average, whereas during a (persistently) high-inflation period, it increases the degree of de-anchorage as inflation perception moves further from its long-term average.

[13] Banerjee and Mehrotra (2018) have reported a similar relationship in the context of anchoring of inflation expectations. They find a U-shaped relationship between actual inflation and forecast disagreement, i.e., the forecast disagreement rises with the absolute levels of both inflation and deflation outcomes.

The public may pay more attention to perceptions of inflation due to households being less informed about the inflation target and actual current inflation. In the Michigan Surveys of Consumers (MSC) survey items on inflation expectations, respondents are required to give a numerical figure for inflation expectations, or else they have to respond that they "do not know." It was found that on average, 12% of the respondents revealed that they did not know what the future inflation would be, and 73% of the consumers revised their long-term inflation expectations. Moreover, only 16% of the respondents reported the long-term inflation forecast to be exactly 2%, whereas 57% of the respondents reported this to be 1%, 2%, or 3% between January 2012 and July 2016 (Binder, 2017). This finding implies that the Fed's announcement of a target rate of inflation has not reached many consumers and consequently, members of the public have formed inflation expectations based on their perceptions of inflation. This is consistent with our findings of the linkage between perceptions of inflation and de-anchorage of households' long-term inflation expectations.

Further, the change in degree of de-anchorage of inflation expectations to economic policy uncertainty is consistent with the hypothesis that households doubt the ability and willingness of policymakers to deliver on their promises. This suggests that decision makers should communicate their intended responses to various exogenous shocks very clearly. A quick and clear response to these shocks may help reduce policy uncertainty (Istrefi and Piloiu, 2014).

5. Conclusion

In this paper, we find that households' long-term inflation expectations in the US do not appear well anchored; rather, they respond to short-term inflation expectations. The results are based on a time-varying parameter model.

Our estimates indicate that the responsiveness of long-term inflation expectations to short-term inflation expectations (i.e., the degree of de-anchorage) varied between 1.72 and 0.44 during the study period. The de-anchorage was greater in the first half of the 1990s. Subsequently, it declined, but it has not yet anchored. The average degree of de-anchorage was 0.92 during the study period. Our findings are in line with the findings of Kumar et al. (2015).

We also find that the change in degree of de-anchorage of long-term inflation expectations can be explained by two channels. The first channel is the inflation perceptions channel, which may find its explanation in the frequency bias hypothesis. According to this channel, a 1-percentage-point increase in perceptions of inflation, on average, leads to a decrease in degree of de-anchorage by 0.045 percentage points during persistently low-inflation-perception periods. On the other hand, it causes a rise in the degree of de-anchorage by 0.012 and 0.065 percentage points, when inflation perceptions are near-average and persistently high, respectively. The second channel which is found to be significant in our model is the economic policy uncertainty channel. We find that an increase in economic policy uncertainty leads to a rise in the degree of de-anchorage. On comparison, it is found that the inflation perceptions channel has higher economic significance than the economic policy uncertainty channel. The impact of the economic policy uncertainty channel seems to be small, and hence, may require further investigation.

Our findings have important policy implications for the monetary authorities that seek price stability, in line with Dräger (2015), who argued that "if central banks want to anchor inflation expectations, they should pay attention to household's inflation perceptions" (Dräger, 2015, p. 698). They may expect the degree of de-anchorage to behave differently now than was the case before the crisis, when inflation perception was close to its long-run average. In the context of the discussion on macroeconomic illiteracy (Blanchflower and Kelly, 2008; Kumar et al., 2015), our results emphasize the importance of effective strategy for communicating to households about actual inflation. This is important when a central bank is seeking to affect inflation expectations through forward guidance. Further, policymakers should communicate their intended response to various exogenous shocks clearly. A quick and clear response to these shocks may help reduce policy uncertainty. Finally, it would be interesting to see whether perceptions of inflation affect actual inflation – a prospect that we leave for future research.

CRediT authorship contribution statement

Pradyumna Dash: Conceptualization, Methodology, Writing - original draft, Supervision, Formal analysis. **Abhishek Kumar Rohit:** Methodology, Software, Writing - review & editing, Visualization, Formal analysis. **Adviti Devaguptapu:** Validation, Writing - review & editing.

Declaration of Competing Interest

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.jmacro.2019.103183.

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