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Inflation, Inflation Expectations, and the Phillips Curve

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Abstract

This paper studies the current state of inflation dynamics through the lens of the Phillips curve and assesses the degree of anchoring of inflation expectations. I first estimate a Phillips curve model with both past inflation and a constant anchor as explanatory variables over the 1999–2018 period for a variety of measures of consumer prices. My results show that the Phillips curve has shifted away from an accelerationist form toward a level form, but that shift is incomplete, particularly for core inflation. I then turn to survey measures of professional forecasters' and consumers' inflation expectations and assess the degree to which those expectations are anchored. My analysis shows that although professional forecasters' expectations have been well anchored, consumers' expectations have not. Further analysis using multiple empirical measures of inflation expectations suggests that in the context of the Phillips curve, consumers' expectations have generally outperformed professional forecasters' expectations in terms of explaining and forecasting the dynamics of inflation over the past two decades.

In addition to analyzing the form of inflation expectations in the Phillips curve model, this paper examines the slope of the Phillips curve, or the sensitivity of inflation to cyclical fluctuations in economic conditions. I follow Stock and Watson (2018) and estimate the Phillips curve for various components of aggregate inflation. The results show that whereas price changes for many service categories (particularly shelter) and food remain largely procyclical, price changes for most goods have been either noncyclical or countercyclical over the past two decades. That finding helps explain the flatness of the Phillips curve on the aggregate level as well as the variation in cyclical sensitivity among the different aggregate inflation measures.

Keywords: inflation, Phillips curve, business cycle, inflation expectations, anchoring

JEL Classification: E17, E31, E37

Contents

1. Introduction

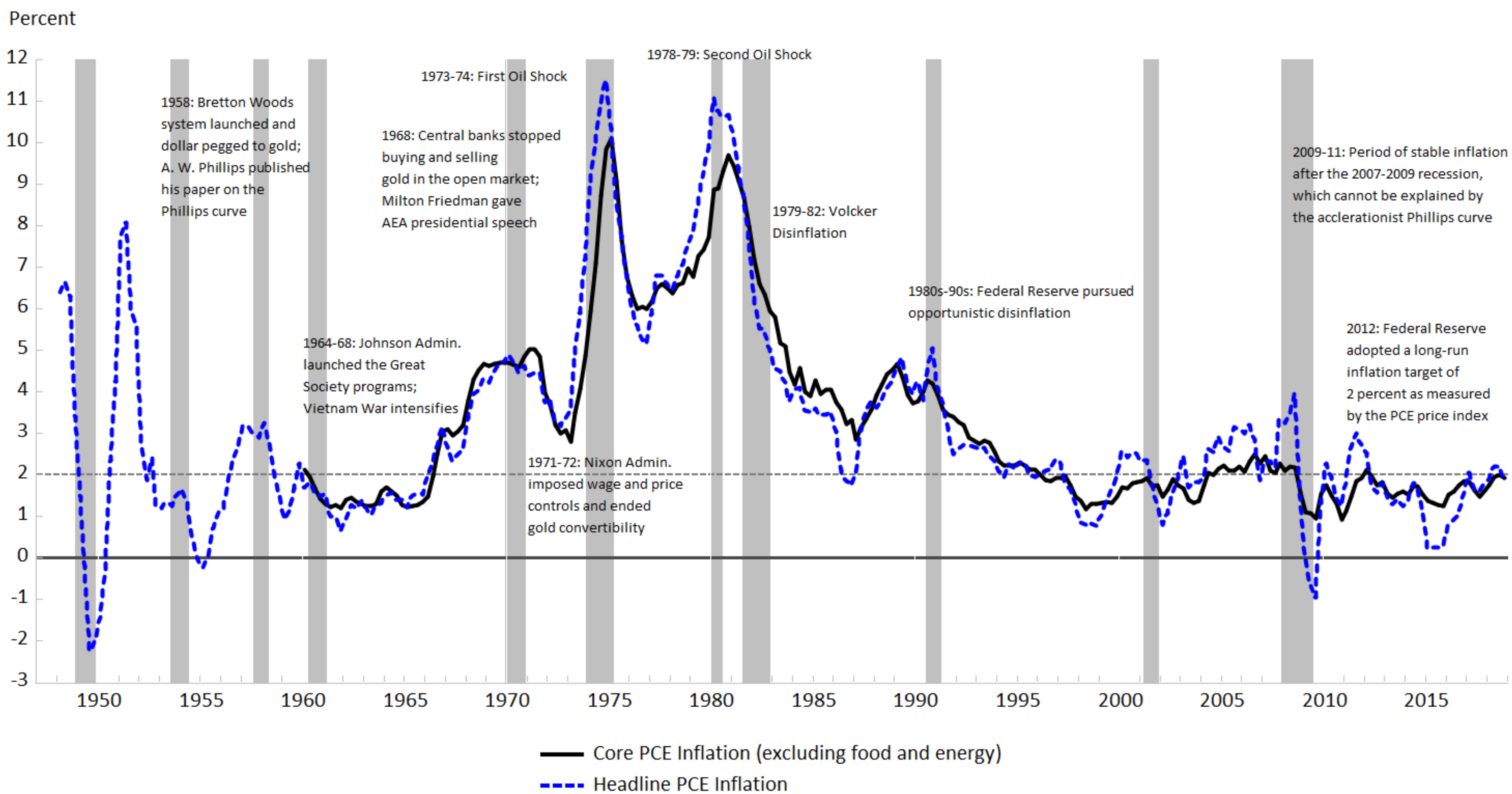
From the “great inflation” of the 1970s to the “missing disinflation” of 2009 to 2011, the dynamics of inflation in the United States has changed profoundly over the past six decades (see Figure 1). To a large extent, that evolution is both a cause and a consequence of the changing nature of inflation expectations over the same period (see Figure 2). This paper examines the current state of inflation through the lens of the reduced-form Phillips curve—a regression model that links the dynamics of inflation to inflation expectations and the state of the real economy—and assesses the current properties of inflation expectations.

The degree of stability in inflation depends critically on the properties of inflation expectations, particularly, whether they are anchored or not. Because unanchored expectations tend to correlate heavily with past inflation (a phenomenon known as backward-looking or adaptive inflation expectations), they can serve as an “accelerator” for the effects of excess or shortfall in demand in the labor and product markets and for the effects of transitory shocks from the supply side of the economy—such as a sudden rise in the price of oil or a sudden change in the exchange value of the U.S. dollar—by forming a feedback loop between inflation expectations and actual inflation. As a result, inflation tends to rise or fall persistently when expectations are unanchored and the economy is in disequilibrium. By contrast, perfectly anchored inflation expectations do not respond to transitory shocks (that is, they are “shock anchored”) and can be tied to a particular level specified by a central bank that sets a target for inflation (a process known as level anchoring; see Ball and Mazumder, 2011). As a result, inflation tends to stay relatively stable when expectations are anchored.

Inflation dynamics in the United States from the late 1960s through the mid-1990s are considered to be generally consistent with the characteristics of an “accelerationist” regime. Trend inflation, as measured by the five-year average rate of annual growth in the personal consumption price (PCE) price index, rose persistently from less than 2 percent in mid-1960s to over 8 percent in the late 1970s and early 1980s before falling gradually back to around 2 percent by the mid-1990s. Over the same period, empirical measures of inflation expectations also rose and fell persistently, generally tracking actual inflation but with a considerable lag. To model the inflation dynamics during that period, economists have used an “accelerationist” Phillips curve model in which inflation expectations are modeled by distributed lags of past inflation with the coefficients summing up to 1 (or close to 1).

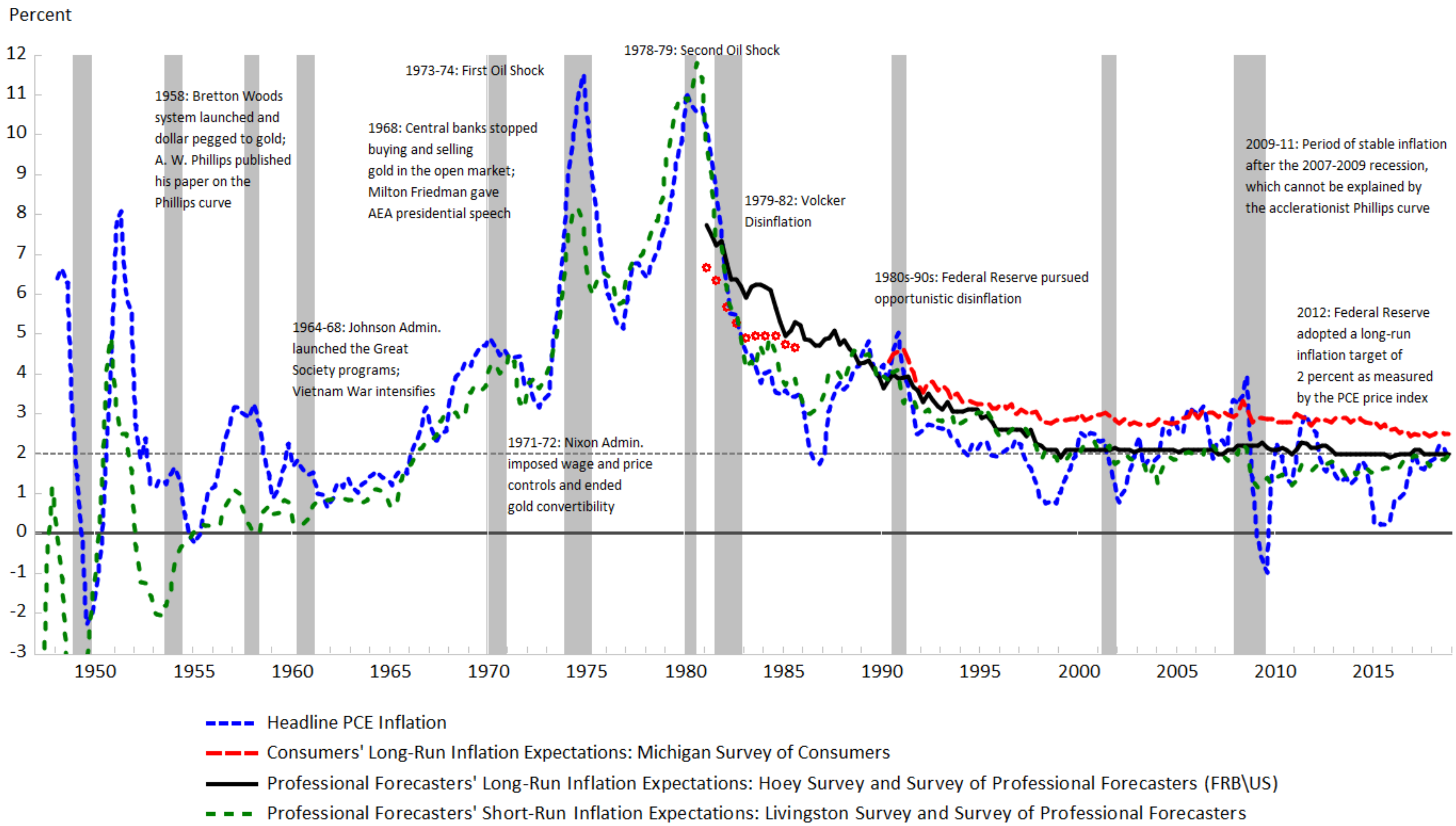
Since the late 1990s, by contrast, inflation dynamics appear to have shifted away from the accelerationist regime, and both inflation and inflation expectations have stayed remarkably stable despite large economic fluctuations (see Figure 3). In particular, following the financial crisis and the recession of 2007–2009, a large unemployment gap opened up that took several years to close. (The unemployment rate rose from 4.5 percent in mid-2007 to nearly 10 percent by late 2009 and stayed above 5 percent until 2016.) The accelerationist Phillips curve

Figure 1: U.S. Inflation



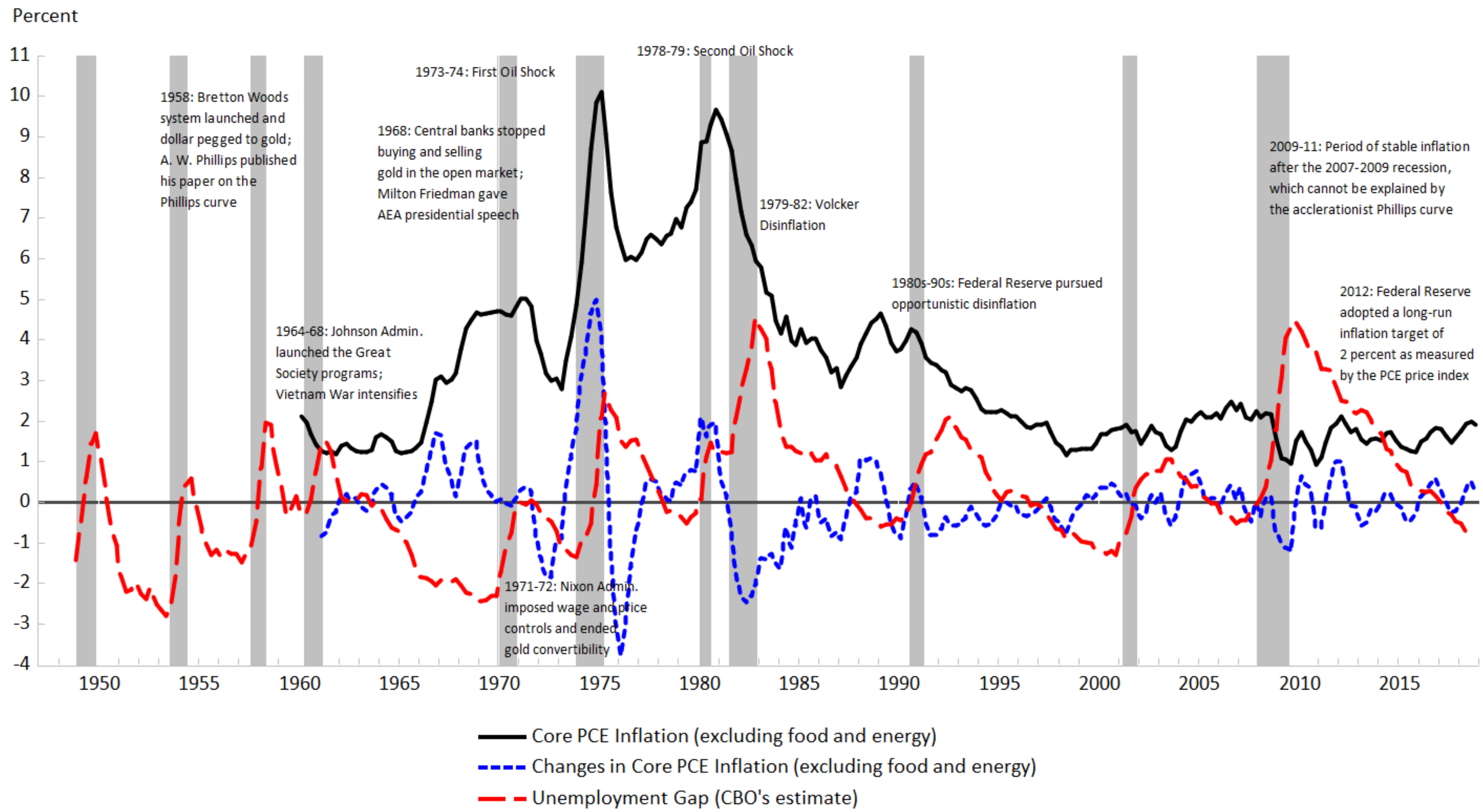
Source: Bureau of Economic Analysis.

Figure 2: Inflation and Inflation Expectations



The extended series of professional forecasters' long-run inflation expectations was taken from the FRB/US model created by the Federal Reserve Board. The FRB/US series is based on data from two surveys: the long-run inflation expectations reported in the Hoey survey of financial market participants from 1981 to 1991Q3 and the median forecasts of long-run CPI or PCE inflation reported in the Survey of Professional Forecasters from 1991Q4 onward, with a downward adjustment of 40 basis points made to the CPI forecasts (all pre-2007 data) to put them on a PCE basis. The extended series of professional forecasters' short-run inflation expectations is based on one-year ahead CPI inflation expectations reported in the Livingston Survey from 1947 to 1981Q2 and in the Survey of Professional Forecasters from 1981Q3 onward. Data from the Livingston survey were adjusted by Haver Analytics and interpolated to put semiannual data on a quarterly basis. The entire series was also adjusted downward to put the CPI expectations on a PCE basis.

Figure 3: Inflation and Unemployment



Sources: Bureau of Economic Analysis; Congressional Budget Office.

predicted that inflation and inflation expectations would fall deeply into the deflation zone in response to the persistent shortfall in aggregate demand, but instead, inflation and empirical measures of inflation expectations—including surveys of professional forecasters and of consumers—stayed stable, ranging mostly between 1 percent and 3 percent per year.

The missing-disinflation (or "missing-deflation") episode that followed the recession of 2007–2009 has led many economists to question whether the Phillips curve has shifted back toward a "level" form in which the level of inflation—not the change in inflation, as in the case of the accelerationist Phillips curve—depends on the amount of slack in the labor market. For example, Blanchard (2016) estimates a Phillips curve in which inflation expectations are modeled as a combination of past inflation and a constant. He estimates the equation for the headline consumer price index (CPI) and allows the coefficients to vary over time. His results show that the weight of past inflation relative to the constant in determining actual inflation and long-run inflation expectations has declined considerably. In addition, Ball and Mazumder (2019) estimate a simple Phillips curve for the *median* CPI with perfectly anchored inflation expectations.[1] They show that the estimated equation can explain the pattern of inflation in the United States since 2000.

Despite the early support for a level Phillips curve, many questions remain. One is whether the level model can explain patterns for different measures of inflation, including both overall and core inflation. That question arises in part because, as Fuhrer (2011) points out, the evidence of a decline in the persistence of inflation—a phenomenon that is not equivalent but closely related to the decline in the weight of past inflation in the Phillips curve—has been much weaker when core inflation measures are considered than it has been when only headline measures are examined. Moreover, recent studies on inflation at the component level show that the cyclical sensitivity of inflation varies considerably across different types of goods and services and that some of those differences stem from measurement issues (Stock and Watson, 2018). As a result, aggregate inflation measures with different compositions of components may exhibit different patterns, which should be taken into account when assessing the overall state of aggregate inflation.

To answer that question, I estimate a Phillips curve in which inflation expectations are modeled as a combination of past inflation and a constant anchor over the 1999–2018 period for 10 different measures of consumer price inflation. In particular, I use three measures of overall inflation, including the headline and the chained CPI published by the Bureau of Labor Statistics (BLS) and the headline PCE price index published by the Bureau of Economic Analysis (BEA). I

[1] The median CPI, published monthly by the Federal Reserve Bank of Cleveland, is a measure of core inflation. Instead of calculating a weighted average of the prices of all the CPI components, as the conventional inflation measures do, the median CPI tracks the median price change—or the price change that is in the middle of the distribution of all the price changes for CPI components.

also include seven measures of core inflation: the official CPI excluding food and energy (XFE) published by the BLS, the XFE PCE price published by the BEA, the median and the 16 percent trimmed-mean CPI published by the Federal Reserve Bank of Cleveland, the sticky overall and the sticky XFE CPI published by the Federal Reserve Bank of Atlanta, and the trimmed-mean PCE price index published by the Federal Reserve Bank of Dallas.

My results show that the reduced-form Phillips curve has indeed shifted away from an accelerationist form toward a level form, but that shift is incomplete and the extent to which it has occurred varies across different inflation measures. In particular, I find that the weight of past inflation, labeled as $(1-\alpha)$ in the model, is well below 1.0 for all measures of inflation and fairly small (about 0.2) for overall inflation, which is consistent with Blanchard's (2016) finding for the headline CPI. However, my results also show that the weight of past inflation is far above zero (about 0.5) for most measures of core inflation, including the median CPI used by Ball and Mazumder (2011). Using a simple experiment with the unemployment gap from 2007 to 2018, I show that although the quantitative difference in the implied inflation paths between a perfectly level Phillips curve (like the one assumed by Ball and Mazumder, 2011) and one with $\alpha = 0.5$ is fairly small when the slope of the Phillips curve is flat, that difference becomes materially larger when the slope of the Phillips curve is steeper. That is not surprising because the partial dependence of current inflation on past inflation—whether it arises through incompletely anchored inflation expectations or other mechanisms—will not only extend the effects of shocks but also compound and amplify them, and the extent of that amplification depends on the sensitivity of inflation to the shocks.

Turning to the sensitivity of inflation to slack (that is, the slope of the Phillips curve), I find that, on average, CPI inflation is more procyclical than PCE inflation. To explain that result, I follow Stock and Watson (2018) and estimate the Phillips curve at the component level. That analysis shows that although price changes for many service categories (particularly shelter) and food remain largely procyclical, price changes for most goods have been either noncyclical or countercyclical over the past two decades. That finding helps explain the flatness of the Phillips curve on the aggregate level as well as the variation in cyclical sensitivity across different aggregate inflation measures.

The next question concerns the state of inflation expectations that underlie the current Phillips curve, which has shifted, though incompletely, to a level form. (Because previous analysis is in a reduced form, the estimated weights of past inflation and the constant in the Phillips curve cannot be used to infer the degree of anchoring—or lack thereof—of inflation expectations.) Are inflation expectations well anchored in a way that directly reflects the central bank's credibility in achieving its inflation goals, or does their stability in recent decades merely reflect the stability of past inflation and the long lag before expectations are adjusted that results from a combination of inattention, lack of information, and irrationality? The distinction has important implications for monetary policy. In recent years, officials from the Federal Reserves have often cited well-anchored inflation expectations as one of the main reasons for stable inflation and as a principal asset of the central bank in conducting its monetary policy. Such remarks, however, have most often referred to *professional forecasters'* expectations. Meanwhile, studies using household survey have shown that *consumers'* expectations may not have been well anchored despite their improved stability (see Coibion, Gorodnichenko, and Kamdar, 2018, for example).

To better understand the nature and degree of anchoring in inflation expectations, I turn to empirical measures of inflation expectations. In that exercise, I follow Ball and Mazumder (2011) and examine two distinct aspects of anchoring—shock anchoring and level anchoring—separately. In addition, I focus on the differences between professional forecasters' expectations, as reported in the Survey of Professional Forecasters (SPF), and consumers' (households') expectations, as reported in the University of Michigan Survey of Consumers (MSC).

My analysis suggests that both short-run and long-run expectations reported by professional forecasters were well anchored over the 1999–2018 period but that those reported by consumers were much less so. Specifically, the long-run inflation expectations reported by consumers in the MSC were shock anchored but not level anchored, and the short-run MSC expectations were neither shock anchored nor level anchored.

Furthermore, the varying degrees to which the inflation expectations reported by professional forecasters and consumers are anchored raises the following question: Whose inflation expectations matter for inflation dynamics in the Phillips curve framework? A previous study by Coibion, Gorodnichenko, and Kamdar (2018) shows that consumers' inflation expectations play a special role in determining the headline CPI inflation under the Phillips curve framework, but again, the authors have only examined the issue for headline CPI. Instead, I run regressions for all 10 measures of inflation using both SPF and MSC data on inflation expectations for the 1999–2018 period. Estimation results show that consumers' inflation expectations have generally outperformed professional forecasters' expectations in terms of in-sample fitness and out-of-sample forecasting performance across a variety of inflation measures under the Phillips curve framework.

The rest of the paper is organized as follows. In Section 2, I provide a brief overview of the 10 measures of consumer price inflation, focusing on the differences in their component makeup. In Section 3, I first estimate the aggregate Phillips curve using 10 inflation measures and compare the relative weight of past inflation and the constant. I show that the weight on past inflation is larger for core measures than for headline measures. I then conduct a component analysis to explain the variation in cyclical sensitivity across different aggregate measures. In Section 4, I turn to empirical measures of inflation expectations and examine the degree of shock anchoring and level anchoring of the inflation expectations of professional forecasters and consumers. I then ask whose expectations matter more through the lens of the Phillips curve. I offer some concluding remarks in Section 5.

2. Ten Measures of Inflation

There are many measures of general inflation in the economy. The choice of measure could affect the estimation results of the Phillips curve and our understanding of the underlying inflation dynamics. In this section, I provide a brief review—focusing on the compositional differences—of 10 measures of consumer price inflation that are published regularly by statistical agencies and regional Federal Reserve banks.

Overall Inflation

The two most commonly used measures of the overall consumer price inflation are the headline CPI published by the BLS and the headline PCE price index published by the BEA. There are many well-known conceptual and measurement differences between the two indexes, including the types and relative weights of goods and services included in the indexes, the formula used to aggregate detailed price information into upper-level indexes, and the methods used for seasonal adjustment and revisions.

Table 1: Weights of Major Sectors in CPI and PCEPI
(Percent)

Major Sectors	CPI	PCEPI
Housing	41.8	18.5
Health Care	8.6	21.2
Food and Beverages	14.2	14.0
Transportation	15.3	9.2
Recreation	5.7	8.7
Education and Communication	6.6	4.3
Apparel	3.1	3.0
Financial Services	0.2	8.0
Other	4.5	13.2
Total	**100**	**100**

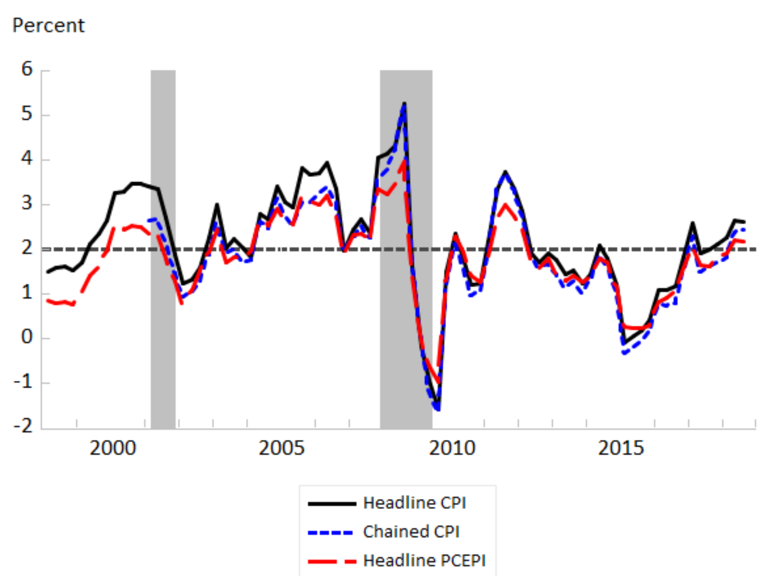
Source: Author's calculations using data from the Bureau of Labor Statistics and the Bureau of Economic Analysis. Weights for the CPI are annual averages for 2018, and those for the PCEPI are annual averages for 2017.

Many of those differences arise from the fact that the two indexes are intended to serve different purposes. The CPI is designed to track households' out-of-pocket expenses to form a basis for cost-of-living adjustments, whereas the PCE price index is designed to be the deflator for all consumption expenditures regardless of who pays for them. As a result, health care, financial services, and many other types of services that tend to be paid for by third-party payers or offered to consumers for free have larger weights in the PCE price index than they do in the CPI (see Table 1). Conversely, shelter accounts for a much larger share in the CPI than it does in the

PCE price index. On average, the headline CPI grew about 0.4 percentage points faster than the headline PCE index each year over the 1999–2018 period (see Figure 4).

A third measure of overall inflation, the chained CPI, is constructed using the same detailed price information as the conventional CPI but an aggregation formula that is similar to the formula used to construct the PCE price index. Thus, it covers the same scope of the goods and services covered under the standard CPI, but it better accounts for households' tendency to substitute similar goods and services for one another when relative prices change (the "substitution bias"). Moreover, unlike the standard CPI, it is relatively unaffected by the statistical bias related to the sample sizes that the BLS uses to compute each index (the "small-sample bias"). Historically, the chained CPI has tended to grow faster than the headline PCE price index but by a much smaller margin than the headline CPI does; it grew less than 0.1 percentage point faster than the PCE price index each year during the 1999–2018 period.

Figure 4: Three Measures of Overall Inflation



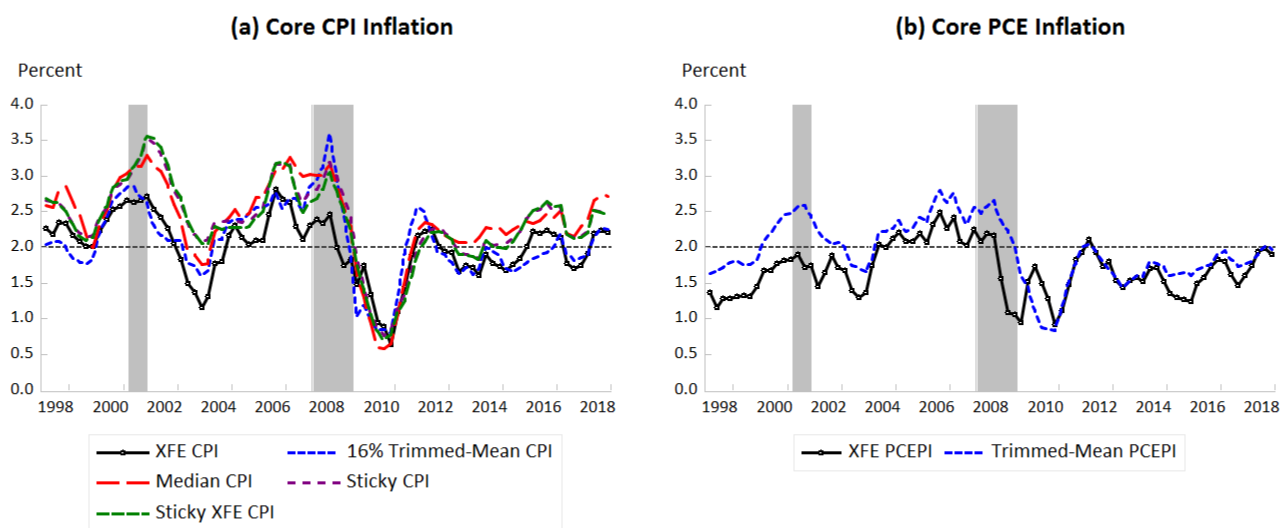
Sources: Bureau of Labor Statistics; Bureau of Economic Analysis.

Core Inflation

Although overall inflation matters for consumer welfare, it contains a lot of statistical noise resulting from idiosyncratic and temporary forces that do not reflect developments in the overall economy or persistent movements in the trend of inflation. To remove the noise and reveal the underlying trend, economists have developed various measures of "core" inflation.

There are several approaches to construct a core measure of inflation. One approach is to remove the most volatile price changes from the aggregate price measure in each period. That approach includes the most popular excluding-food-and-energy measures for the CPI and the PCE price index as well as the trimmed-mean and the median price indexes. A second approach is to remove price changes that tend to occur more frequently (and therefore tend to generate a lot of noise). An example of that approach is the sticky CPI. In this paper, I examine seven measures of core inflation, including five measures of core CPI (the XFE CPI, median CPI, trimmed-mean CPI, sticky CPI, and sticky XFE CPI) and two measures of the core PCE price index (XFE PCE and trimmed-mean PCE; see Figure 5).[2]

Figure 5: Seven Measures of Core Inflation



Sources: Bureau of Labor Statistics; Bureau of Economic Analysis; Federal Reserve Bank of Cleveland; Federal Reserve Bank of Atlanta; Federal Reserve Bank of Dallas.

Excluding Food and Energy. The rationale for excluding food and energy prices to gauge trend inflation is four-fold. First, food and energy prices have historically been more volatile than other prices. Second, domestic food and energy prices are heavily influenced by agricultural and energy commodity prices, which are determined in the global market. Third, fluctuations in food and energy prices tend to reflect noneconomic factors—weather and diseases in the case of food, and technological changes and geopolitical developments in the case of energy. Lastly, although

[2] There are many more approaches to construct core measures of inflation, including persistence and variance weighting, component and exponential smoothing, and dynamic factors (see Rich and Steindel, 2007, and Detmeister, 2011, for example). I did not include those measures in this analysis because they are not published officially on a regular basis.

food and energy price changes can have a substantial impact on the overall price level, they tend to be transitory and often reverse quickly, thus they do not require a monetary policy response.[3]

Compared with the other measures of core inflation that are discussed below, XFE price indexes have the advantage of being convenient, transparent, and easy to interpret. Every month, XFE indexes track the price changes of a fixed set of goods and services, thereby providing a consistent measure of inflation over time. However, the flip side is that XFE indexes are also subject to a substantial number of idiosyncratic price shocks of various amounts to nonfood, non-energy items, and they therefore do not sufficiently separate the signal from the noise. In addition, XFE inflation may offer a biased view of trend inflation if there are long-run movements in the price of food and energy relative to other goods and services.

Trimmed-Mean Price Indexes. Trimmed-mean indexes eliminate any individual component if the change in its price is above or below a certain threshold, regardless of what the component is. In theory, one can trim more or less aggressively and come up with a different reading of trend inflation. In practice, what the threshold should be is often unclear and depends on the specific price measure. For example, the Federal Reserve Bank of Cleveland publishes a 16 percent trimmed-mean CPI (developed by Bryan and Pike, 1991, and Bryan and Cecchetti, 1994), which removes the highest 8 percent and the lowest 8 percent of price changes from the CPI each month. By contrast, the Federal Reserve Bank of Dallas produces a trimmed-mean PCE price index (developed by Dolmas, 2005) for which it chooses the optimal trim points each month to minimize the average monthly discrepancy between the trimmed-mean inflation rate and a proxy for the true trend inflation in the past.[4] Historically, that method has resulted in more aggressive trimming: For December 2017, for example, 24.7 percent was excluded from the lower tail of the distribution of monthly price changes in the PCE price index, and 26.5 percent was excluded from the upper tail to construct the trimmed-mean PCE price index. That said, studies have shown that a wide variety of trims have performed similarly statistically (see Meyer and Venkatu, 2014).

The main issue surrounding trimmed-mean indexes is that they simply remove the largest and smallest price changes without any regard for the nature of those price changes. Although some extreme price changes do indeed represent idiosyncratic and transitory disturbances, not all of them do. Removing price changes on the basis of size alone could, therefore, lead to losing a valuable signal about the underlying movement in trend inflation.

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[3] Today, the case for removing food prices is much weaker than it has been in the past, particularly for food services (food away from home in the CPI and food consumed off premises in the PCE), which are not especially volatile or subject to volatility in agricultural commodity prices in the global market. In fact, the BEA includes food consumed off premises in its core (XFE) PCE measure; the BLS continues to exclude food away from home from the core (XFE) CPI.

[4] The proxy for trend inflation used to select the trim points is usually a centered moving average of inflation.

Another potential problem of using trimmed-mean indexes arises when one of the components in the aggregate measure of inflation has a large weight. For example, the owners' equivalent rent (OER) component accounts for about 24 percent of the total CPI. OER's influence can grow disproportionately large as the proportion of extreme changes trimmed from the data increases.[5]

Median Price Indexes. The median price change in each month is a natural candidate for excluding noise from outliers. The Federal Reserve Bank of Cleveland produces the median CPI along with its 16 percent trimmed-mean CPI. In fact, the median CPI is a special case of trimmed-mean measure because it is produced by removing almost all of the price changes from the lower tail and almost all the changes from the upper tail. Ball and Mazumder (2011) drew attention to the median CPI price index by arguing that using it as the measure of core inflation could explain the so-called missing disinflation of 2009–2011.

The large weight of OER in the CPI poses a major issue for the median CPI measure. As Bryan (2007) calculated, OER was the median component of the CPI in 52 percent of the months between January 1998 and July 2007, and the rent of primary residence (the other major rent index, which is highly correlated with the OER) was the median component in 5 percent of those months. (Food away from home and recreation together accounted for 18 percent of the monthly median components over that period.) Since 2012, however, the influence of housing costs on the median CPI has been weaker. A regression of monthly median CPI inflation on monthly OER inflation and a constant over the 2013–2017 period yields an adjusted R^2 of 0.17; over the 1998–2007 period, the adjusted R^2 was 0.41.

Sticky Price Indexes. An alternative approach to categorizing price changes is to look at how frequently they occur. Frequent price changes indicate that prices are responding quickly to changes in the conditions of the economy, but they also tend to be noisy. Infrequent price changes, by contrast, imply that when prices are set, they reflect more information about expectations for the future. The degree of "stickiness" in price setting may therefore have important implications for the Phillips curve model.

It has been well documented that considerable heterogeneity exists in the frequency of price changes across different categories of goods and services. Bils and Klenow (2004), for example, found that the average frequency of price change is 4.3 months with huge variations across types of goods and services. For example, whereas prices for motor fuel change about every other day,

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[5] To reduce the influence of OER on its trimmed-mean and median CPI measures, the Federal Reserve Bank of Cleveland breaks OER into four subcomponents by geographical region (Northeast, Midwest, South, and West). That method reduces the proportion of times that the OER component is the median component from 64 percent to 52 percent. For details, see Federal Reserve Bank of Cleveland, "Methodological Adjustments to the Median and 16 Percent Trimmed-Mean CPI Estimators" (July 2007), https://bit.ly/2FqHcWn (PDF, 143 KB).

prices for new vehicles change about every other month, and prices for personal care services change every other year, on average.

Because of the variation in the frequency of price changes, the Federal Reserve Bank of Atlanta constructs a sticky-price CPI, which includes categories of goods and services whose prices change *less* frequently than the average frequency of 4.3 months, and a flexible-price CPI, which includes categories of goods and services whose prices change *more* frequently than the average. The sticky-price CPI includes many service-based categories, including medical services, education, personal care services, and residential housing services (a category comprising OER and rent of primary residence).[6] By contrast, food and energy goods constitute about half of the flexible-price CPI; the remainder is made up of apparel, autos, and lodging away from home. Overall, the sticky-price index includes about 70 percent of all CPI items, whereas the XFE CPI contains about 77 percent of those items, on average.

Table 2: Summary Statistics and Categorization of Major Components of the CPI

Major CPI Components	Summary Statistics			Categorization	
	Mean (percent)	Standard Deviation (percent)	Relative Importance (2017Q4)	Sticky CPI	Probability (= Median CPI) (1998-2007)
Core (XFE) Services					
Owners' Equivalent Rent	2.7	1.1	23.2%	Y	52%
Rent of Primary Residence	3.2	1.1	7.9%	Y	5%
Medical Care Services	3.8	1.3	6.7%	Y	2%
Education Services	4.9	1.5	3.0%	Y	0%
Transportation Services	2.7	1.8	6.0%	Y	5%
XFE Goods					
Apparel	-0.3	2.5	3.1%	N	2%
New Vehicles	0.1	2.3	3.6%	N	3%
Used Cars and Trucks	-0.3	8	2.1%	N	0%
Medical Care Goods	2.9	1.6	1.8%	Y	1%
Food and Energy					
Food Away From Home	2.8	0.9	5.9%	Y	11%
Food at Home	2.1	2.7	7.7%	N	6%
Energy	3.6	20.2	7.5%	N	1%

Sources: Bureau of Labor Statistics; Federal Reserve Bank of Cleveland; Federal Reserve Bank of Atlanta.

[6] The rents that the BLS uses to construct the CPI rent indexes are computed over six-month horizons, making the prices sticky by construction.

There is some overlap in the makeup of the various core measures, but there are also important differences. For example, shelter is included in both the XFE and the sticky CPI, and it is highly likely to be included in the trimmed-mean and to be the median component of the CPI in any given month. Most, if not all, of the XFE services are included in the sticky CPI. By contrast, all the food and energy categories except for food away from home are excluded from the sticky CPI. XFE goods seem to be evenly split: The nondurables tend to be flexible, and the durables tend to be sticky. The categorization of the major components of CPI under the different core measures is shown in Table 2 along with summary statistics, including each component's mean rate of change, volatility, and relative importance in the aggregate index. The differences at the component level have important implications for the degree of persistence and cyclical sensitivity of the aggregate inflation process characterized by the various measures, which I will discuss in greater detail in Section 3.

3. Reestimating the Phillips Curve

In this section, I reestimate the expectation-augmented Phillips curve using 10 measures of inflation over the 1999–2018 period. Inflation expectations are modeled as a weighted average of lagged inflation $A(L)\pi_{t-1}$ and a constant anchor π^*:

$$\pi_t = \alpha\pi^* + (1-\alpha)A(L)\pi_{t-1} + \beta(U_t - U^*) + \gamma Z_t + \epsilon_t \quad (1)$$

In equation (1), π_t is the current inflation rate, $(U_t - U^*)$ denotes the unemployment gap, Z_t represents a set of shocks to the supply side of the economy (such as shocks to import prices), and ϵ_t is an error term, which is assumed to be white noise. The first parameter of interest is α, which equals 1 under accelerationist Phillips curve and 0 under a level Phillips curve with perfectly anchored inflation expectations. In more general terms, $(1-\alpha)$ is associated with the amount of "intrinsic persistence" embedded in the inflation process, which in turn depends critically on the nature of inflation expectations. The other parameter of interest is the slope parameter, β, which indicates the degree of cyclical sensitivity of inflation.

Benchmark Specifications

To estimate equation (1), a decision needs to be made about how to model the anchor π^* and estimate its coefficient α at the same time. One approach (referred to as the restricted case) is to preset the value for π^* and estimate α with the long-run restriction that the coefficients on all the inflation terms on the right side of the equation must sum to unity. In this paper, I set the level of the anchor π^* at 2.0 percent for all measures of PCE inflation and at 2.5 percent for all measures of CPI inflation (because the 10-year-ahead CPI inflation expectations from the Survey of Professional Forecasters were anchored at 2.5 percent in the 2000s). Alternatively (the unrestricted case), I estimate the intercept of the equation, which in theory equals the product of

α and π^*, and then calculate the sizes of α and π^* by *ex post* imposing the long-run restriction on the estimated coefficients.[7]

The other right-hand-side variables in the benchmark equation are identical in the restricted and the unrestricted cases. Specifically, I use four lagged quarters of past inflation and a weighted average of the current and four lagged values of the unemployment gap as a proxy for slack in the labor market. The unemployment gap itself is measured as the difference between the actual U3 (civilians age 16 or older) unemployment rate from the BLS and CBO's estimate of the natural rate of unemployment.[8] In addition, I control for two supply-side shocks in the estimation: shocks to the relative price of imported goods (defined as the difference between the current rate of inflation for nonpetroleum, non-capital-goods imports and the 4-quarter core PCE inflation, weighted by the share of such imports in GDP) and shocks to the relative price of energy goods (defined in a similar fashion).

Estimation Method and Sample Period: 1999–2018. I estimate equation (1) using the ordinary-least-squares method with quarterly data from 1999 through 2018. The estimation of the Phillips curve is known to be sensitive to sample period and other aspects of the specification, suggesting instability in the underlying relationships and a threat of misspecification. To avoid complications from structural breaks in the coefficients that occurred in earlier periods, I focus on the most recent two decades (1999–2018) for most of the analysis in this paper because previous research has shown that the coefficients are relatively stable over that period. In addition, I exclude the fourth quarter of 2008 from headline inflation measures because they are outliers in the data. Finally, to assess the stability of the estimates, I estimate equation (1) unrestricted on recursive samples that all start in 1998Q1 but end in various quarters. Results of the stability checks are presented in Appendix A.

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[7] That is, the sum of the coefficients on lagged inflation terms is assumed to equal (1-α), which allows us to calculate an estimate for α and subsequently for π^* (by using the estimated constant term, which is assumed to equal $\alpha\pi^*$).

[8] In recent years, some economists have questioned whether the unemployment gap is the proper measure of slack to be used in the Phillips curve. They argue that if slack in the labor market is less than what the unemployment gap indicates, it is not surprising that inflation fell less than the model would predict. In particular, some argue that the unemployment gap—which is based on the total unemployment rate—overstated the true amount of slack in the labor market after the 2007–2009 recession because an unusually large share of the unemployed had been out of work over the long term (that is, for 27 weeks or more) and were therefore too loosely attached to the labor market to exert any pressure on prices (see Gordon, 2013, among others). In other words, the real slack in the labor market, as represented by the short-term unemployment, was much less than the overall unemployment statistics indicated. Although that theory does help explain the missing disinflation episode, it fails to explain how inflation remained low even after the short-run unemployment rate had declined to a normal level. In a recent paper, Stock and Watson (2018) surveyed various measures of slack in the Phillips curve framework and concluded that the differences in the measures of slack do not account for the pattern of inflation in the past decade.

Estimation Results

Estimation results for the benchmark model are presented in Table 3(a) for the restricted case and in Table 3(b) for the unrestricted case. In the following discussion, I first focus on the estimates for the coefficient α (that is, the relative weight of the constant anchor and past inflation) and examine the extent to which the Phillips curve has shifted from accelerationist toward a level form. I then assess the steepness or flatness of the slope of the Phillips curve for the various measures of consumer price inflation.

Result I. In terms of the relative weight of past inflation and the anchor, the estimation results suggest the following:

The reduced-form Phillips curve has shifted away from an accelerationist form toward a level form, but that shift is incomplete and the extent to which it has occurred varies across different inflation measures.

In particular, I found that the weight of past inflation, labeled $(1-\alpha)$ in the model, is well below 1.0 for all measures of inflation and fairly small (about 0.2) for all three measures of overall inflation. That result confirms and extends the finding of Blanchard (2016), who presented similar findings for the headline CPI.

By contrast, for all of the alternative measures of core inflation (which include trimmed-mean PCE, trimmed-mean CPI, median CPI, sticky CPI, and sticky XFE CPI), the sum of the coefficients on lagged inflation terms is estimated to be much more substantial—close to 0.5. That finding is robust under both the restricted and the unrestricted estimation, with and without controlling for energy price shocks. (As the estimated coefficients on the energy price terms indicate, the pass-through of energy price shocks to core inflation is fairly low.) That result also holds for the XFE CPI and XFE PCE inflation in the restricted case, when π^* is set to 2.5 percent for XFE CPI and 2.0 percent for XFE PCE inflation. (It does not, however, hold in the unrestricted case as π^* is estimated to be 2.1 percent for XFE CPI and 1.8 percent for XFE PCE inflation—materially lower than the anchor I preset in the restricted case. (The differences between the XFE and the alternative measures of core inflation are discussed in detail below.)

Result I is consistent with previous literature on the decline of inflation persistence. In particular, the presence of past inflation in the Phillips curve is linked to what is sometimes called intrinsic inflation persistence; that is, persistence that is not inherited from the driving process (shocks to aggregate demand or supply). It is well documented that the observed persistence of headline inflation has declined over time (Mishkin, 2007, and Fuhrer, 2011, among many others). Moreover, Fuhrer (2011) shows that the decline in the overall persistence in inflation stems primarily from diminished intrinsic persistence—as reflected in the diminished importance of past inflation in the Phillips curve—whereas the inherited persistence from the shock processes has not changed much over time. However, he also points out that the evidence of a decline in

Table 3(a): Partially Anchored Phillips Curve—Estimation Results (Benchmark, Restricted)

	CPIU	Chained CPIU	PCE	Core PCE (XFE)	Trimmed-Mean PCE	Core CPI (XFE)	Trimmed-Mean CPI	Median CPI	Sticky CPI	Sticky CPI (XFE)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Inflation Expectations:										
Lagged Inflation	**0.201**	**0.233**	**0.211**	**0.376**	**0.595**	**0.604**	**0.689**	**0.532**	**0.532**	**0.508**
	(0.084)	*(0.124)*	*(0.086)*	*(0.157)*	*(0.117)*	*(0.149)*	*(0.107)*	*(0.122)*	*(0.139)*	*(0.143)*
"Anchor"	**0.799**	**0.767**	**0.789**	**0.624**	**0.405**	**0.396**	**0.311**	**0.468**	**0.468**	**0.492**
	(0.084)	*(0.124)*	*(0.086)*	*(0.157)*	*(0.117)*	*(0.149)*	*(0.107)*	*(0.122)*	*(0.139)*	*(0.143)*
Slack:										
Unemployment Gap	**-0.200**	**-0.261**	**-0.112**	**-0.086**	**-0.067**	**-0.094**	**-0.071**	**-0.104**	**-0.130**	**-0.147**
	(0.051)	*(0.077)*	*(0.039)*	*(0.041)*	*(0.028)*	*(0.057)*	*(0.037)*	*(0.041)*	*(0.044)*	*(0.048)*
Supply-Side Shocks:										
Import Prices	**1.370**	**1.762**	**1.200**	**0.603**	**0.031**	**0.219**	**0.722**	**0.120**	**-0.183**	**-0.220**
	(0.356)	*(0.569)*	*(0.285)*	*(0.231)*	*(0.139)*	*(0.244)*	*(0.187)*	*(0.167)*	*(0.168)*	*(0.181)*
Energy Prices	**1.345**	**1.166**	**0.893**	**0.055**	**0.138**	**0.079**	**0.233**	**0.126**	**0.145**	**0.153**
	(0.092)	*(0.143)*	*(0.074)*	*(0.068)*	*(0.040)*	*(0.074)*	*(0.054)*	*(0.048)*	*(0.049)*	*(0.053)*
Adjusted R^2	**0.86**	**0.74**	**0.83**	**0.22**	**0.65**	**0.22**	**0.69**	**0.72**	**0.68**	**0.66**
Observations	**79**	**66**	**79**	**80**	**80**	**80**	**80**	**80**	**80**	**80**
SSR	**29.32**	**48.10**	**18.77**	**16.60**	**6.39**	**19.11**	**10.09**	**8.84**	**9.45**	**10.98**

This table shows estimates of equation (1) using the ordinary-least-squares method with quarterly data from 1999 through 2018. Estimated coefficients and standard deviations (in parentheses) are reported. For headline inflation measures, 2008Q4 was excluded from the sample because it is an outlier. All inflation rates are annualized rates. Four lags of past inflation, as well as the current and four lags of the unemployment gap, are used in the estimation. This table reports the sum of the coefficients on those lagged terms, which represents the size of the cumulative effect over a year (four quarters). The anchor is set at 2.5 percent for all CPI and 2.0 percent for all PCE inflation measures. The coefficients on the lagged inflation terms and the anchor are restricted to sum to unity. The relative price of imported goods is calculated as the difference between the current rate of inflation for nonpetroleum, non-capital-goods imports and the four-quarter XFE PCE inflation, weighted by the share of such imports in GDP. The relative price of energy goods is calculated in a similar fashion.

Table 3(b): Partially Anchored Phillips Curve—Estimation Results (Benchmark, Unrestricted)

	CPIU	Chained CPIU	PCE	Core PCE (XFE)	Trimmed-Mean PCE	Core CPI (XFE)	Trimmed-Mean CPI	Median CPI	Sticky CPI	Sticky CPI (XFE)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Inflation Expectations:										
Lagged Inflation	**0.192**	**0.133**	**0.209**	**0.214**	**0.586**	**0.115**	**0.536**	**0.534**	**0.541**	**0.521**
	(0.073)	*(0.115)*	*(0.083)*	*(0.177)*	*(0.123)*	*(0.180)*	*(0.121)*	*(0.127)*	*(0.144)*	*(0.146)*
Constant	**1.626**	**1.589**	**1.398**	**1.424**	**0.840**	**1.843**	**1.008**	**1.161**	**1.134**	**1.168**
	(0.200)	*(0.293)*	*(0.181)*	*(0.323)*	*(0.264)*	*(0.396)*	*(0.276)*	*(0.335)*	*(0.375)*	*(0.379)*
Implied "Anchor"	***2.0***	***1.8***	***1.8***	***1.8***	***2.0***	***2.1***	***2.2***	***2.5***	***2.5***	***2.4***
Slack:										
Unemployment Gap	**-0.104**	**-0.103**	**-0.066**	**-0.067**	**-0.071**	**-0.137**	**-0.067**	**-0.103**	**-0.124**	**-0.136**
	(0.049)	*(0.082)*	*(0.042)*	*(0.041)*	*(0.032)*	*(0.052)*	*(0.035)*	*(0.046)*	*(0.049)*	*(0.053)*
Supply-Side Shocks:										
Import Prices	**0.898**	**1.338**	**0.974**	**0.499**	**0.044**	**-0.058**	**0.566**	**0.117**	**-0.199**	**-0.251**
	(0.327)	*(0.525)*	*(0.289)*	*(0.233)*	*(0.150)*	*(0.230)*	*(0.192)*	*(0.177)*	*(0.179)*	*(0.193)*
Energy Prices	**1.520**	**1.335**	**0.974**	**0.090**	**0.134**	**0.132**	**0.273**	**0.127**	**0.151**	**0.166**
	(0.089)	*(0.137)*	*(0.078)*	*(0.069)*	*(0.044)*	*(0.068)*	*(0.055)*	*(0.053)*	*(0.054)*	*(0.058)*
Adjusted R^2	**0.89**	**0.79**	**0.85**	**0.25**	**0.65**	**0.37**	**0.71**	**0.72**	**0.68**	**0.65**
Observations	**79**	**66**	**79**	**80**	**80**	**80**	**80**	**80**	**80**	**80**
SSR	**22.07**	**38.25**	**17.20**	**15.78**	**6.38**	**15.34**	**9.29**	**8.84**	**9.44**	**10.94**

This table shows estimates of equation (1) using the ordinary-least-squares method with quarterly data from 1999 through 2018. Estimated coefficients and standard deviations (in parentheses) are reported. For headline inflation measures, 2008Q4 was excluded from the sample because it is an outlier. All inflation rates are annualized rates. Four lags of past inflation, as well as the current and four lags of the unemployment gap, are used in the estimation. This table reports the sum of the coefficients on those lagged terms, which represents the size of the cumulative effect over a year (four quarters). The implied anchor is calculated by imposing the long-run restriction on coefficients retrospectively. The relative price of imported goods is calculated as the difference between the current rate of inflation for nonpetroleum, non-capital-goods imports and the four-quarter XFE PCE inflation, weighed by the share of such imports in GDP. The relative price of energy goods is calculated in a similar fashion.

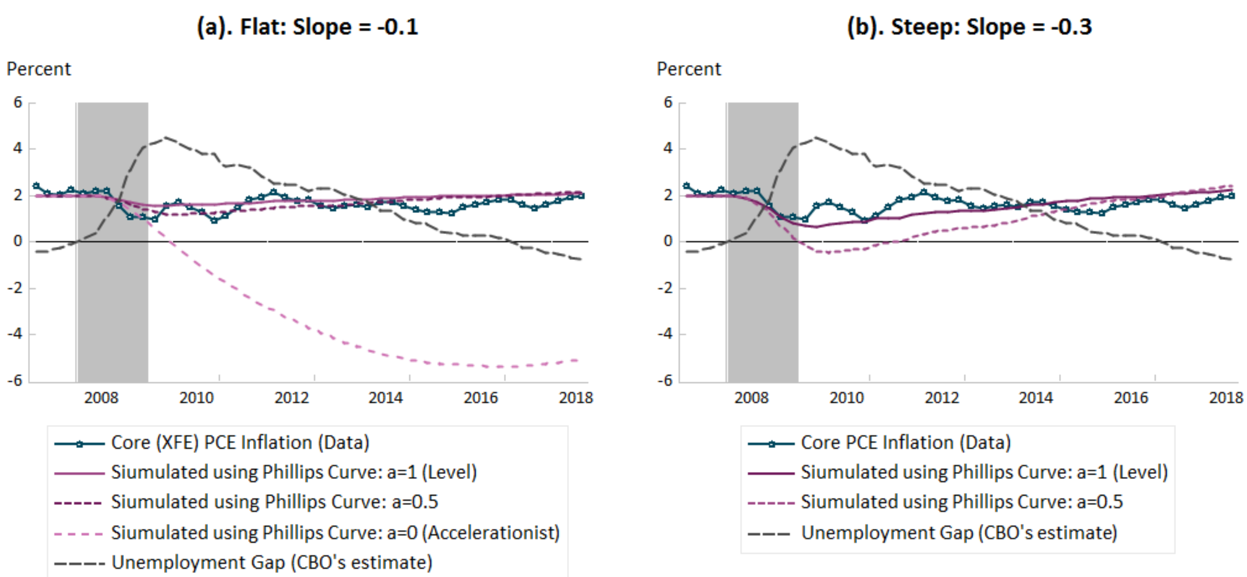
the persistence from core measures is generally weaker than the evidence from headline measures, a finding that is consistent with Result I.

It is worth noting that the quantitative difference in the implied inflation paths under a generating process characterized by a quarterly Phillip curve model with $\alpha = 0.5$ and one with $\alpha = 1$ is quite modest when the slope of the Phillips curve is flat but can get materially larger when the slope of the Phillips curve is steeper. To illustrate this, I conducted a simple experiment in which I simulated the paths of core (XFE) PCE inflation using a simple Phillips curve model:

$$\pi_t = \alpha\pi^* + (1 - \alpha)\pi_{t-1} + \beta(U_t - U^*) \qquad (2)$$

I used various specifications for the parameters α and β, and I set $\pi^* = 2.0$ and used CBO's estimate of the unemployment gap to simulate counterfactual inflation paths for the 2007–2018 period.

Figure 6: Simulated Core PCE Inflation Paths Under Different Phillips Curves



As Figure 6 shows, when the slope of the Phillips curve is −0.1 (close to the estimates reported in Tables 3(a) and 3(b)), the simulated paths under $\alpha = 0.5$ and $\alpha = 1$ are very close. However, when β is set to equal −0.3, which is close to its value in the 1970s, the model with $\alpha = 0.5$ generates deflation. That example illustrates that the dependence of current inflation on past inflation—whether it arises through incompletely anchored inflation expectations or other mechanisms—will not only extend the effects of shocks but also compound and amplify them. The overall impact on the path of inflation could be significant when inflation is sufficiently sensitive to those shocks. (The slope of the Phillips curve is discussed in further detail below.)

Result II. In terms of the overall fit of the Phillips curve model for various measures of inflation, the estimations resulted in the following finding:

The Phillips curve model fits the data quite well for overall inflation and all the alternative measures of core inflation, but it is not a good fit for the XFE measures.

Specifically, for all three headline measures of inflation, the estimated adjusted R^2 statistics are about 0.8. Even if the shocks to the relative price of energy goods are excluded, they remain above 0.4. For core inflation measures, the model fits all the non-XFE measures quite well: The adjusted R^2 statistics are above 0.6 in both the restricted and unrestricted cases.

Interestingly, the fit of the model is considerably poorer for the XFE measure of core inflation: The adjusted R^2 statistics are around 0.2 for both XFE CPI and XFE PCE inflation. That result implies that the XFE measures of core inflation are influenced by a wider array of idiosyncratic shocks than non-XFE measures. That is not surprising given the way that those core measures are constructed, as discussed above in Section 2. Prices for some of the XFE items, such as apparel and lodging services, are quite volatile. Other large, one-off shocks to the price level—such as the spike in the index for tobacco in 2009, which resulted from an increase in excise taxes, and the precipitous drop in the index for wireless phone services in 2017, which resulted from large quality adjustment—can drive the XFE inflation up or down significantly in the short run. By contrast, such large one-off changes in prices, regardless of the origin, are automatically excluded in the calculation of the trimmed-mean and median price indexes; they are also, by construction, rarer for sticky-priced items.

Result II is broadly consistent with previous studies comparing different measures of core inflation. For example, Detmeister (2011) finds that XFE measures often perform worse than other measures of core inflation in out-of-sample tests of predicting future inflation or tracking an *ex post* measure of underlying trend inflation.

Result III. Turning to the slope of the Phillips curve, my estimation results suggest the following:

The Phillips curve is "alive," particularly for CPI inflation measures.

The Phillips curve is said to be alive if there is a meaningful negative relationship between inflation and the slack in the labor markets in the short run. In practice, that generally means that in the reduced-form Phillips curve, the coefficient on the slack term meets the following three conditions: It has the correct sign, its magnitude is economically meaningful, and it is statistically significant at the 5 percent or 1 percent level. My results show that this is generally the case, although there is notable variation in the estimated size of the slope coefficients across the 10 inflation measures, suggesting that the Phillips curve relationship is less muted for some measures than it is for others.

Specifically, I found that the slope of the Phillips curve is, on average, steeper for CPI inflation measures than for their PCE counterparts. The estimated slope coefficients for various core CPI measures range from −0.10 to −0.15, meaning that a 1 percentage-point decline in the unemployment rate relative to its natural rate is correlated with a cumulative increase of between 0.1 percentage point and 0.15 percentage points in core CPI inflation over the following year. By contrast, the estimated slope coefficient for the two core PCE inflation measure is only −0.05 and −0.08. The same is true for the headline CPI and PCE inflation measures as well.

Why is the Phillips curve steeper for the CPI than for the PCE inflation measures? In other words, why does CPI inflation appear to be more cyclically sensitive than PCE inflation? A simple explanation is that shelter, one of the most cyclically sensitive components, accounts for a much larger share in the CPI than the PCE (see Table 1). By contrast, the largest component in the PCE and the core PCE is health care, which is less cyclically sensitive and more influenced by noneconomic factors such as government policy. In the next subsection, I delve deeper into the Phillips curve relationships at the component level.

Cyclical Sensitivity: A Component-Level Analysis

The variation across different aggregate inflation measures in cyclical sensitivity reflects, in part, the wide dispersion of the cyclical sensitivity of the underlying components as well as the difference in the components included in each of the aggregate measures. To show this, I follow Stock and Watson (2018) and estimate a simple Phillips curve for the prices of different types of goods and services as measured in the CPI and PCE price index. Estimated results are reported in Table 4.

Several observations follow. First, some price components show clear responsiveness to cyclical fluctuations in economic activities (that is, they are procyclical); those components largely consist of services and food. The two components that are most cyclically sensitive are shelter (including the rent of primary residence and the imputed owners' equivalent rent) and food at home. Moreover, for their subaggregates, including the PCEPI for services less energy and the CPI for services less energy and shelter, the estimated slope coefficients not only have the correct sign, they also are highly statistically significant. (The estimated slope coefficients for many other service components have the correct sign but are statistically insignificant, possibly reflecting noise at the detailed category level.) The fact that shelter inflation remains strongly procyclical is particularly important because it accounts for about 40 percent of XFE CPI and for only 18 percent of XFE PCE, which helps explain why the CPI appears to be more cyclically sensitive than the PCE price index.

Second, some price components appear to be noncyclical or even countercyclical over the past two decades; those components largely consist of goods. One example is the price index for autos, which rose sharply following the recession of 2007 to 2009. That countercyclical movement stems in part from the various government programs implemented

Table 4: Estimated Phillips Curve for PCEPI and CPI Components, 1999 to 2018

	Unemployment Gap	Lagged Inflation	Constant	Adjusted R^2	Obs.
PCE: Services Less Energy (XE)	**-0.15**	**0.28**	**2.05**	**0.47**	**80**
	(0.05)	*(0.13)*	*(0.37)*		
PCE: Housing Services	**-0.23**	**0.57**	**1.32**	**0.80**	**80**
	(0.05)	*(0.08)*	*(0.25)*		
CPI-U: Owner's Equivalent of Rent	**-0.21**	**0.63**	**1.12**	**0.78**	**80**
	(0.05)	*(0.08)*	*(0.24)*		
CPI-U: Rent of Primary Residence	**-0.16**	**0.66**	**1.19**	**0.84**	**80**
	(0.05)	*(0.07)*	*(0.27)*		
PCE: Health Care Services	**-0.05**	**0.64**	**0.84**	**0.43**	**80**
	(0.07)	*(0.10)*	*(0.27)*		
CPI-U: Medical Care Services	**-0.06**	**0.69**	**1.22**	**0.34**	**80**
	(0.08)	*(0.11)*	*(0.45)*		
PCE: Other XE Services	**-0.07**	**0.31**	**1.86**	**0.39**	**80**
	(0.07)	*(0.11)*	*(0.30)*		
CPI-U: Education Services	**-0.09**	**0.92**	**0.38**	**0.81**	**80**
	(0.05)	*(0.06)*	*(0.29)*		
CPI-U: Transportation Services	**-0.05**	**-0.12**	**3.30**	**0.15**	**80**
	(0.12)	*(0.11)*	*(0.37)*		
CPI-U: Food away from Home	**-0.10**	**0.62**	**1.07**	**0.57**	**80**
	(0.05)	*(0.09)*	*(0.26)*		
CPI-U: Services Less Energy Services & Rent of Shelter	**-0.16**	**0.39**	**1.92**	**0.34**	**80**
	(0.06)	*(0.13)*	*(0.40)*		
PCE: Durable Goods	**0.06**	**0.27**	**-1.51**	**0.25**	**80**
	(0.08)	*(0.10)*	*(0.24)*		
PCE: Motor Vehicles and Parts	**0.30**	**0.31**	**-0.22**	**0.43**	**80**
	(0.16)	*(0.09)*	*(0.25)*		
CPI-U: New Vehicles	**0.39**	**0.03**	**-0.36**	**0.34**	**80**
	(0.15)	*(0.10)*	*(0.24)*		
CPI-U: Used Cars and Trucks	**0.44**	**0.17**	**-0.33**	**0.35**	**80**
	(0.54)	*(0.12)*	*(0.86)*		
PCE: Video, Audio, Photo &	**0.04**	**0.57**	**-3.97**	**0.42**	**80**
Information Processing Equipment & Media	*(0.16)*	*(0.09)*	*(0.84)*		
PCE: Other Durable Goods	**-0.09**	**0.39**	**-0.52**	**0.29**	**80**
	(0.09)	*(0.10)*	*(0.19)*		
PCE: Nondurable Goods Less Food and Energy (XFE)	**0.08**	**0.19**	**0.66**	**0.34**	**80**
	(0.09)	*(0.10)*	*(0.17)*		
PCE: Pharmaceutical & Other Medical Products	**0.02**	**0.37**	**1.81**	**0.22**	**80**
	(0.13)	*(0.10)*	*(0.39)*		
PCE: Other XFE Nondurable Goods	**0.10**	**0.24**	**-0.03**	**0.42**	**80**
	(0.11)	*(0.09)*	*(0.19)*		
CPI-U: Apparel	**0.52**	**0.16**	**-0.66**	**0.20**	**80**
	(0.17)	*(0.11)*	*(0.30)*		
PCE: Food & Beverage Purch. for Off-Premises Consumption	**-0.21**	**0.67**	**0.63**	**0.54**	**80**
	(0.12)	*(0.08)*	*(0.25)*		
CPI-U: Food at Home	**-0.22**	**0.64**	**0.69**	**0.52**	**80**
	(0.14)	*(0.08)*	*(0.29)*		
CPI-U: Alcoholic Beverages	**-0.17**	**0.34**	**1.48**	**0.17**	**80**
	(0.08)	*(0.10)*	*(0.26)*		

Estimated coefficients and standard errors (in parentheses) are reported. In each regression, the dependent variable is the annualized quarterly growth rates of the price component. Independent variables include lagged inflation rates (that is, lagged terms of the dependent variable), current and lagged terms of the unemployment gap, the relative price of imports, and a constant. Lag structures are chosen based on the Akaike information criterion and the statistical significance of the estimated coefficients. Dummy variables are used to control for outliers.

to support the auto industry after the recession began, including the 2009 program commonly referred to as cash for clunkers. In addition, buyers of cheaper vehicles were more likely to be hit hard by the recession and, as a result, exited the market en masse, thereby raising the average price of vehicles sold.

Why are price movements for some components more procyclical than others? Stock and Watson (2018) argue that the most procyclical prices, such as those for shelter and food, tend to be determined in local markets. By contrast, prices of many goods, including electronics, furniture, and apparel are increasingly determined in international markets. In addition, they are more exposed to the likely deflationary effects of the rise of e-commerce that has occurred over the past two decades. Moreover, even though prices of both goods and services may suffer from measurement issues, they tend to suffer from different types of measurement issues that have different implications for cyclical properties. For instance, the price index for apparel is poorly measured because of the constant introduction of new varieties and the near impossibility of controlling for quality changes; as a result, its movements are generally regarded as having little information content. By contrast, price indexes for some PCE service categories (such as those provided by nonprofit institutions serving households) may be poorly measured because such prices are not posted or do not actually exist and have to be imputed using a cost approach. However, because the costs used to impute such prices are procyclical, the constructed price indexes sometimes also exhibit procyclicality.

A third observation of the estimation results in Table 4 is that the coefficients on the lagged inflation terms tend to be larger for those cyclically sensitive components. That result helps illustrate why the coefficients on past inflation were larger for the aggregate inflation measure in which those components have a larger share (that is, the alternative measures of core inflation). However, the result should be interpreted with caution to prevent drawing any false conclusions, particularly when making any link between the persistence of inflation at the component level and the nature of inflation expectations. Shelter inflation, for example, is among the more persistent components, but that persistence stems at least in part from the fact that the index is constructed using a moving average of six months of rent data.

4. Inflation Expectations

Reduced-form analysis in the previous section suggests that the Phillips curve has shifted from an accelerationist form toward a level form, and the curve for overall inflation has moved in that direction somewhat more than that of core inflation has. However, the estimated coefficients cannot be used to indicate the state of the underlying inflation expectations, especially not the degree to which those expectations are anchored. To shed light on that issue, I now turn to empirical measures of inflation expectations.

Are Inflation Expectations Anchored?

In this analysis, I follow Ball and Mazumder's (2011) approach and examine two distinct aspects of anchoring. The first aspect is shock anchoring, which means that transitory shocks to inflation are not passed into current expectations about inflation or into future inflation. The second aspect is level anchoring, which means that inflation expectations are tied to a particular level of inflation that is chosen *ex ante*, such as the inflation target of 2 percent (as measured by the PCE price index) adopted by the Federal Reserve.[9] Ball and Mazumder (2011) suggest that shock anchoring of inflation expectations in the United States can be traced back to the early 1980s, following the success of the Volcker disinflation. By contrast, level anchoring is a more recent concept: The idea that the central bank should have a specific target for inflation to provide an external numerical anchor for inflation expectations was first discussed in the early 1990s (Taylor, 1993) and only slowly became prominent.[10]

My analysis using a variety of survey-based and market-based measures of inflation expectations, coupled with a review of previous studies, shows that the case for the anchoring of inflation expectations is mixed. In particular, the answer to the question, "Are inflation expectations anchored?" depends on *whose* expectations are being discussed:

- Professional forecasters' inflation expectations have been both shock anchored and level anchored over the 1999–2018 period.[11]

- Consumers' expectations about inflation in the long-run have been shock-anchored, but their expectations about short-term inflation have not; neither the long-run nor the short-run inflation expectations reported by consumers are level anchored.

In the rest of the section, I focus on professional forecasters' and consumers' inflation expectations because they are most widely used in the Phillips curve literature. I include a brief

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[9] Note that even if expectations are shock anchored, the level of inflation could still drift as long as that drift is not driven by identifiable shocks. Similarly, level-anchored inflation expectations need not be shock anchored if they both respond to shocks and revert to the mean.

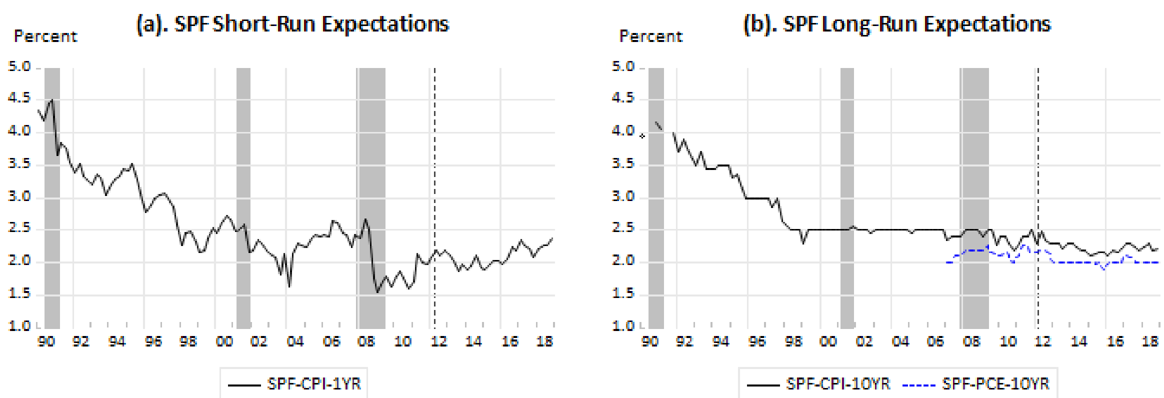
[10] Because the concept of level anchoring of inflation expectations is intimately related to inflation targeting, it is worth noting that an inflation target can be specified in various forms: a point target, a point target with a tolerance interval, or a range. In practice, however, the different ways targets are specified by central banks "do not seem to matter," according to Svensson (2010), who explains: "A central bank with a target range seems to aim for the middle of the range, and the edges of the range are normally interpreted as 'soft edges' in the sense that they do not trigger discrete policy changes, and being just outside the range is not considered much different from being just inside."

[11] The Federal Reserve did not officially adopt an inflation target until January 2012. However, it was widely considered to be setting targets implicitly (Thornton, 2012). In addition, the Federal Open Market Committee routinely published the range of its inflation forecast—typically 1.7 percent to 2.0 percent—as part of its efforts to provide forward guidance before it officially adopted an inflation goal.

discussion of financial market participants' inflation expectations (implied by the prices of financial assets), addressing their anchoring and other properties, in Appendix B.

Professional Forecasters. The most widely used source of professional forecasters' inflation expectations is the Survey of Professional Forecasters, which is currently conducted quarterly by the Federal Reserve Bank of Philadelphia. Within the SPF, the two longest-running series of expectations on consumer price inflation are the 1-year-ahead CPI inflation expectations (SPF-CPI-1YR), which became available in 1981, and the 10-year-ahead CPI inflation expectations (SPF-CPI-10YR), which dates back to 1979. In 2007, the SPF added the 10-year-ahead PCE inflation expectations (SPF-PCE-10YR) (see Figure 7).[12]

Figure 7: Inflation Expectations From the Survey of Professional Forecasters



The dashed vertical line marks January 2012, when the Federal Reserve adopted a longer-run inflation objective of 2 percent as measured by the annual growth of the PCE price index.

Shock Anchoring. Several previous studies suggested that inflation expectations by professional forecasters have been shock anchored since as early as the 1980s. For example, Hooker (2002) found that oil price movements during the 1980s and 1990s had little or no effect on core inflation, whereas in earlier decades such movements had a substantial influence. Fuhrer, Olivei, and Tootell (2009) and Sommer (2002), among others, reported similar results.

More recently, Ball and Mazumder (2011) showed that over the 1985–2007 period, lagged overall CPI inflation has no additional explanatory power for the variation in SPF-CPI-1YR once lagged core (XFE) CPI inflation is accounted for, suggesting that the effects of those shocks on actual inflation are not passed on to expectations. The idea is that the overall CPI inflation contains variations resulting from shocks (to food and energy prices). If such shocks had a

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[12] The SPF also added 5-year-ahead CPI and PCE inflation expectations (SPF-CPI-5YR and SPF-PCE-5YR) in 2005.

significant effect on short-run expectations, the coefficient on the overall inflation term would dominate the coefficient on the core inflation term. Starting in the mid-1980s, however, the opposite was true.

I extend the simple analysis in Ball and Mazumder (2011) using data through 2018 with three modifications. First, I test both short-run and long-run SPF measures of inflation expectations instead of focusing only on SPF-CPI-1YR. Second, to better capture core inflation on the right-hand side of the equation, I use the median CPI (for SPF-CPIs) and the trimmed-mean PCE price index (for SPF-PCE-10YR) instead of the XFEs as the measure for core inflation. Third, I use the changes in the relative price between the overall and the core indexes (instead of the overall inflation itself) to better split the shocks from the core. I refer to that measure as noncore inflation in the regression equations. The results of that analysis are presented in Table 5.

Table 5: Shock Anchoring of Professional Forecasters' Inflation Expectations

(a). Sample Period: 1985 to 1998

	Core Inflation	Noncore Inflation (Shocks)	Constant	Adjusted R^2	Observations
SPF-CPI-1YR	**0.78**	**0.10**	**0.93**	**0.67**	**56**
	0.00	*0.21*	*0.00*		
SPF-CPI-10YR	**0.72**	**0.04**	**1.14**	**0.56**	**56**
	0.00	*0.71*	*0.00*		

(b). Sample Period: 1999 to 2018

	Core Inflation	Noncore Inflation (Shocks)	Constant	Adjusted R^2	Observations
SPF-CPI-1YR	**0.32**	**0.09**	**1.43**	**0.55**	**80**
	0.00	*0.00*	*0.00*		
SPF-CPI-10YR	**0.09**	**0.08**	**2.18**	**0.35**	**80**
	0.00	*0.00*	*0.00*		
SPF-PCE-10YR	**0.05**	**0.04**	**1.99**	**0.03**	**48**
	0.11	*0.04*	*0.00*		

Regressions of SPF short-run and long-run inflation expectations on lagged core and overall inflation were used to test the degree of shock anchoring of SPF expectations. Estimated coefficients and p-values are reported. All inflation rates are quarterly, annualized rates. For SPF-CPI-1YR and SPF-CPI-10YR, the median CPI as published by the Federal Reserve Bank of Cleveland was used as the measure for core inflation. For SPF-PCE-10YR, the trimmed-mean PCE price index published by the Federal Reserve Bank of Dallas was used as the measure for core inflation. In each regression, four lags of past core inflation and four lags of past overall inflation terms are included.

Results generally support the notion that professional forecasters' inflation expectations, as measured by the SPF, have been reasonably shock anchored since 1985, although there is also some evidence for weak responses in the SPF-CPIs to supply shocks in the past two decades. More specifically, over the earlier period, the coefficients on lagged core inflation were large and highly statistically significant for both the short-run and the long-run SPF expectations, whereas the coefficients on the shock terms were statistically insignificant (see Table 5(a)). That is the same pattern as described in Ball and Mazumder (2011), and it indicates that the responses of professional forecasters' inflation expectations to changes in trend inflation were strong during most of the 1980s and 1990s, when inflation gradually declined and the Federal Reserve was known to be pursuing "opportunistic disinflation," whereas their responses to supply shocks were muted.

Since the late 1990s, the link between SPF measures of inflation expectations and core inflation has weakened, and the constant term has become more dominant (see Table 5(b)). That is particularly true for long-run SPF expectations, and it is linked to increased level anchoring during that period (see discussion below). In the meantime, the coefficients on the noncore inflation terms for the two CPI inflation measures (SPF-CPI-1YR and SPF-CPI-10YR) became statistically significant, albeit small, indicating some weak responses of these measures to supply shocks during that period. Nonetheless, because the magnitude of those estimated effects was small compared with the constant term, it is still reasonable to consider the SPF inflation expectations to be generally shock anchored over the period.

Level Anchoring. There is also considerable evidence that professional forecasters' inflation expectations have been reasonably level anchored. One of the most striking features of the data is that the average 10-year-ahead CPI inflation expectations from the SPF were more or less constant at 2.5 percent from as early as the late 1990s through the years leading up to the financial crisis and the 2007–2009 recession (see Figure 7(a)). Starting in 2012 when the Federal Reserve officially adopted its long-run inflation target and phrased it in terms of the growth rates of the PCE price index, the SPF-PCE-10YR became near constant at 2 percent (see Figure 7(b)). Detmeister, Massaro, and Peneva (2015) show that the official adoption of the target in January 2012 caused SPF-PCE-10YR to be more anchored at 2 percent.

To roughly quantify the degree of level anchoring of professional forecasters' inflation expectations, I regress the observed SPF inflation expectations π_t^e on a constant anchor π^* and past actual inflation rates, with the parameter $\lambda \in [0, 1]$ indicating the degree of level anchoring:

$$\pi_t^e = \lambda\pi^* + (1-\lambda)\sum_j \omega_j \pi_{t-j} + u_t \qquad (4)$$

Estimation results (see Table 6) suggest that short-run SPF inflation expectations have been level anchored to some degree and that long-run SPF inflation expectations have been level anchored either completely or near completely (with some caveats discussed below). In particular, the estimated level anchoring parameter λ was 0.98 for SPF-CPI-10YR during the 1998–2008 period and 1.0 for SPF-PCE-10YR during the 2009–2018 period in quarters for which data are available. [13]

Table 6: Level Anchoring of Professional Forecasters' Inflation Expectations

	SPF-CPI-1YR	SPF-CPI-10YR	SPF-PCE-10YR
λ: 1999 to 2018	**0.75**	**0.90**	
λ: 1999 to 2008	0.84	0.98	
λ: 2009 to 2018	0.74	0.89	1.01
"Anchor"	**(2.5)**	**(2.5)**	**(2.0)**

One implication of a high degree of level anchoring is usually that the inflation expectations exhibit a diminished dependence on past inflation. As shown in Table 3 and discussed in the previous section, expectations' weakened dependence on actual inflation is a particularly salient feature of long-run SPF expectations. That is also consistent with Kiley (2015) and Blanchard (2016), which show that the link between expected inflation and lagged inflation weakened substantially during the 1990s.

One caveat in interpreting the results in Table 6 is that the estimates of parameter λ presented there were calculated using *ex post facto* anchors of 2.5 percent for SPF-CPI inflation during the 2000s and 2.0 percent for SPF-PCE inflation during the 2010s. The choice of 2.0 percent for PCE inflation is obvious, but it is less clear what the anchor for CPI inflation should be. One justifiable alternative to the 2.5 percent anchor is 2.3 percent, which is the average wedge between SPF-CPI-10YR and SPF-PCE-10YR between 2007 and 2017 in quarters for which both series are available. Although using alternative anchors (with plausible values) affects the magnitude of λ, it does not affect the qualitative results of the analysis.

It is also worth noting that the estimated λ for SPF-CPI-10YR for the past decade, 0.89, is less than the anchor for the previous decade, 0.98; and as Figure 7(b) shows, the SPF-CPI-10YR has slipped from 2.5 percent since the 2007–2009 recession. However, that slippage is not necessarily evidence against level anchoring of professional forecasters' long-run inflation expectations in general, because SPF-*PCE*-10YR was solidly level anchored at the Federal Reserve's long-run inflation target of 2 percent over most of the past 10 years. Instead, it is likely that when reporting inflation expectations for multiple measures, forecasters chose a base measure and formed their expectations for other measures by first forecasting the corresponding

[13] Ball and Mazumder (2011) studied the time-varying path of the parameter λ associated with SPF-CPI-1YR (by assuming that it follows a random-walk process) and found that it increased over time, from 0 in the early 1980s to about 0.7 by 2010. The authors concluded that level anchoring of professional forecasters' inflation expectations was "partial and incomplete." This paper presents a static version of that analysis for multiple inflation expectation measures.

gaps between measures. Many forecasters (CBO included) changed their base measure of inflation from the CPI to the PCE price index over the past two decades, especially after the Federal Reserve set its inflation objective in terms of the PCE price index in 2012. In the meantime, the gap between the CPI and the PCE inflation has declined (particularly during the 1990s) as general inflation has declined and the composition of consumption has shifted.[14] As a result, the average gap between professional forecasters' long-run CPI inflation expectation and their PCE inflation expectations has also fallen, with the SPF-PCE-10YR anchored at 2 percent and SPF-CPI-10YR falling slightly over time.

Consumers. There are currently two major surveys of consumers' expectations: the University of Michigan Survey of Consumers and the Survey of Consumer Expectations conducted by the Federal Reserve Bank of New York. The monthly MSC survey first began in 1978, but data on long-run inflation expectations for years before 1990 are only available at a lower frequency. The SCE is a much larger survey and contains more information about the demographics of the respondents. It also differs from the MSC in that it uses density forecasts instead of point predictions. However, the SCE began in 2013, so there are not enough data for regression analysis at this point. Hence, in the analysis below, I rely on the MSC data.

I consider several measures of consumers inflation expectations based on MSC. I include measures for both short-run and long-run inflation expectations, namely, the 1-year-ahead inflation rate (MSC-1YR) and the average inflation rates of the next 5 to 10 years (MSC-5YR) (see Figure 8). I use the *median* expectation data from the MSC files for those measures. In addition, I also consider the *mean* expectations reported by consumers with low uncertainty about the inflation outlook, as calculated by Binder (2017).[15] I report estimation results with quarterly data below; results using monthly data are similar.

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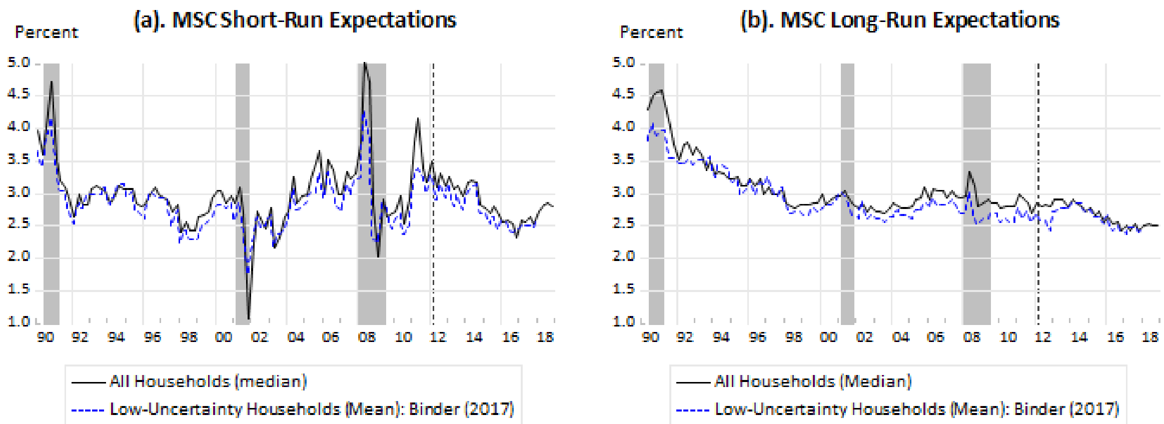
[14] One possible driver increasing the gap between CPI and PCE inflation is the rising share of GDP that health care services account for. Over the past few decades, the share of health care services has risen much more rapidly in the PCE (part of GDP) than in the CPI because the PCE health care index includes all health care expenditures (including those paid for by Medicare, Medicaid, and other public and private insurance programs), whereas the CPI medical care index tracks only households' out-of-pocket medical expenses. Because health care inflation has typically outpaced general inflation in the past (the period since 2011 being the exception), its rising share of GDP has the effect of reducing the gap between the CPI and the PCE inflation rates.

[15] In Binder (2017), respondents of MSC surveys are divided into two groups on the basis of the patterns of their responses: those highly uncertain about the inflation outlook and those with low uncertainty. In identifying the two groups, the author draws on findings from psychology literature that people tend to use numbers that are multiples of 5 (that is, 0, 5, 15, 20, and so on) when they are uncertain.

Figure 8: Inflation Expectations From the Michigan Survey of Consumers



Shock Anchoring. My analysis suggests that consumers' short-run inflation expectations have not been shock anchored, even though their long-run expectations have been. Consumers' short-run inflation expectations appear to respond significantly to shocks in food and energy prices, particularly gasoline prices. In addition, there is evidence that consumers' inflation expectations not only respond to the changes in gasoline prices but also are correlated with the level of gasoline prices.

To demonstrate those properties, I ran a regression analysis for various MSC measures of inflation expectations over the 1999–2018 period using the following explanatory variables: one lag of the year-over-year growth rates of gasoline prices, one lag of the log levels of gasoline prices, one lag of the year-over-year growth rates of food prices, and four lags of past XFE CPI inflation rates (annualized quarterly rates), and a constant (see Table 7).[16]

Estimation results strongly support the notion that gasoline prices have a large influence on consumers' short-run inflation expectations. According to the estimates, a 1 percent increase in gasoline prices would lead to a 0.005 percentage-point increase in the median MSC-1YR, and a 1 percentage-point increase in gasoline price inflation would lead to a 0.008 percentage-point increase in the median MSC-1YR.[17] Because gasoline price fluctuations can be very large, those estimated effects on inflation expectations are not trivial. The results are consistent with Binder (2018), who, using a different model, found that a 1 percentage-point increase in gasoline price inflation increased the MSC-1YR by about 0.01 percentage points. Those finding are also consistent with Coibion and Gorodnichenko (2015), who argue that the median MSC-1YR has tracked the price of oil very closely since the early 2000s, pointing out that almost all of the

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[16] I use the CPI for food prices, which includes both food at home and food away from home.
[17] A change in gasoline prices would trigger both channels.

short-run volatility in inflation forecasts corresponds to short-run changes in the level of oil prices.

Table 7: Shock Anchoring of Consumers' Inflation Expectations

	Core Inflation	Gasoline Price Inflation	Gasoline Price (Log Level)	Food Price Inflation	Constant	Adjusted R^2	Sample Period
Median MSC-1YR	**-0.06**	**0.008**	**0.53**	**0.10**	**3.02**	**0.37**	**1999-2018**
	0.64	*0.00*	*0.00*	*0.01*	*0.00*		*(obs.=80)*
Mean MSC-1YR	**0.01**	**0.005**	**0.43**	**0.07**	**2.79**	**0.40**	**1999-2017**
(Low Uncertainty)	*0.89*	*0.01*	*0.00*	*0.02*	*0.00*		*(obs.=76)*
Median MSC-5YR	**0.01**	**0.002**	**-0.02**	**0.06**	**2.64**	**0.22**	**1999-2018**
	0.87	*0.08*	*0.72*	*0.00*	*0.00*		*(obs.=80)*
Mean MSC-5YR	**0.06**	**0.001**	**-0.04**	**0.02**	**2.50**	**0.11**	**1999-2017**
(Low Uncertainty)	*0.12*	*0.29*	*0.43*	*0.12*	*0.00*		*(obs.=76)*

The mean MSC short-run and long-run inflation expectations of consumers identified as having low uncertainty were based on Binder (2017).

There are many potential explanations for why consumers' short-run inflation expectations are particularly sensitive to the "price at the pump": People purchase gasoline very frequently, so any price change is salient. Also, the demand for gasoline tends to be fairly inelastic in the short run; any price change can therefore have a large impact on consumers' finances, particularly for people at the lower end of the income distribution whose consumption budgets are more likely to be constrained. In addition, people tend to notice and remember extreme price changes and to use such changes to form expectations of future inflation (Morewedge, Gilbert, and Wilson, 2005; Bruine de Bruin, van der Klaauw, and Topa, 2011). Since gasoline price changes are particularly volatile, they tend to have a large impact on consumers' short-run inflation expectations.[18]

By contrast, consumers' long-run inflation expectations have been fairly well shock anchored. As Table 7 shows, for MSC-5YR measures, the coefficients on both gas price terms are small and statistically insignificant. In fact, for the mean MSC-5YR expectations reported by consumers identified as having low uncertainty, none of the explanatory variables (other than the constant) are statistically significant. That is also consistent with previous findings. For example, Verbrugge and Higgins (2015) used a structural vector autoregression (SVAR) model and found

[18] There is currently debate over whether consumers are excessively sensitive to gasoline prices. For example, Trehand (2011) and Coibion and Gorodnichenko (2015) argue that they are. By contrast, Binder (2018) argues that consumers do not seem to allow gasoline prices to influence their perception of inflation inordinately given the share of their total expenditures that goes toward gasoline; instead, consumers believe gasoline price inflation is negatively auto-correlated and feeds into core inflation moderately.

that energy price shocks have a statistically significant, but very small, impact on consumers' long-run inflation expectations.

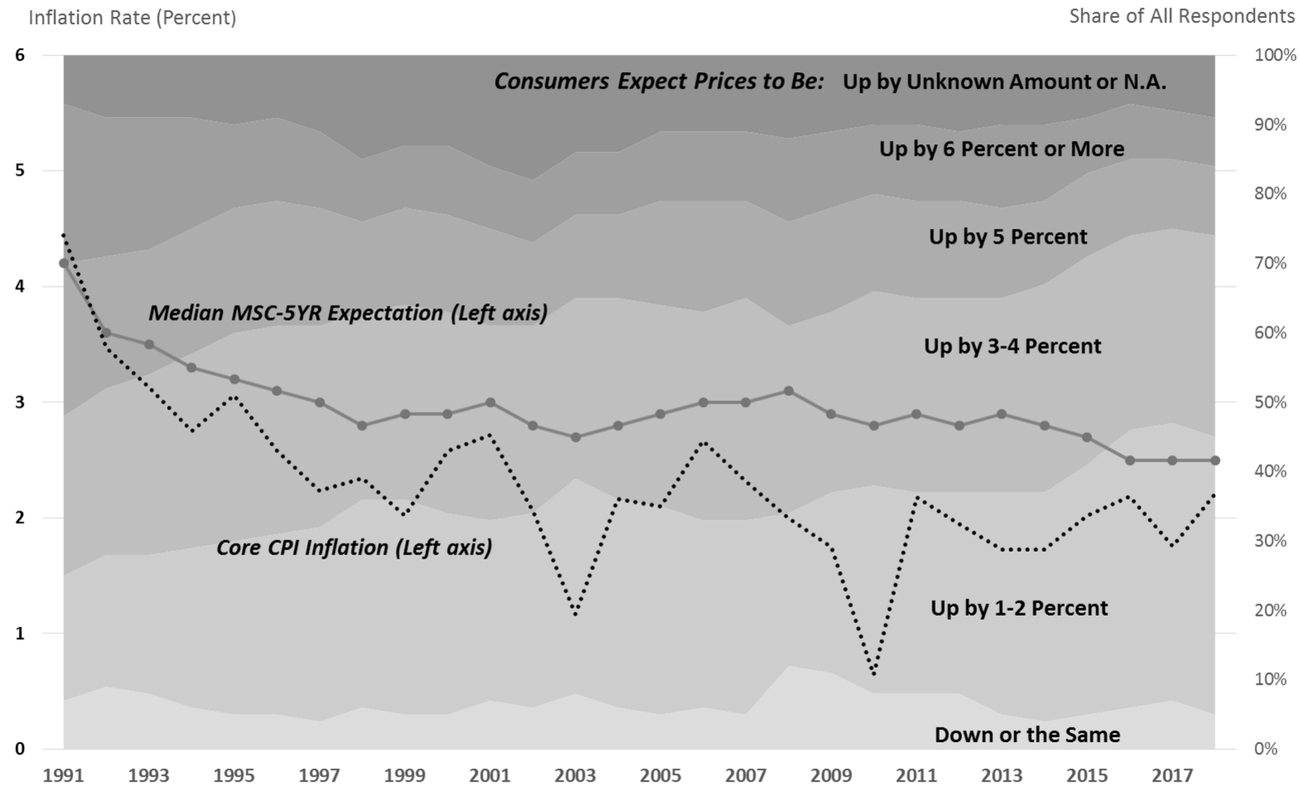
Level Anchoring. Consumers' long-run inflation expectations do not appear to have been level anchored. Even though the median and the mean MSC-5YR displayed remarkable stability from the late 1990s through the first half of 2014, they were at levels that were consistently higher than the average of actual inflation and professional forecasters' expectations over the same period. Moreover, MSC-5YR expectations have declined since 2014. Even though that decline has brought MSC-5YR expectations closer to the Federal Reserve's target, the downward movement itself indicates that level anchoring has yet to be achieved.

Two features of the MSC data, in particular, can help us better understand the levels of the aggregate measures of consumers' inflation expectations. First, there is a wide dispersion of expectations among MSC respondents at any given time (see Figure 9). Second, that wide distribution of expectations has shifted over time, but it has done so with a substantial lag behind changes in actual inflation. For example, in the early 1990s, nearly half of MSC respondents expected the average inflation over the next five years to be 5 percent or higher. That fraction has declined over the years—reaching 22 percent by 1998—but as of today, it has nevertheless remained above 15 percent. Meanwhile, at any given time, there is always a nontrivial fraction of respondents who expect price levels to fall over the next five years. Many factors may have contributed to such a wide dispersion of expectations, including the ambiguity of the language used in the survey and possible systematic cognitive bias in the respondents (Thomas, 1999; Mehra, 2002; and Souleles, 2014, among others).[19]

The wide and relatively stable distribution of inflation expectations reported by the MSC has several important implications. One implication of having a substantial fraction of consumers whose inflation expectations are significantly higher than the average of inflation in recent history is that the mean and the median of MSC respondents' expectations are consistently higher than the average of actual inflation. The median MSC-5YR expectation for the years 1998 to 2013 hovered around 2.9 percent, but average CPI inflation in those years was actually only about 2.3 percent, and the average core CPI inflation was only about 2.1 percent. As a result, economists have long believed that only the contour—not the level—of consumers' inflation expectations matters for actual inflation dynamics (Yellen, 2015, among others).

[19] The MSC asks households about the changes in "prices in general" rather than about any specific measure, such as the CPI or the PCE price index. The question for year-ahead inflation expectation has two parts: (1) "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 (2) "By about what percent do you expect prices to go (up/down) on the average, during the next 12 months?" Also, only whole numbers are accepted, which further complicates the interpretation of the aggregate measures. For a discussion of adjusting the survey data to account for bias, see Ang, Bekaert, and Wei (2007).

Figure 9: Distribution of Long-Run Inflation Expectations Among MSC Respondents



Sources: University of Michigan Survey of Consumers; Bureau of Labor Statistics.

Another implication of a substantial fraction of consumers' having elevated inflation expectations is that when those consumers eventually adjust their expectations, the aggregate measures of inflation expectations would fall accordingly. Such a shift has been happening since 2014: After being stable—between 2.8 percent and 2.9 percent—for over a decade, the median MSC-5YR expectation started to decline markedly in the second half of 2014. By early 2018, it had fallen by almost one-half of one percentage point, to around 2.4 percent.[20] As Figure 9 shows, the decline in the median MSC-5YR expectation was driven by a decrease in the share of respondents who expected inflation to be very high in the future. As Verbrugge and Binder (2016) argue, that decrease in the share respondents with extremely high inflation expectations reflects, in part, a decline in consumers' uncertainty about future inflation.[21] Although it is reasonable to argue that the downward trend in MSC-5YR since the second half of 2014 represents a move toward better anchoring of consumers' long-run inflation expectations, it is

[20] A similar downward trend is also present in the data from the Survey of Consumer Expectations conducted by the Federal Reserve Bank of New York.

[21] It is unclear what triggered the decline in uncertainty about future inflation at that particular time because inflation has been relatively stable (certainly well below 5 percent) for more than two decades.

unclear whether the current distribution of expectations among MSC respondents will remain stable or continue to shift.

Moreover, given that inflation has been relatively low for over two decades now, the long lag of adjustments in inflation expectations suggests that a substantial fraction of consumers do not pay attention to inflation developments or monetary policy goals in an environment in which inflation is low and stable.[22] By contrast, in previous eras, when inflation was high and rising, consumers and business paid close attention to developments in inflation.

Last but not least, the lack of salience of inflation in consumers' decisions also partially explains why their expectations have diverged from professional forecasters' expectations over time. When inflation was high, as it was in the 1970s, contracts were typically indexed for inflation, and professional forecasters' views on recent developments were regularly transmitted, along with their forecasts, to consumers and businesses via news programs and thus had a tangible impact on inflation. By contrast, as inflation fell over time and has stayed low for the past two decades, inflation indexing has become less important, and consumers and businesses seem to have largely stopped following professional forecasters on inflation. Thus, the transmission from professional forecasters to consumers and businesses has become much weaker (Pfajfar and Santoro, 2013; Peneva, Massaro, and Jorento, 2015). Indeed, Detmeister, Massaro, and Peneva (2015) found that the Federal Open Market Committee's January 2012 announcement of an explicit 2 percent objective for inflation had "some effect on professional forecasters' long-run inflation expectations, but not on households' expectations."

Whose Inflation Expectations Matter?

Given that professional forecasters' and consumers' inflation expectations have diverged substantially in terms of anchoring, a relevant question is whose inflation expectations matter for inflation dynamics in the Phillips-curve framework. Using a simple Phillips curve, Coibion, Gorodnichenko, and Kamdar (2018) show that, for the headline CPI inflation, consumers' short-run inflation expectations dominate professional forecasters' expectations and past inflation in terms of explaining and predicting inflation dynamics over the 2000–2014 period, in part because short-run MSC-1YR expectations respond significantly to the fluctuations in oil prices.

To answer the question more broadly, I estimated the Phillips curve equation using SPF and MSC data on inflation expectations as explanatory variables for 10 measures of inflation (three measures of overall inflation and seven measures of core inflation). For each measure, I ran regressions under 10 specifications that differed only in the way that inflation expectations were

[22] There is evidence to suggest that the same is true for firm managers. After conducting interviews with over 500 businesspeople responsible for purchasing and setting prices at a variety of companies, Bewley (2016) reported that none of them mentioned expectations about inflation or future Federal Reserve policy as a factor in their pricing decisions and even noted that "questions along this line provoked ridicule." See also Blinder et al. (1998).

modeled: For some, I used survey measures of short-run or long-run expectations alone, and for others, I used a weighted average of lagged inflation and survey measures of long-run inflation expectations. I also included the constant anchor (as presented in Table 3(a)) in the race for comparison. To control for the effects of the supply shocks, I included the relative prices of imported goods and energy in the regressions. Detailed results are presented in Appendix C, Tables C1 to C10. In each table, I report the estimated coefficients, the adjusted R^2, and the average 1-year-ahead root-mean-squared-errors (RMSEs) from out-of-sample forecasts for three recent periods: 2009Q1–2011Q4, 2012Q1–2014Q2, and 2014Q3–2018Q4.

The main takeaway from that exercise is that consumers' inflation expectations generally dominate professional forecasters' in terms of overall fitness and out-of-sample forecasting performance. In the majority of cases, using the household expectations in the Phillips curve yields a higher adjusted R^2 or a lower RMSE. (To show this, I highlighted the highest adjusted R^2 statistic and the lowest RMSE for each out-of-sample forecasting period in each table of Appendix C.) In addition to extending the finding of Coibion, Gorodnichenko, and Kamdar (2018) to a broader set of inflation measures, my results also suggest that the relevance of the consumers' expectations in the Phillips curve framework does not depend on high-frequency comovements with energy prices, because the effects of contemporaneous energy price shocks have been explicitly controlled for in those regressions. Also, in many cases, the best-performing specifications are the ones that use long-run MSC expectations, which, as I showed in the previous section, have been reasonably shock anchored.

But, more generally, why do consumers' inflation expectations seem to play a special role in explaining the inflation dynamics in the Phillips-curve framework? One theory is that consumers' inflation expectations are more similar to the expectations of firm managers (who are often considered the ultimate price setters) than professional forecasters' and financial investors' expectations are. According to Kumar et al. (2015), in surveys conducted in New Zealand, both the mean and dispersion of the surveyed firms' forecasts were much more aligned with consumers' expectations than they were with those of professional forecasters.

Consumers' and firms' expectations may be similar for two reasons. First, as Kumar et al. (2015) documented, most firm managers rely primarily on their personal shopping experience to form their inflation expectations. Second, households' expectations may inform firms' price-setting behavior. For example, firms are aware that consumers regard it as unfair for firms to raise prices in response to shifts in demand but acceptable to raise prices in response to increasing costs; they also know that consumers are willing to incur costs to punish firms that they deem to have behaved unfairly (Kahneman, Knetsch, and Thaler, 1986).

5. Conclusion

This paper investigated the state of inflation dynamics through the lens of the Phillips curve and assessed the degree of anchoring of inflation expectations. I first estimated a Phillips curve model with both past inflation and a constant anchor as explanatory variables over the 1999–2018 period for a variety of measures of consumer prices. My results show that the Phillips curve has shifted away from an accelerationist form toward a level form, but that shift is less complete for core inflation than it is for headline measures.

I then turned to empirical measures of inflation expectations and assessed their degree of anchoring. My analysis suggests that professional forecasters' short-run and long-run expectations have been well anchored over the 1999–2018 period; consumers' inflation expectations, however, have been much less anchored. Specifically, consumers' long-run inflation expectations, as reported in the MSC, are shock anchored but not level anchored, and their short-run expectations are neither shock anchored nor level anchored. Furthermore, regressions using survey measures of inflation expectations indicate that consumers' expectations dominate professional forecasters' expectations in explaining the dynamics of inflation over the past two decades.

Taken together, those findings suggest that both the Phillips curve and inflation expectations are currently in a transitional period. Whether the process of anchoring will continue or reverse probably depends on many factors, including how stable inflation remains, how consumers form their inflation expectations, and how those expectations change over time. In the long run, monetary policy presumably plays a key role in shaping those expectations by influencing the average rate of inflation experienced over long periods of time and by providing guidance about the central bank's objectives for inflation in the future. In the short run and medium run, however, it is unclear how much monetary policy can influence inflation expectations, particularly those of consumers (who are typically less informed about the central bank's policies than professional forecasters are), in part because economists' understanding of how consumers (and businesses) form their expectations is still limited.[23] Research in this area is therefore critical for furthering our understanding of inflation dynamics and improving the conduct of monetary policy.

Finally, my analysis also shows that there is still a meaningful Phillips-curve relationship between inflation and slack, particularly for service categories. Inflation in the prices of goods, however, appears to have been counter-cyclical or noncyclical over the past twenty years, most likely reflecting a combination of factors: competition from imports, the rise of e-commerce, and measurement issues, to name a few. That finding helps explain the flatness of the Phillips curve

[23] Coibion, Gorodnichenko, and Kamdar (2018), among others, provide evidence against the rational expectation hypothesis.

on the aggregate level as well as the variation in cyclical sensitivity among the different aggregate inflation measures.

Appendix A.
Stability Checks

To assess the stability of the estimates, I estimated equation (1) unrestricted on recursive samples that all start in 1999Q1 but end in various dates. Results show that for most inflation measures, the time path of the sum of the coefficient on past inflation and the slope of the Phillips curve have been quite stable in recent years (see Figures A1 and A2).

Figure A1: Stability Checks—Estimated Coefficients on Lagged Inflation (Unrestricted)

(Recursive Samples: [1999Q1, t])

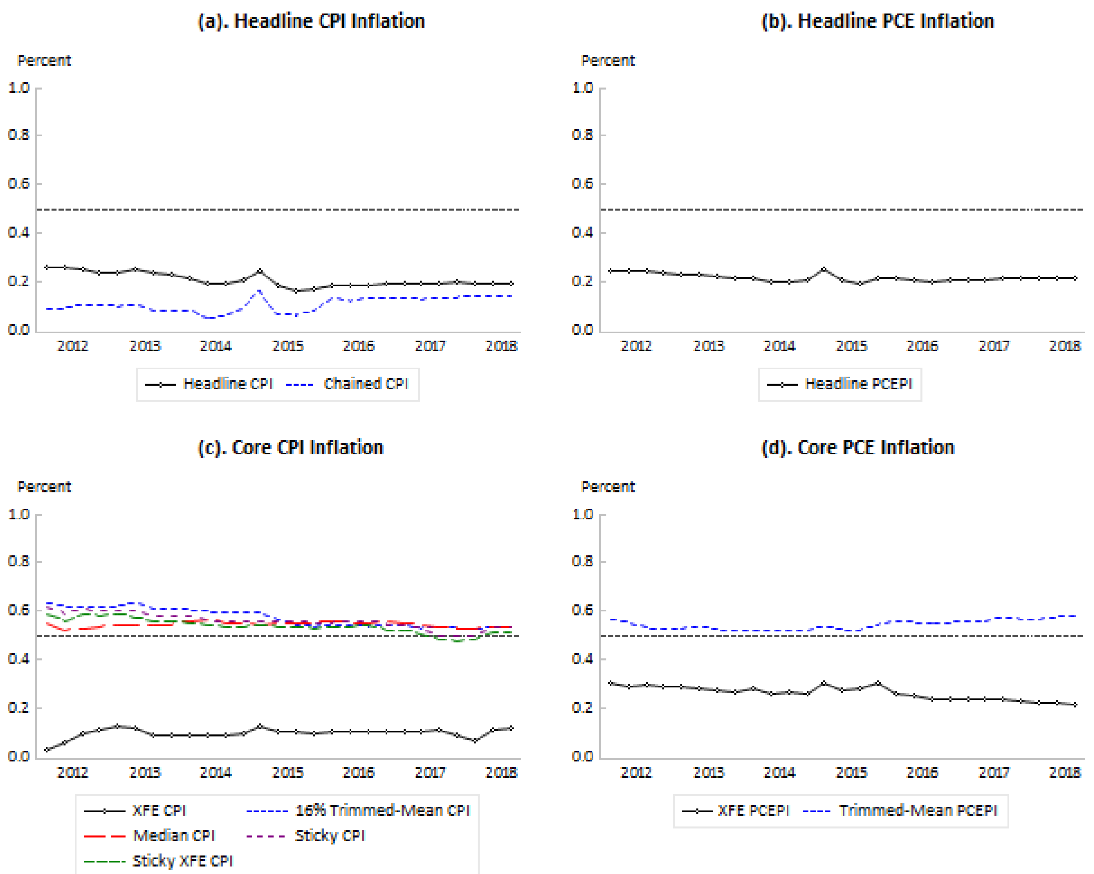
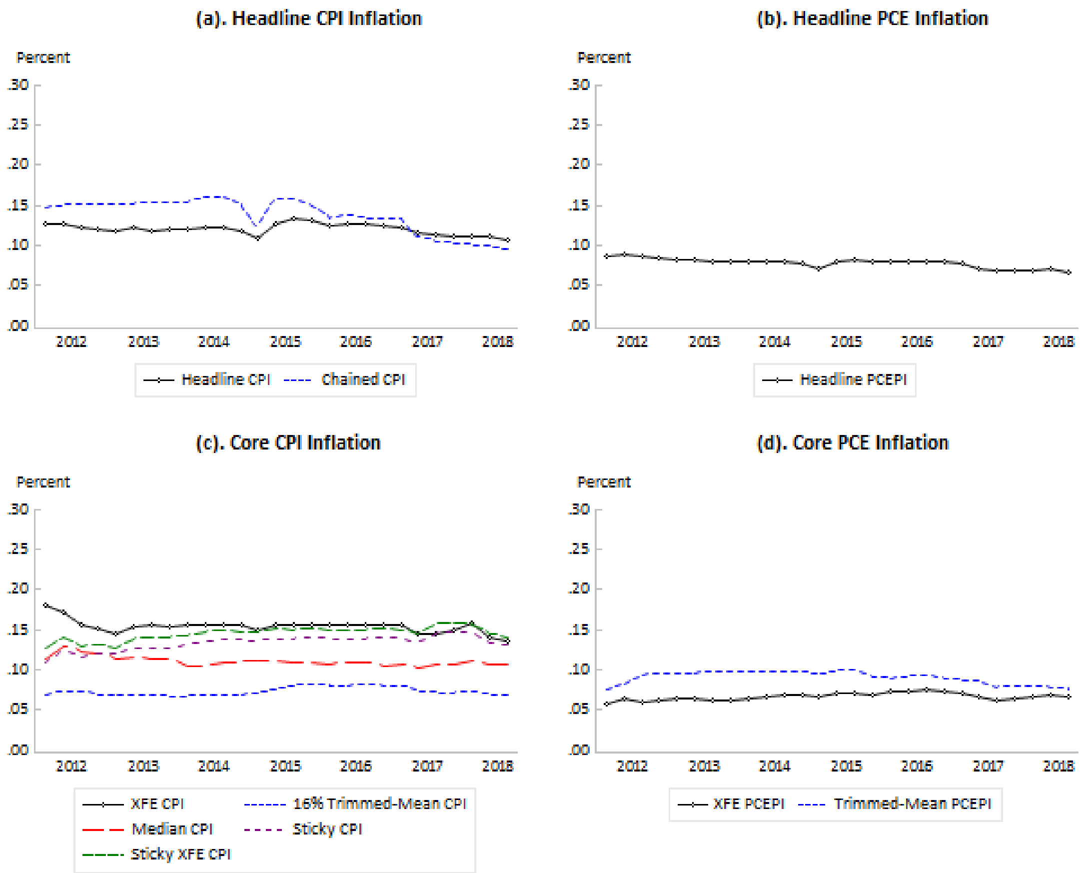


Figure A2: Stability Checks—Estimated Coefficients on Unemployment Gap (Unrestricted)

(Recursive Samples: [1999Q1, t])



Appendix B.
Inflation Expectations of Financial Market Participants

There are currently two measures of the inflation expectations of participants in financial markets. The first measure is the TIPS breakeven inflation rate, which is based on the difference in yields between Treasury inflation-protected securities (TIPS) and nominal Treasuries of the same maturity. The second measure is based on inflation swaps, a financial derivative in which investors swap a fixed payment for payments based on the consumer price index.

The main advantage of market-based measures of inflation expectations is that updated data are available more frequently than they are for other measures. Compared with survey-based measures of the inflation expectations of professional forecasters and consumers, which are often conducted monthly or quarterly, updated measures based on new financial market data are often available daily. Also, they are available for more continuous forecasting horizons.

However, market-based measures on inflation expectations also suffer from two major disadvantages. First, they are typically affected by factors that are unrelated to inflation, such as risk premiums and, in the case of TIPS, liquidity premiums (differences in the liquidity of TIPS and nominal securities). As a result, market-based measures are highly imperfect representations of the underlying inflation expectations (Christensen, Lopez, and Rudebusch, 2010; D'Amico, Kim, and Wei, 2018; Gürkaynak, Sack, and Wright, 2010). Second, historical data on market-based measures are limited—TIPS started trading in 1997, and inflation swaps were not traded at a meaningful volume until 2003—which limits their usefulness in time series analyses.

The evidence regarding the anchoring of market-based inflation expectations is mixed. Celasun, Mihet, and Ratnovski (2012) found that oil price shocks have a statistically significant, but economically small, impact on inflation compensation in Treasury bonds. Meanwhile, other studies have found that far-ahead forward inflation compensation in the United States exhibits substantial volatility, especially at low frequencies, and displays a high sensitivity to economic news. In addition, some studies suggest that the financial crisis of 2007 to 2008 had a long-lasting, disruptive impact on the stability of inflation expectations embedded in the prices of financial assets. For example, Nautz and Strohsal (2015) suggest that the market-based inflation expectations were "de-anchored" following the outbreak of the crisis and had not been "re-anchored" since.

Appendix C.
The Phillips Curve With
Survey Measures of Inflation Expectations

To answer the question, "Whose inflation expectations matter?" I estimated the Phillips curve equation using data on inflation expectations from the Survey of Professional Forecasters (SPF) and the University of Michigan Survey of Consumers (MSC). For each of the 10 measures of inflation (three measures of overall inflation and seven measures of core inflation), I ran regressions under 10 specifications that differed only in the way that inflation expectations were modeled: For some, I used survey measures of short-run (SR) or long-run (LR) expectations alone, and for others, I used a weighted average of lagged inflation and survey measures of long-run inflation expectations. I also included the constant anchor (as presented in Table 3(a)) in the comparison. Tables C1 to C10 present detailed estimation results as well as the mean root-mean-squared-error (RMSE) for different subperiods as part of the out-of-sample forecast evaluation.

Table C1: Estimation Results for Headline CPI-U Inflation

	Hybrid: Lagged + LR Expectations				Survey LR Expectations			Survey SR Expectations		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Inflation Expectations:										
Lagged CPIU Inflation	**0.201**	**0.109**	**0.304**	**0.248**						
	(0.084)	*(0.088)*	*(0.100)*	*(0.093)*						
"Anchor" (= 2.5)	**0.799**									
	(0.084)									
SPF-CPI-10YR		**0.891**			**0.891**					
		(0.088)			*(0.037)*					
MSC-5YR (Median)			**0.696**			**0.764**				
			(0.100)			*(0.030)*				
MSC-5YR (Mean)				**0.752**			**0.797**			
				(0.093)			*(0.033)*			
SPF-CPI-1YR								**0.936**		
								(0.036)		
MSC-1YR (Median)									**0.738**	
									(0.028)	
MSC-1YR (Mean)										**0.791**
										(0.030)
Slack:										
Unemployment Gap	**-0.200**	**-0.179**	**-0.243**	**-0.223**	**-0.145**	**-0.173**	**-0.152**	**-0.041**	**-0.230**	**-0.225**
	(0.051)	*(0.048)*	*(0.063)*	*(0.057)*	*(0.050)*	*(0.048)*	*(0.050)*	*(0.046)*	*(0.047)*	*(0.048)*
Supply-Side Shocks:										
Import Prices	**1.370**	**1.286**	**1.331**	**1.357**	**1.345**	**1.336**	**1.403**	**1.276**	**0.858**	**1.053**
	(0.356)	*(0.338)*	*(0.427)*	*(0.402)*	*(0.286)*	*(0.275)*	*(0.283)*	*(0.271)*	*(0.258)*	*(0.262)*
Energy Prices	**1.345**	**1.361**	**1.258**	**1.307**	**1.448**	**1.441**	**1.460**	**1.449**	**1.361**	**1.383**
	(0.092)	*(0.088)*	*(0.111)*	*(0.103)*	*(0.091)*	*(0.088)*	*(0.090)*	*(0.087)*	*(0.085)*	*(0.085)*
Adjusted R^2	**0.86**	**0.87**	**0.81**	**0.84**	**0.88**	**0.88**	**0.88**	**0.89**	**0.89**	**0.90**
Observations	**79**	**79**	**79**	**76**	**79**	**79**	**76**	**79**	**79**	**76**
Mean RMSE: 2009Q1-11Q4	**0.97**	**0.99**	**1.03**	**0.95**	**1.09**	**1.00**	**0.99**	**0.90**	**0.93**	**0.90**
Mean RMSE: 2012Q1-14Q2	**0.59**	**0.59**	**0.65**	**0.66**	**0.63**	**0.55**	**0.56**	**0.59**	**0.49**	**0.49**
Mean RMSE: 2014Q3-17Q4	**0.73**	**0.56**	**0.69**	**0.71**	**0.34**	**0.29**	**0.33**	**0.35**	**0.31**	**0.36**

Table C2: Estimation Results for Chained CPI-U Inflation

	Hybrid: Lagged + LR Expectations				Survey LR Expectations			Survey SR Expectations		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Inflation Expectations:										
Lagged CPIU Inflation	**0.233**	**0.135**	**0.354**	**0.306**						
	(0.124)	*(0.135)*	*(0.133)*	*(0.130)*						
"Anchor" (= 2.5)	**0.767**									
	(0.124)									
SPF-CPI-10YR		**0.865**			**0.805**					
		(0.135)			*(0.055)*					
MSC-5YR (Median)			**0.646**			**0.690**				
			(0.133)			*(0.046)*				
MSC-5YR (Mean)				**0.694**			**0.716**			
				(0.130)			*(0.048)*			
SPF-CPI-1YR								**0.837**		
								(0.057)		
MSC-1YR (Median)									**0.658**	
									(0.044)	
MSC-1YR (Mean)										**0.701**
										(0.046)
Slack:										
Unemployment Gap	**-0.261**	**-0.243**	**-0.307**	**-0.276**	**-0.130**	**-0.155**	**-0.130**	**-0.027**	**-0.195**	**-0.185**
	(0.077)	*(0.075)*	*(0.090)*	*(0.084)*	*(0.074)*	*(0.073)*	*(0.073)*	*(0.070)*	*(0.075)*	*(0.074)*
Supply-Side Shocks:										
Import Prices	**1.762**	**1.744**	**1.615**	**1.740**	**1.702**	**1.697**	**1.767**	**1.649**	**1.255**	**1.451**
	(0.569)	*(0.557)*	*(0.629)*	*(0.612)*	*(0.396)*	*(0.387)*	*(0.393)*	*(0.394)*	*(0.388)*	*(0.382)*
Energy Prices	**1.166**	**1.163**	**1.124**	**1.142**	**1.257**	**1.249**	**1.265**	**1.254**	**1.177**	**1.198**
	(0.143)	*(0.141)*	*(0.161)*	*(0.154)*	*(0.128)*	*(0.125)*	*(0.126)*	*(0.127)*	*(0.129)*	*(0.125)*
Adjusted R^2	**0.74**	**0.75**	**0.70**	**0.71**	**0.78**	**0.79**	**0.79**	**0.79**	**0.79**	**0.79**
Observations	**66**	**66**	**66**	**66**	**70**	**70**	**70**	**70**	**70**	**70**
Mean RMSE: 2009Q1-11Q4	**1.67**	**1.73**	**1.82**	**1.73**	**1.30**	**1.21**	**1.19**	**1.18**	**1.17**	**1.15**
Mean RMSE: 2012Q1-14Q2	**0.74**	**0.70**	**0.75**	**0.77**	**0.67**	**0.60**	**0.60**	**0.68**	**0.56**	**0.60**
Mean RMSE: 2014Q3-17Q4	**1.11**	**0.96**	**1.03**	**1.08**	**0.56**	**0.54**	**0.66**	**0.58**	**0.56**	**0.68**

Table C3: Estimation Results for Headline PCE Inflation

	Hybrid: Lagged + LR Expectations				Survey LR Expectations			Survey SR Expectations		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Inflation Expectations:										
Lagged CPIU Inflation	**0.211**	**0.199**	**0.668**	**0.592**						
	(0.086)	*(0.093)*	*(0.090)*	*(0.092)*						
"Anchor" (= 2.0)	**0.789**									
	(0.086)									
SPF-PCE-10YR		**0.801**			**0.884**					
		(0.093)			*(0.036)*					
MSC-5YR (Median)			**0.332**			**0.652**				
			(0.090)			*(0.026)*				
MSC-5YR (Mean)				**0.408**			**0.677**			
				(0.092)			*(0.028)*			
SPF-CPI-1YR								**0.797**		
								(0.032)		
MSC-1YR (Median)									**0.629**	
									(0.024)	
MSC-1YR (Mean)										**0.672**
										(0.026)
Slack:										
Unemployment Gap	**-0.112**	**-0.141**	**-0.150**	**-0.155**	**-0.111**	**-0.105**	**-0.083**	**0.009**	**-0.152**	**-0.145**
	(0.039)	*(0.042)*	*(0.059)*	*(0.057)*	*(0.043)*	*(0.041)*	*(0.043)*	*(0.040)*	*(0.041)*	*(0.041)*
Supply-Side Shocks:										
Import Prices	**1.200**	**1.210**	**0.817**	**0.925**	**1.263**	**1.223**	**1.281**	**1.168**	**0.812**	**0.984**
	(0.285)	*(0.296)*	*(0.406)*	*(0.400)*	*(0.243)*	*(0.235)*	*(0.243)*	*(0.237)*	*(0.226)*	*(0.224)*
Energy Prices	**0.893**	**0.864**	**0.824**	**0.827**	**0.955**	**0.948**	**0.967**	**0.957**	**0.882**	**0.902**
	(0.074)	*(0.077)*	*(0.109)*	*(0.104)*	*(0.078)*	*(0.075)*	*(0.077)*	*(0.076)*	*(0.075)*	*(0.073)*
Adjusted R^2	**0.83**	**0.82**	**0.69**	**0.72**	**0.83**	**0.85**	**0.84**	**0.84**	**0.85**	**0.86**
Observations	**79**	**79**	**79**	**76**	**79**	**79**	**76**	**79**	**79**	**76**
Mean RMSE: 2009Q1-11Q4	**0.82**	**0.80**	**1.36**	**1.21**	**0.72**	**0.74**	**0.75**	**0.73**	**0.55**	**0.53**
Mean RMSE: 2012Q1-14Q2	**0.43**	**0.46**	**0.58**	**0.50**	**0.47**	**0.41**	**0.42**	**0.44**	**0.36**	**0.38**
Mean RMSE: 2014Q3-17Q4	**0.47**	**0.50**	**0.69**	**0.64**	**0.34**	**0.27**	**0.30**	**0.32**	**0.31**	**0.35**

Table C4: Estimation Results for Core (XFE) PCE Inflation

	Hybrid: Lagged + LR Expectations				Survey LR Expectations			Survey SR Expectations		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Inflation Expectations:										
Lagged CPIU Inflation	**0.376**	**0.450**	**0.884**	**0.848**						
	(0.157)	*(0.151)*	*(0.070)*	*(0.078)*						
"Anchor" (= 2.0)	**0.624**									
	(0.157)									
SPF-PCE-10YR		**0.550**			**0.873**					
		(0.151)			*(0.033)*					
MSC-5YR (Median)			**0.116**			**0.642**				
			(0.070)			*(0.024)*				
MSC-5YR (Mean)				**0.152**			**0.666**			
				(0.078)			*(0.026)*			
SPF-CPI-1YR								**0.785**		
								(0.030)		
MSC-1YR (Median)									**0.608**	
									(0.025)	
MSC-1YR (Mean)										**0.655**
										(0.025)
Slack:										
Unemployment Gap	**-0.086**	**-0.098**	**-0.052**	**-0.056**	**-0.102**	**-0.094**	**-0.069**	**0.019**	**-0.135**	**-0.128**
	(0.041)	*(0.044)*	*(0.046)*	*(0.046)*	*(0.039)*	*(0.039)*	*(0.040)*	*(0.038)*	*(0.043)*	*(0.040)*
Supply-Side Shocks:										
Import Prices	**0.603**	**0.573**	**0.476**	**0.500**	**0.490**	**0.444**	**0.502**	**0.382**	**0.050**	**0.212**
	(0.231)	*(0.233)*	*(0.254)*	*(0.258)*	*(0.222)*	*(0.221)*	*(0.225)*	*(0.225)*	*(0.232)*	*(0.219)*
Energy Prices	**0.055**	**0.051**	**0.087**	**0.083**	**0.085**	**0.079**	**0.091**	**0.082**	**0.047**	**0.042**
	(0.068)	*(0.070)*	*(0.077)*	*(0.077)*	*(0.068)*	*(0.068)*	*(0.069)*	*(0.069)*	*(0.073)*	*(0.068)*
Adjusted R^2	**0.22**	**0.20**	**0.09**	**0.11**	**0.26**	**0.26**	**0.27**	**0.23**	**0.15**	**0.29**
Observations	**80**	**80**	**80**	**77**	**80**	**80**	**77**	**80**	**80**	**77**
Mean RMSE: 2009Q1-11Q4	**0.98**	**1.00**	**1.12**	**1.12**	**0.77**	**0.82**	**0.82**	**0.85**	**0.69**	**0.68**
Mean RMSE: 2012Q1-14Q2	**0.34**	**0.35**	**0.38**	**0.37**	**0.30**	**0.28**	**0.31**	**0.29**	**0.27**	**0.31**
Mean RMSE: 2014Q3-17Q4	**0.39**	**0.42**	**0.50**	**0.53**	**0.35**	**0.36**	**0.35**	**0.37**	**0.41**	**0.41**

Table C5: Estimation Results for Trimmed-Mean PCE Inflation

	Hybrid: Lagged + LR Expectations				Survey LR Expectations			Survey SR Expectations		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Inflation Expectations:										
Lagged CPIU Inflation	**0.595**	**0.524**	**0.945**	**0.901**						
	(0.117)	*(0.128)*	*(0.061)*	*(0.072)*						
"Anchor" (= 2.0)	**0.405**									
	(0.117)									
SPF-PCE-10YR		**0.476**			**1.013**					
		(0.128)			*(0.025)*					
MSC-5YR (Median)			**0.055**			**0.746**				
			(0.061)			*(0.017)*				
MSC-5YR (Mean)				**0.099**			**0.780**			
				(0.072)			*(0.019)*			
SPF-CPI-1YR								**0.912**		
								(0.022)		
MSC-1YR (Median)									**0.710**	
									(0.018)	
MSC-1YR (Mean)										**0.768**
										(0.018)
Slack:										
Unemployment Gap	**-0.067**	**-0.094**	**-0.031**	**-0.042**	**-0.197**	**-0.189**	**-0.168**	**-0.058**	**-0.240**	**-0.237**
	(0.028)	*(0.031)*	*(0.032)*	*(0.033)*	*(0.029)*	*(0.028)*	*(0.029)*	*(0.029)*	*(0.031)*	*(0.028)*
Supply-Side Shocks:										
Import Prices	**0.031**	**0.039**	**0.082**	**0.094**	**0.142**	**0.091**	**0.152**	**0.018**	**-0.359**	**-0.185**
	(0.139)	*(0.138)*	*(0.157)*	*(0.161)*	*(0.166)*	*(0.158)*	*(0.166)*	*(0.168)*	*(0.167)*	*(0.153)*
Energy Prices	**0.138**	**0.125**	**0.119**	**0.114**	**0.111**	**0.103**	**0.115**	**0.107**	**0.062**	**0.056**
	(0.040)	*(0.040)*	*(0.048)*	*(0.048)*	*(0.051)*	*(0.048)*	*(0.051)*	*(0.052)*	*(0.053)*	*(0.048)*
Adjusted R^2	**0.65**	**0.66**	**0.59**	**0.60**	**0.51**	**0.56**	**0.54**	**0.50**	**0.49**	**0.59**
Observations	**80**	**80**	**80**	**77**	**80**	**80**	**77**	**80**	**80**	**77**
Mean RMSE: 2009Q1-11Q4	**0.54**	**0.51**	**0.76**	**0.75**	**0.56**	**0.64**	**0.65**	**0.72**	**0.55**	**0.53**
Mean RMSE: 2012Q1-14Q2	**0.23**	**0.24**	**0.33**	**0.34**	**0.26**	**0.28**	**0.31**	**0.31**	**0.32**	**0.38**
Mean RMSE: 2014Q3-17Q4	**0.26**	**0.28**	**0.29**	**0.32**	**0.30**	**0.20**	**0.24**	**0.25**	**0.29**	**0.29**

Table C6: Estimation Results for Core (XFE) CPIU Inflation

	Hybrid: Lagged + LR Expectations				Survey LR Expectations			Survey SR Expectations		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Inflation Expectations:										
Lagged CPIU Inflation	**0.604**	**0.516**	**0.867**	**0.760**						
	(0.149)	*(0.167)*	*(0.104)*	*(0.120)*						
"Anchor" (= 2.5)	**0.396**									
	(0.149)									
SPF-CPI-10YR		**0.484**			**0.876**					
		(0.167)			*(0.030)*					
MSC-5YR (Median)			**0.133**			**0.750**				
			(0.104)			*(0.025)*				
MSC-5YR (Mean)				**0.240**			**0.784**			
				(0.120)			*(0.027)*			
SPF-CPI-1YR								**0.919**		
								(0.031)		
MSC-1YR (Median)									**0.710**	
									(0.026)	
MSC-1YR (Mean)										**0.769**
										(0.027)
Slack:										
Unemployment Gap	**-0.094**	**-0.098**	**-0.033**	**-0.063**	**-0.151**	**-0.178**	**-0.156**	**-0.046**	**-0.225**	**-0.224**
	(0.057)	*(0.055)*	*(0.055)*	*(0.055)*	*(0.042)*	*(0.041)*	*(0.042)*	*(0.039)*	*(0.046)*	*(0.043)*
Supply-Side Shocks:										
Import Prices	**0.219**	**0.133**	**0.166**	**0.152**	**-0.032**	**-0.046**	**0.019**	**-0.115**	**-0.508**	**-0.325**
	(0.244)	*(0.238)*	*(0.254)*	*(0.255)*	*(0.238)*	*(0.231)*	*(0.235)*	*(0.232)*	*(0.250)*	*(0.232)*
Energy Prices	**0.079**	**0.080**	**0.110**	**0.099**	**0.112**	**0.103**	**0.115**	**0.106**	**0.067**	**0.059**
	(0.074)	*(0.073)*	*(0.079)*	*(0.078)*	*(0.073)*	*(0.071)*	*(0.072)*	*(0.071)*	*(0.079)*	*(0.073)*
Adjusted R^2	**0.22**	**0.24**	**0.16**	**0.20**	**0.25**	**0.30**	**0.31**	**0.29**	**0.15**	**0.30**
Observations	**80**	**80**	**80**	**77**	**80**	**80**	**77**	**80**	**80**	**77**
Mean RMSE: 2009Q1-11Q4	**0.80**	**0.80**	**0.97**	**0.91**	**0.94**	**0.86**	**0.84**	**0.86**	**0.85**	**0.83**
Mean RMSE: 2012Q1-14Q2	**0.44**	**0.39**	**0.48**	**0.49**	**0.38**	**0.37**	**0.40**	**0.38**	**0.36**	**0.38**
Mean RMSE: 2014Q3-17Q4	**0.50**	**0.44**	**0.48**	**0.46**	**0.42**	**0.41**	**0.40**	**0.42**	**0.47**	**0.45**

Table C7: Estimation Results for Trimmed-Mean CPI Inflation

	Hybrid: Lagged + LR Expectations				Survey LR Expectations			Survey SR Expectations		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Inflation Expectations:										
Lagged CPIU Inflation	**0.689**	**0.662**	**0.842**	**0.773**						
	(0.107)	*(0.127)*	*(0.081)*	*(0.092)*						
"Anchor" (= 2.5)	**0.311**									
	(0.107)									
SPF-CPI-10YR		**0.338**			**0.931**					
		(0.127)			*(0.027)*					
MSC-5YR (Median)			**0.158**			**0.799**				
			(0.081)			*(0.022)*				
MSC-5YR (Mean)				**0.227**			**0.831**			
				(0.092)			*(0.025)*			
SPF-CPI-1YR								**0.979**		
								(0.027)		
MSC-1YR (Median)									**0.765**	
									(0.020)	
MSC-1YR (Mean)										**0.823**
										(0.021)
Slack:										
Unemployment Gap	**-0.071**	**-0.063**	**-0.052**	**-0.062**	**-0.147**	**-0.176**	**-0.149**	**-0.037**	**-0.234**	**-0.227**
	(0.037)	*(0.036)*	*(0.038)*	*(0.037)*	*(0.038)*	*(0.035)*	*(0.038)*	*(0.034)*	*(0.034)*	*(0.033)*
Supply-Side Shocks:										
Import Prices	**0.722**	**0.649**	**0.714**	**0.722**	**0.600**	**0.588**	**0.661**	**0.515**	**0.116**	**0.311**
	(0.187)	*(0.186)*	*(0.196)*	*(0.198)*	*(0.216)*	*(0.201)*	*(0.212)*	*(0.201)*	*(0.186)*	*(0.179)*
Energy Prices	**0.233**	**0.241**	**0.234**	**0.231**	**0.200**	**0.189**	**0.202**	**0.191**	**0.140**	**0.135**
	(0.054)	*(0.054)*	*(0.059)*	*(0.058)*	*(0.066)*	*(0.062)*	*(0.065)*	*(0.062)*	*(0.059)*	*(0.056)*
Adjusted R^2	**0.69**	**0.69**	**0.68**	**0.68**	**0.54**	**0.60**	**0.58**	**0.60**	**0.65**	**0.69**
Observations	**80**	**80**	**80**	**77**	**80**	**80**	**77**	**80**	**80**	**77**
Mean RMSE: 2009Q1-11Q4	**0.74**	**0.74**	**0.84**	**0.81**	**0.79**	**0.74**	**0.74**	**0.79**	**0.67**	**0.66**
Mean RMSE: 2012Q1-14Q2	**0.36**	**0.40**	**0.40**	**0.36**	**0.37**	**0.32**	**0.34**	**0.41**	**0.32**	**0.36**
Mean RMSE: 2014Q3-17Q4	**0.39**	**0.40**	**0.42**	**0.46**	**0.25**	**0.21**	**0.25**	**0.24**	**0.25**	**0.28**

Table C8: Estimation Results for Median CPI Inflation

	Hybrid: Lagged + LR Expectations				Survey LR Expectations			Survey SR Expectations		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Inflation Expectations:										
Lagged CPIU Inflation	**0.532**	**0.600**	**0.644**	**0.553**						
	(0.122)	*(0.112)*	*(0.117)*	*(0.127)*						
"Anchor" (= 2.5)	**0.468**									
	(0.122)									
SPF-CPI-10YR		**0.400**			**1.067**					
		(0.112)			*(0.027)*					
MSC-5YR (Median)			**0.356**			**0.914**				
			(0.117)			*(0.021)*				
MSC-5YR (Mean)				**0.447**			**0.950**			
				(0.127)			*(0.024)*			
SPF-CPI-1YR								**1.120**		
								(0.027)		
MSC-1YR (Median)									**0.868**	
									(0.023)	
MSC-1YR (Mean)										**0.935**
										(0.023)
Slack:										
Unemployment Gap	**-0.104**	**-0.070**	**-0.107**	**-0.114**	**-0.235**	**-0.268**	**-0.235**	**-0.108**	**-0.328**	**-0.319**
	(0.041)	*(0.036)*	*(0.048)*	*(0.045)*	*(0.037)*	*(0.035)*	*(0.036)*	*(0.034)*	*(0.040)*	*(0.036)*
Supply-Side Shocks:										
Import Prices	**0.120**	**0.043**	**0.218**	**0.182**	**0.066**	**0.049**	**0.134**	**-0.035**	**-0.507**	**-0.280**
	(0.167)	*(0.174)*	*(0.170)*	*(0.172)*	*(0.211)*	*(0.198)*	*(0.205)*	*(0.199)*	*(0.217)*	*(0.196)*
Energy Prices	**0.126**	**0.142**	**0.078**	**0.095**	**0.071**	**0.059**	**0.075**	**0.062**	**0.011**	**0.005**
	(0.048)	*(0.049)*	*(0.053)*	*(0.051)*	*(0.065)*	*(0.061)*	*(0.062)*	*(0.061)*	*(0.068)*	*(0.061)*
Adjusted R^2	**0.72**	**0.72**	**0.70**	**0.71**	**0.55**	**0.60**	**0.59**	**0.60**	**0.50**	**0.62**
Observations	**80**	**80**	**80**	**77**	**80**	**80**	**77**	**80**	**80**	**77**
Mean RMSE: 2009Q1-11Q4	**0.50**	**0.50**	**0.51**	**0.51**	**0.72**	**0.75**	**0.75**	**0.83**	**0.72**	**0.68**
Mean RMSE: 2012Q1-14Q2	**0.33**	**0.41**	**0.26**	**0.25**	**0.34**	**0.22**	**0.22**	**0.34**	**0.27**	**0.25**
Mean RMSE: 2014Q3-17Q4	**0.34**	**0.38**	**0.34**	**0.36**	**0.29**	**0.29**	**0.31**	**0.31**	**0.35**	**0.36**

Table C9: Estimation Results for Sticky CPI Inflation

	Hybrid: Lagged + LR Expectations				Survey LR Expectations			Survey SR Expectations		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Inflation Expectations:										
Lagged CPIU Inflation	**0.532**	**0.560**	**0.667**	**0.582**						
	(0.139)	*(0.127)*	*(0.118)*	*(0.131)*						
"Anchor" (= 2.5)	**0.468**									
	(0.139)									
SPF-CPI-10YR		**0.440**			**1.063**					
		(0.127)			*(0.026)*					
MSC-5YR (Median)			**0.333**			**0.910**				
			(0.118)			*(0.021)*				
MSC-5YR (Mean)				**0.418**			**0.951**			
				(0.131)			*(0.024)*			
SPF-CPI-1YR								**1.114**		
								(0.026)		
MSC-1YR (Median)									**0.861**	
									(0.024)	
MSC-1YR (Mean)										**0.935**
										(0.023)
Slack:										
Unemployment Gap	**-0.130**	**-0.105**	**-0.127**	**-0.135**	**-0.253**	**-0.285**	**-0.260**	**-0.126**	**-0.343**	**-0.344**
	(0.044)	*(0.037)*	*(0.048)*	*(0.046)*	*(0.036)*	*(0.035)*	*(0.037)*	*(0.034)*	*(0.042)*	*(0.037)*
Supply-Side Shocks:										
Import Prices	**-0.183**	**-0.279**	**-0.096**	**-0.141**	**-0.176**	**-0.197**	**-0.127**	**-0.280**	**-0.755**	**-0.543**
	(0.168)	*(0.173)*	*(0.170)*	*(0.172)*	*(0.204)*	*(0.196)*	*(0.207)*	*(0.198)*	*(0.227)*	*(0.201)*
Energy Prices	**0.145**	**0.161**	**0.101**	**0.120**	**0.076**	**0.066**	**0.082**	**0.070**	**0.022**	**0.012**
	(0.049)	*(0.049)*	*(0.053)*	*(0.052)*	*(0.062)*	*(0.060)*	*(0.063)*	*(0.061)*	*(0.071)*	*(0.063)*
Adjusted R^2	**0.68**	**0.69**	**0.67**	**0.68**	**0.55**	**0.58**	**0.56**	**0.57**	**0.42**	**0.57**
Observations	**80**	**80**	**80**	**77**	**80**	**80**	**77**	**80**	**80**	**77**
Mean RMSE: 2009Q1-11Q4	**0.58**	**0.58**	**0.53**	**0.56**	**0.70**	**0.73**	**0.73**	**0.79**	**0.76**	**0.69**
Mean RMSE: 2012Q1-14Q2	**0.29**	**0.31**	**0.37**	**0.35**	**0.31**	**0.30**	**0.35**	**0.33**	**0.33**	**0.36**
Mean RMSE: 2014Q3-17Q4	**0.37**	**0.38**	**0.38**	**0.37**	**0.37**	**0.34**	**0.39**	**0.36**	**0.42**	**0.45**

Table C10: Estimation Results for Sticky CPI (XFE) Inflation

	Hybrid: Lagged + LR Expectations				Survey LR Expectations			Survey SR Expectations		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Inflation Expectations:										
Lagged CPIU Inflation	**0.508**	**0.525**	**0.677**	**0.578**						
	(0.143)	*(0.132)*	*(0.120)*	*(0.134)*						
"Anchor" (= 2.5)	**0.492**									
	(0.143)									
SPF-CPI-10YR		**0.475**			**1.053**					
		(0.132)			*(0.028)*					
MSC-5YR (Median)			**0.323**			**0.901**				
			(0.120)			*(0.023)*				
MSC-5YR (Mean)				**0.422**			**0.942**			
				(0.134)			*(0.025)*			
SPF-CPI-1YR								**1.104**		
								(0.028)		
MSC-1YR (Median)									**0.851**	
									(0.026)	
MSC-1YR (Mean)										**0.925**
										(0.025)
Slack:										
Unemployment Gap	**-0.147**	**-0.123**	**-0.131**	**-0.145**	**-0.270**	**-0.301**	**-0.277**	**-0.144**	**-0.358**	**-0.359**
	(0.048)	*(0.042)*	*(0.052)*	*(0.050)*	*(0.038)*	*(0.037)*	*(0.039)*	*(0.035)*	*(0.045)*	*(0.041)*
Supply-Side Shocks:										
Import Prices	**-0.220**	**-0.326**	**-0.131**	**-0.173**	**-0.220**	**-0.241**	**-0.171**	**-0.322**	**-0.799**	**-0.586**
	(0.181)	*(0.186)*	*(0.186)*	*(0.187)*	*(0.216)*	*(0.211)*	*(0.220)*	*(0.210)*	*(0.247)*	*(0.220)*
Energy Prices	**0.153**	**0.171**	**0.115**	**0.130**	**0.089**	**0.079**	**0.094**	**0.082**	**0.037**	**0.026**
	(0.053)	*(0.052)*	*(0.058)*	*(0.056)*	*(0.066)*	*(0.065)*	*(0.067)*	*(0.064)*	*(0.078)*	*(0.069)*
Adjusted R^2	**0.66**	**0.66**	**0.64**	**0.65**	**0.53**	**0.55**	**0.54**	**0.55**	**0.36**	**0.52**
Observations	**80**	**80**	**80**	**77**	**80**	**80**	**77**	**80**	**80**	**77**
Mean RMSE: 2009Q1-11Q4	**0.66**	**0.65**	**0.58**	**0.64**	**0.77**	**0.79**	**0.78**	**0.83**	**0.83**	**0.76**
Mean RMSE: 2012Q1-14Q2	**0.33**	**0.34**	**0.41**	**0.40**	**0.35**	**0.34**	**0.38**	**0.36**	**0.37**	**0.38**
Mean RMSE: 2014Q3-17Q4	**0.40**	**0.41**	**0.41**	**0.40**	**0.40**	**0.38**	**0.43**	**0.39**	**0.46**	**0.49**

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