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The Nonpuzzling Behavior of Median Inflation

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For decades, textbooks have explained inflation behavior with Friedman (1968)'s Phillips curve: the inflation rate depends on expected inflation and the deviation of unemployment from its natural rate. Yet this theory has always been controversial, and skepticism has been rampant in the decade since the 2008 financial crisis. For several years following the crisis, researchers such as Stock (2011) and Coibion and Gorodnichenko (2015) puzzled over a "missing deflation:" inflation did not fall much despite a sharp rise in the unemployment rate. More recently, as the economy has approached full employment, economists have puzzled over the failure of inflation to rise toward the Federal Reserve's target of 2 percent. According to Bernstein (2017), recent low inflation is "puzzle #1 in economics."

Some observers, such as Summers (2017) and The Economist (2017), have lost patience with the Phillips curve and suggested it is "broken." Blinder (2018) wonders "whether the Phillips curve has died or has just taken an extended vacation." Blanchard (2016) offers a tepid defense of the theory, by saying the Phillips curve is alive and "at least as well as it has been in the past." Blanchard emphasizes that the residuals in the relationship are large.

This paper argues that inflation behavior is less puzzling if we separate the headline-inflation rate into two components: an

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underlying or core level of inflation that the Phillips curve explains, and a transitory component arising from changes in relative prices due to microeconomic factors. A good proxy for the core-inflation rate is a measure proposed by Bryan and Cecchetti (1994): the weighted median of price changes across industries.

Many previous researchers, and the policymakers at the Federal Reserve, examine core inflation in an effort to filter out transitory shocks. However, the usual measure of core inflation is the inflation rate excluding the prices of food and energy. This variable filters out shocks in the food and energy industries, but many other industries also experience large price changes that materially influence the headline-inflation rate. The weighted median filters out all of these shocks and produces a less noisy measure of core inflation whose movements are easier to understand.

Section 1 of this paper briefly reviews the theoretical case for measuring core inflation with the weighted median, and the previous empirical literature. Section 2 begins our empirical work by examining the univariate behavior of alternative measures of core inflation. We show that, for both the CPI and PCE (Personal Consumption Expenditure)-deflator versions of inflation, the weighted median of industry price changes is less volatile than inflation excluding food and energy.

Section 3 illustrates the usefulness of weighted-median inflation with a careful study of inflation over 2017 and early 2018. Some observers believe that inflation behavior was especially puzzling during that period: In particular, despite low unemployment rates, the Fed's preferred measure of core inflation—the twelve-month percentage change in the PCE deflator less food and energy—fell from 1.9 in December 2016 to 1.3 in August 2017 and to 1.5 in December. At a September press conference, Fed Chair Yellen said that low inflation before 2017 was consistent with the Fed's specification of the Phillips curve, but: "This year, the shortfall of inflation from 2 percent [...] is more of a mystery, and I will not say that the [Federal Open Market] Committee clearly understands what the causes are of that."

We show that this mystery disappears if we measure core inflation with the weighted-median inflation rate rather than inflation less food and energy. The weighted median does not fall significantly over 2017 because it filters out price decreases in a number of industries that pushed down the Fed's core-inflation measure. Examining the weighted median also helps resolve confusion among policymakers about an apparent uptick in core inflation in early 2018.

Section 4 turns to the Phillips curve. We examine the fit of a simple specification in which quarterly core inflation depends on expected inflation (as measured by long-term forecasts from the Survey of Professional Forecasters) and the cyclical component of unemployment (as measured by the Hodrick-Prescott filter). We first measure core inflation with inflation less food and energy and see the source of recent skepticism about the Phillips curve: the equation fits the data poorly, especially for inflation in the PCE deflator and especially since 2008. We then see that the Phillips curve shows up clearly when core inflation is measured more precisely with weighted median inflation.

All in all, our results suggest that economists should use the weighted-median or related variables (such as trimmed means of industry price changes) as their primary measures of core inflation. Researchers should also work on refining these measures. Section 5 concludes this paper by discussing directions for future research.

1. Background

According to the Phillips curve, the inflation rate depends on expected inflation and the level of slack in the economy. Economists often suggest, however, that inflation movements are also influenced by price changes in certain industries. We will discuss, for example, Chair Yellen's view that large price decreases for cell-phone services and prescription drugs reduced inflation during 2017. In earlier episodes, economists have explained high inflation with rising medical costs, and low inflation with falling prices of imported goods.

The practice of explaining aggregate inflation with industry price changes can, however, be dangerous. There are always some prices that rise by significantly more than the aggregate inflation rate and others that rise by less or fall; that is, there are always changes in relative prices. If the inflation rate is higher than the Phillips curve predicts, one can always find a cheap "explanation" by citing industries whose prices have risen by more than average; in turn, low inflation can be explained by industries with price decreases. To avoid such vacuity, we need a theory of which relative-price changes truly affect aggregate inflation.

Ball and Mankiw (1995) present such a theory, one in which relative-price changes matter if they are unusually large. This result arises because, with costs of nominal price adjustment, large shocks to industries' optimal prices induce them to change their actual prices, while prices are sticky in response to smaller shocks.

The disproportionate effects of large shocks imply that inflation is influenced by asymmetries in the distribution of price changes across industries. If there is a tail of unusually large price increases, which skew the distribution to the right, it raises inflation; in turn, a tail of large price decreases does the opposite. Ball and Mankiw find strong support for these predictions in U.S. data.

Measures of core inflation are intended to filter out the effects on headline inflation of unusual relative-price changes, thereby isolating the component of inflation explained by the Phillips curve. In pioneering work, Bryan and Cecchetti (1994) develop a measure of core inflation by extending the reasoning of Ball and Mankiw. If asymmetries in the price-change distribution cause fluctuations in headline inflation, then one can measure core inflation by eliminating the effects of these asymmetries. A simple variable that does so is the median of industry price changes, weighted by industries' relative importance in the aggregate price index.

The traditional measure of core inflation is the inflation rate excluding food and energy prices. In the U.S. economy, many of the large relative-price changes that influence inflation occur in the food and energy industries (especially energy), so dropping those industries is a step toward isolating the core level of inflation. However, large relative-price changes also occur in industries other than food and energy. Based on the disaggregated PCE deflator, Dolmas (2005) reports that large price changes are common in industries such as computers and software, televisions, clothing, airline services, financial services, and auto insurance. As we will see in our empirical work, filtering out large shocks to all industries with the weighted median yields a core-inflation measure that is less volatile and easier to understand than inflation less food and energy.

Weighted-median measures of core inflation—as well as trimmed means of industry price changes, which also filter out large shocks—have gained increasing attention in recent years. In 2016, the Bank of Canada announced that it would include a weighted median and a trimmed mean among its primary measures of core inflation. Yet most researchers still define core inflation as inflation excluding food and energy. Staff at the Federal Reserve produce forecasts of PCE-deflator inflation less food and energy, and this variable is a focus of FOMC meetings and speeches by Fed officials. We hope that this paper helps push economists and policymakers toward changing their measures of core inflation.

This paper studies the behavior of two versions of weighted-median inflation. One is the weighted-median CPI inflation rate published by the Cleveland Fed, which is currently based on dividing the basket of goods in the CPI into 45 industries. The other is a weighted-median PCE-deflator inflation rate that we have constructed from data on 178 industries provided by the Dallas Fed. Researchers at Dallas use these data to construct a trimmed-mean measure of core inflation; we construct a weighted median instead for comparability with the median CPI series. The relative merits of the weighted-median and trimmed-mean measures of core inflation are an important topic for future research.[1]

2. Univariate Evidence

This section examines the univariate behavior of headline inflation, inflation excluding food and energy, and weighted-median inflation. We examine the period 1985–2017. We find that both of the core-inflation measures filter out much of the transitory variation in headline inflation, but that the weighted median filters out more and is therefore less volatile.

Table 1 measures the volatility of each inflation series with the standard deviation of the change in inflation. We compute this statistic for both the CPI and PCE-deflator versions of inflation. We examine annualized monthly inflation rates, annualized quarterly inflation rates, and a monthly series on the inflation rate over the previous twelve months.[2]

The results in the table are consistent across the two price indices and the three data frequencies: the standard deviation of changes in inflation is smaller for inflation less food and energy than for headline inflation, but smaller still for weighted-median inflation. The ratio of the standard deviations of changes in ex-food-energy and median inflation range from 1.4 to 1.6 (except for monthly PCE data, where the ratio is higher because of an outlier discussed below).

1. A number of previous researchers advocate weighted medians or trimmed means as measures of core inflation because these variables are strongly correlated with an underlying trend in headline inflation, or because they are good forecasters of future inflation. Examples include Bryan and others (1997), Clark (2001), Smith (2004), Brischetto and Richards (2006), and Ball and Mazumder (2011). Crone and others (2013) question the value of medians and trimmed means for forecasting.

2. The series for median CPI inflation from the Cleveland Fed is monthly, and our series for median PCE inflation is derived from monthly data on industry inflation rates. We multiply monthly inflation by 12 to produce annualized inflation rates. To derive annualized quarterly inflation rates, we convert monthly inflation to monthly price levels, average over three months to get quarterly price levels, compute the percentage change from the previous to the current quarter, and multiply by four.

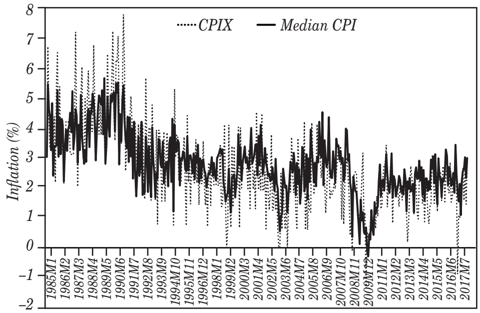
Table 1. Volatility of Alternative Inflation Measures

	Monthly	*Quarterly*	*12-Month*
Headline CPI	3.278	2.307	0.387
CPIX	1.403	0.653	0.131
Median CPI	0.916	0.447	0.095
Headline PCE	2.408	1.567	0.268
PCEX	1.633	0.681	0.134
Median PCE	0.868	0.436	0.085

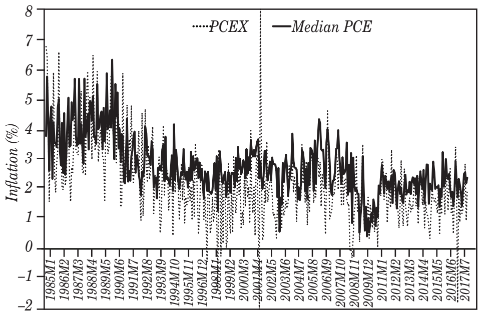
Source: Authors' calculations.
Note: The numbers in the table are standard deviations of the change in the annualized inflation rate over 1985–2017. The monthly numbers for headline PCE, PCEX, and median PCE inflation are 2.36, 1.36, and 0.89, respectively, when September–November 2001 are excluded.

Figure 1. CPI and PCE Core Monthly Inflation

A. CPI



B. PCE



Source: Authors' calculations.

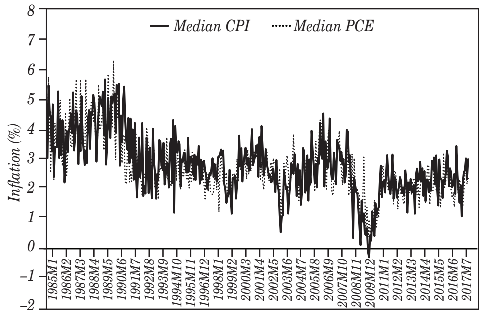
To illustrate these results, figure 1 presents the monthly time series for the two measures of core inflation; in figure 1(a), both are based on the CPI price index, and in figure 1(b) they are based on the PCE deflator. We can see the greater volatility of the ex-food-energy measure of core. In the CPI case, for example, in the late 1980s and early 1990s, median inflation generally fluctuates in a range of about 3–5 percent; inflation less food and energy (CPIX inflation) is often in the same range but spikes up to 6 or 7 percent in a number of months. Stating in the late 1990s, CPIX inflation spikes downward to zero or below in a number of months, whereas median inflation falls that far at only one point (February and March 2010).

The PCE-deflator graph also shows that ex-food-energy inflation is more volatile than median inflation. Some of the months with outliers in PCE inflation less food and energy (PCEX) are also outliers in CPIX inflation (such as March 2017, an observation that we examine closely below). But other times, the outlier months differ for CPIX and PCEX. For example, CPIX inflation spikes down to 0.2 percent in April 2013 and then rises to 2.7 percent in July 2013; PCEX inflation is more stable, with rates of 0.7 percent in April and 1.2 percent in July. Evidently, movements in ex-food-energy measures of core inflation can differ due to differences in the industries covered by the CPI and PCE deflator and/or differences in how industry prices are measured.

One episode produces large outliers in the PCEX data: the annualized inflation rate falls to –6.6 percent in September 2001 and then jumps to 8.6 percent in October. These numbers reflect huge transitory movements in life insurance premiums, which could be related to the September 11 terrorist attacks. Life insurance premiums fell at an annualized rate of 655 percent in September and then rebounded at a rate of 1457 percent in October. These price changes were large enough to strongly influence monthly PCEX inflation rates. Weighted-median inflation, by contrast, filters out this episode along with less dramatic shocks to industry prices.

Figure 2 compares our two versions of median inflation: median CPI inflation and median PCE inflation. Usually, the two medians move together fairly closely: it appears that they isolate more or less the same underlying level of inflation, despite the differences between the CPI and PCE price indices. The standard deviation of the difference between median CPI and median PCE inflation is 0.7, compared to a standard deviation of 1.2 for the difference between CPIX and PCEX inflation.

Figure 2. Median CPI and Median PCE Monthly Inflation



Source: Authors' calculations.

As figure 2 suggests, the average levels over time of the two medians are close. For 1985–2017, median CPI inflation averages 2.8 percent and median PCE inflation averages 2.7 percent. By contrast, it is well known that the average levels of headline and ex-food-energy inflation are higher for the CPI than for the PCE deflator. For 1985–2017, the averages of CPIX and PCEX inflation are 2.6 and 2.2 percent, respectively. For the PCE, the fact that the average of median inflation (2.7 percent) significantly exceeds the average of PCEX inflation (2.2 percent) suggests a tendency toward left skewness in the distribution of industry inflation rates. The reason for such a pattern is unclear and might be a subject for future research.

3. A Case Study: Inflation in 2017–2018

Recent history helps us understand the usefulness of weighted-median inflation. During 2017, the Fed's primary measure of core inflation, the 12-month inflation rate in the PCEX, fell noticeably despite low unemployment, a development that Fed Chair Yellen called a "mystery".[3] In trying to explain this mystery, Yellen stated "there have been some idiosyncratic factors I think that have held down inflation in recent months" including price changes in several industries.[4] We find that inflation in 2017 is less mysterious if we

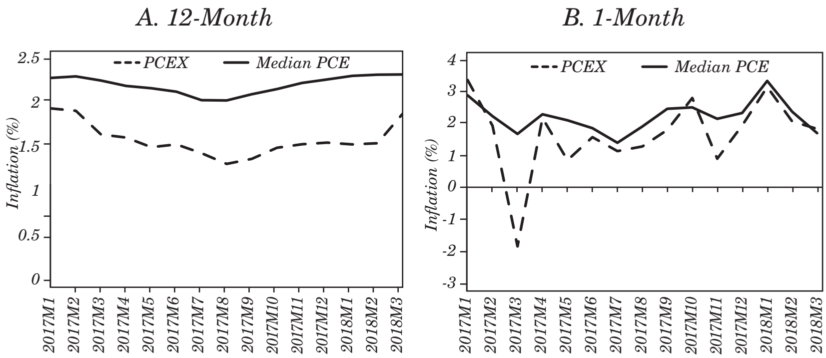
3. See Yellen (2017a).
4. See Yellen (2017b).

examine the weighted median, which filters out unusual price changes systematically. Examining the weighted median also resolves a puzzle about an uptick in PCEX inflation in early 2018.

Figure 3 shows inflation rates for the PCEX and median PCE from January 2017 through March 2018. Panel (a) shows inflation over the previous 12 months, which is the focus of many discussions by economists and policymakers. We see the behavior of 12-month PCEX inflation that puzzled the Fed: This inflation rate fell from 1.9 percent in January to 1.3 percent in August and 1.5 percent in December, a period when the unemployment rate fell from 4.8 to 4.1 percent. In discussing this experience in September, Chair Yellen said, "I will not say that the [FOMC] clearly understands what the causes are."

The behavior of 12-month median PCE inflation is different. We see that this inflation rate starts three tenths of a percent above PCEX inflation and stays above it, in line with our earlier finding that average median PCE inflation is modestly higher than average PCEX inflation. For our purposes, however, the key fact about 12-month median inflation is that it is stable: it stays in a range from 2.0 to 2.2 throughout 2017. Policymakers would not have perceived a puzzling decline in core inflation if the median were their measure of core.

Figure 3. PCEX and Median PCE Inflation, January 2017–March 2018



Source: Authors' calculations.

Panel (b) of figure 3 shows the one-month inflation rates underlying the smoother 12-month rates in Panel (a). For PCEX, we see an important outlier: March 2017, when the PCEX inflation rate was –1.8 percent. This rate is 3.8 points below the Fed's inflation target of 2.0, so for 12-month periods including March 2017, that month pushes inflation below the target by approximately (3.8)/12 = 0.32 points. Other months in 2017 that pull down the 12-month rate are May and November, which each have a PCEX inflation rate of 0.9. For median PCE, by contrast, one-month inflation rates in 2017 stay in a relatively narrow range from 1.4 to 2.9, thus leading to a very stable series when these rates are averaged over twelve months.

For the influential month of March 2017, figure 4 shows a histogram of industry price changes within the PCEX index. Each bar in the graph represents an interval of 5 percentage points in annualized inflation rates and shows the total weights of the industries in that range. We see a tail of large price decreases that skews the histogram to the left and pulls down PCEX inflation. Industries with sizable weights in the PCEX and highly negative inflation rates include air transportation (weight of 0.5 percent and annualized inflation rate of –65 percent), communications (weight of 2.5 percent and inflation rate of –38 percent), hotels and motels (weight of 0.9 percent and inflation rate of –34 percent), and men's and boys' clothing (also weight of 0.9 percent and inflation rate of –34 percent). Large price decreases also occur in smaller industries such as watches and videocassettes, and discs.

In a series of speeches and news conferences in 2017, officials from the Federal Reserve sought to explain the low level of PCEX inflation. On several occasions (in May, June, September, and October), Fed officials cited a large decline in the quality-adjusted prices of cell-phone service that occurred when cell-phone companies introduced unlimited data plans.[5] In June, Fed Chair Yellen also mentioned a drop in prescription-drug prices, and in October she mentioned slow growth in medical costs in general. In September, she suggested that "a variety of special factors" had restrained inflation.

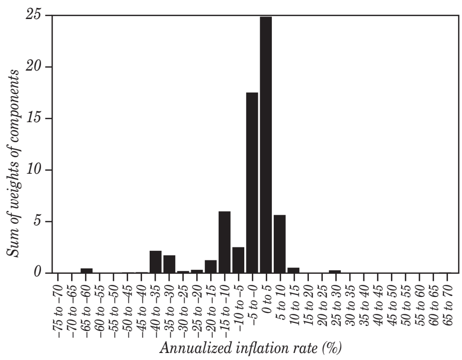
In these remarks, Fed officials are trying in a haphazard way to do what the weighted-median inflation rate does more easily and systematically: uncover a stable level of underlying inflation by

5. See Brainard (2017), Yellen (2017b), Evans (2017), and Yellen (2017c).

filtering out unusual industry price changes. Yellen is right about "a variety of factors": many different industries contributed to the negative PCEX inflation of March 2017, and others contributed to the low inflation of May and November. Officials are also on target in specifically mentioning cell phones, which are a significant factor in the March outlier. The March inflation rate was –84 percent for cell-phone services and –38 percent in the broader communications sector.

On the other hand, Yellen's reference to prescription drugs is puzzling. Prices in that industry rose at an annual rate of 4.7 percent in March and 3.4 percent over the 12 months of 2017, numbers that go in the wrong direction for explaining low inflation. Yellen is correct that some medical industries experienced low inflation in 2017—the prices of physician's services, for example, rose by 0.5 percent over the 12 months. However, this inflation rate is only modestly lower than aggregate PCEX inflation, and theory suggests that only large relative-price changes are relevant. In explaining aggregate inflation, it is suspect to point out industries whose inflation rates are modestly higher or lower than average, because there are many such industries at all times.

Figure 4. Histogram of Industry Price Changes in March 2017



Source: Authors' calculations.
Note: The vertical axis is cut off at 25—the sum of industry weights in the 0 to 5 percent inflation range is 45.6. Food and energy industries are excluded. Industries in tails: air transportation (–65 to –60), watches (–50 to –45), video cassettes and discs (–40 to –35), communication (–40 to –35), and children's and infants' clothing, hotels and motels, and men's and boys' clothing (–35 to –30) in the lower tail, and prerecorded and blank audio discs/tapes/digital files/downloads (–65 to –70) in the upper tail.

We conclude that it would have been easier for the Fed to accurately interpret core-inflation movements in 2017 if its measure of core had been weighted-median inflation rather than PCEX.[6]

A focus on median inflation might also have clarified the Fed's analysis of inflation in early 2018. In the minutes of the FOMC meeting held on May 1, some participants suggest that inflation is likely to overshoot the Fed's 2 percent target, noting "the recent increase in inflation." This increase is presumably the jump in 12-month PCEX inflation from 1.5 percent in February to 1.8 percent in March, the last month for which the Committee had data. Other Committee members question the importance of the increase, saying "it may have represented transitory price changes in some categories of health care and financial services."

This reference to industry price changes, like some of Yellen's remarks in 2017, is questionable. In the first three months of 2018, price changes in health care industries were unremarkable. As the minutes suggest, the prices of financial services rose substantially in March: the annualized inflation rate for financial charges, fees, and commissions was 24 percent. But the effect on aggregate inflation was modest. The weight on financial fees in the PCEX is 2.6 percent, which means the 24 percent inflation rate contributed approximately 0.6 percentage points to PCEX inflation in March, and only 0.05 points to 12-month inflation.

What then explains the March uptick in 12-month PCEX inflation? The answer is that March 2018 is the month when the –1.8 percent inflation rate of March 2017 drops out of the 12-month average and is replaced by the current monthly rate of 1.9 percent. Some journalists, such as Rugaber (2018) and Mutikani (2018), note the role of March 2017 in explaining 12-month inflation a year later, but this point does not appear in the FOMC minutes.

Once again, there is less inflation variability to explain, and potentially become confused about, if we focus on weighted-median inflation. Over the first three months of 2018, there are no outliers in the monthly median inflation rates that enter or exit the 12-month average. The 12-month inflation rate is stable at 2.2 percent.

6. In her September speech, Yellen briefly mentions that trimmed-mean inflation has fallen by less than PCEX inflation, which is some acknowledgment of the usefulness of systematically filtering out large industry price changes.

4. Phillips Curves

Many of the economists who have puzzled over recent inflation behavior emphasize the apparent absence of an unemployment–inflation relationship consistent with a textbook Phillips curve. Here we ask how well a simple Phillips curve fits quarterly data since 1985, and especially whether the relationship has broken down since the onset of the Great Recession in 2008. The answers depend on how inflation is measured. With headline inflation, there is no discernable Phillips curve. With core inflation as measured by the CPIX or PCEX, the evidence is mixed and we can see why many analysts would not find a Phillips curve or would think it has broken down. With weighted-median inflation, by contrast, the data show a clear and robust Phillips curve that remains stable after 2008.

4.1 Specification

We consider a simple version of Milton Friedman (1968)'s expectations-augmented Phillips curve, in which the inflation rate depends on expected inflation and on deviations of unemployment from its natural rate. Specifically, in quarterly data, we assume

$$\pi_t = \pi_t^e + \alpha\overline{(u - u^*)}_t + \varepsilon_t, \tag{1}$$

where π is inflation, π^e is expected inflation, and $\overline{(u - u^*)}_t$ is the average of the unemployment rate, u, minus the natural rate, u^*, from $t - 3$ through t. Our inclusion of three unemployment lags follows previous research on the Phillips curve.[7] For parsimony, we assume the coefficients on the current and three lags of $u - u^*$ are all the same, so only the average of these terms appears in the equation (a restriction that the data do not reject).

Again following previous work,[8] we measure expected inflation with long-term inflation forecasts, specifically, the mean of ten-year forecasts from the Survey of Professional Forecasters (SPF). When we measure inflation with any version of the Consumer Price Index (whether headline or one of the core measures), we use ten-year forecasts of CPI inflation. When we measure inflation with the PCE deflator, we have the problem that ten-year SPF forecasts of PCE

7. See Stock and Watson (2010).
8. See Fuhrer and Olivei (2010); Ball and Mazumder (2019).

inflation only started in 2007. We use these PCE forecasts when they are available. As a proxy for PCE expectations before 2007, we use the forecasts of CPI inflation minus the average difference between CPI and PCE forecasts when both are available (which is 0.23).

We measure the natural rate of unemployment, u^*, with the trend in unemployment from the Hodrick-Prescott filter with a smoothing parameter of 1600. We eschew more sophisticated methods, such as Staiger and others (1997), which use inflation and unemployment data to estimate u^* along with the parameters of an assumed Phillips curve. This approach can bias the estimates of u^* in the direction of fitting a Phillips curve relationship even if none exists—a problem that does not arise with our univariate estimation of u^*.

To estimate the Phillips curve, we move expected inflation to the left side of the equation and estimate:

$$\pi_t - \pi_t^e = \alpha\overline{(u-u^*)}_t + \varepsilon_t . \qquad (2)$$

This equation does not include a constant term: when $u - u^*$ is zero, Friedman's Phillips curve says $\pi - \pi^e$ should also be zero. However, if we add a constant to the equation, we sometimes find it is statistically significant, so we present estimates both with and without a constant. Arguably, one test of Friedman's theory is whether the estimated constant is close to zero. We do not put too much weight on this test, however, because a constant might reflect measurement error in π^e or u^* with a non-zero mean.[9]

4.2 Estimates for 1985–2017

Table 2 presents Phillips curve estimates with inflation measured with the CPI—panel (a)—and with the PCE deflator—panel (b). For each of these price indexes, we compare results for headline inflation and the two measures of core inflation: inflation less food and energy (CPIX or PCEX) and weighted-median inflation. For the two core measures, figures 5 and 6 present scatterplots of the data underlying our regressions.

9. In particular, the HP filter forces the mean of u^* to equal the mean of u. Other estimates suggest that u^* and u have different means over our sample period of 1985–2017; for example, the mean of the u^* series produced by the Congressional Budget Office exceeds the mean of u by 0.78 percentage points.

Table 2. Phillips Curves for 1985–2017

$$\pi_t - \pi_t^e = \alpha\overline{(u - u^*)}_t + \varepsilon_t$$

a. CPI inflation						
	Headline		*CPIX*		*Median*	
Constant		-0.355		-0.319		-0.167
		(0.173)		(0.065)		(0.061)
α	-0.195	-0.224	-0.424	-0.450	-0.648	-0.661
	(0.312)	(0.331)	(0.181)	(0.128)	(0.117)	(0.093)
$\overline{R^2}$	-0.031	-0.002	-0.052	0.216	0.408	0.480
S.E. of Reg.	1.884	1.857	0.627	0.541	0.468	0.439

b. PCE inflation						
	Headline		*PCEX*		*Median*	
Constant		-0.533		-0.531		0.017
		(0.138)		(0.063)		(0.062)
α	-0.093	-0.136	-0.201	-0.244	-0.478	-0.477
	(0.233)	(0.264)	(0.148)	(0.080)	(0.078)	(0.079)
$\overline{R^2}$	-0.156	-0.003	-0.785	0.066	0.319	0.315
S.E. of Reg.	1.435	1.337	0.768	0.555	0.445	0.446

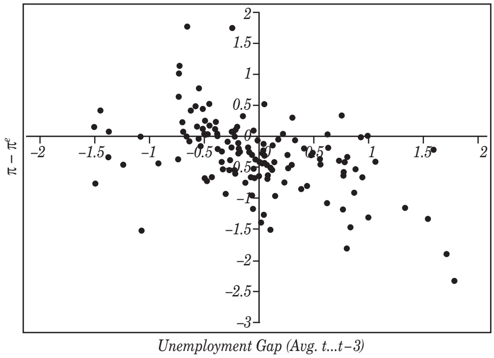
Source: Authors' calculations.
Note: OLS with robust (HAC) standard errors is used (standard errors in parentheses). The unemployment gap is the deviation of the unemployment rate from the HP filtered series, where the filter is applied over 1948–2017.

These results make it clear, first, that the fit of the Phillips curve is highly sensitive to the choice between headline and core inflation. It is easy to see why someone who focuses on headline inflation would doubt that the Phillips curve exists. For both headline CPI and headline PCE, the Phillips curve slope α is insignificant and the $\overline{R^2}$ of the equations are negative (either with or without a constant). The noise in quarterly headline inflation obscures any underlying Phillips curve.

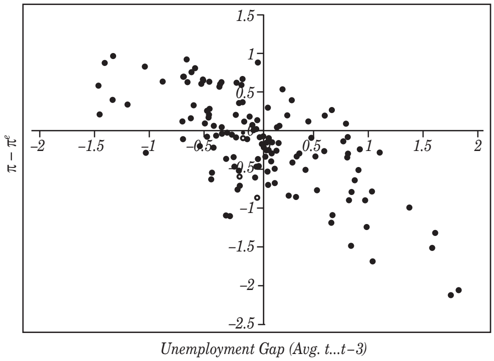
We can also see that the choice between the two core-inflation measures is important—to a substantial degree for CPI inflation and even more for PCE inflation. For CPIX, the Phillips curve slope is significant at the 5 percent level, but the $\overline{R^2}$ is negative with no constant term and only 0.22 with a constant. The fit is better with weighted-median CPI—the $\overline{R^2}$ is 0.41 without a constant and 0.48 with a constant.

Figure 5. Scatterplots of $\pi - \pi^e$ vs. Unemployment Gap, CPI Inflation, 1985–2017

A. CPIX



B. Median CPI



Source: Authors' calculations.

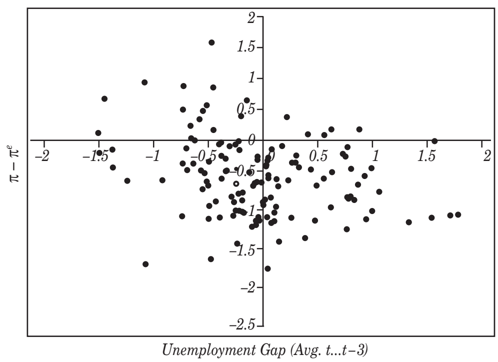
The scatterplots in figure 5 confirm that a Phillips curve appears more clearly for median CPI than for CPIX.

When we turn to PCE inflation, the differences between the results for the two core-inflation measures become larger. For PCEX, the $\overline{R^2}$ for the Phillips curve is negative without a constant and only 0.07 with a constant; for median PCE, the $\overline{R^2}$ is 0.32 in both cases. Figure 6 confirms these big differences in fit.

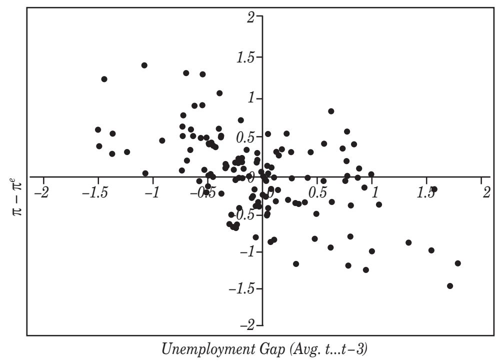
Some researchers damn the Phillips curve with faint praise, saying that the relationship exists but it is flat—the effect of unemployment on inflation is small—and the residuals are large. Blanchard (2016), for example, reports an unemployment coefficient of about –0.20 since the 1990s and a standard error of the residual of 1.0, indicating a "fairly poor fit." In our results for median inflation, the unemployment coefficients are substantially larger in absolute value: –0.48 for median PCE and –0.65 or –0.66 for median CPI. The standard errors of residuals are between 0.4 and 0.5.

Figure 6. Scatterplots of $\pi - \pi^e$ vs. Unemployment Gap, PCE Inflation, 1985–2017

A. PCEX



B. Median PCE



Source: Authors' calculations.

4.3 Has the Phillips Curve Taken a Vacation?

Some economists, such as Blinder (2018), suggest that the Phillips curve once existed but has disappeared since the Great Recession of 2008. Our findings on this issue depend on how core inflation is measured, even more strongly than before. When our sample period is restricted to 2008–2017, the fit of the Phillips curve becomes weaker for inflation less food and energy but stronger for median inflation.

Table 3 and figures 7 and 8 present our results for 2008–2017. Notice first that the Phillips curve always fits well in this period if core inflation is measured with the weighted median. For both median CPI and median PCE, and with and without a constant term, the $\overline{R^2}_s$ range from 0.54 to 0.64. The estimated coefficients on unemployment are close to those for the full sample since 1985. The Phillips curve appears clearly in figures 7(b) and 8(b). Based on these results, we doubt that economists would worry about the demise of the Phillips curve if they examined median inflation.

When core inflation is measured with inflation less food and energy, our results differ somewhat for the CPI and PCE deflator. For the CPIX, the evidence for a post-2008 Phillips curve is borderline. The unemployment coefficient is significant at the 5 percent level when a constant term is included in the equation but not without a constant. We can also see in figure 7(a) that the results depend heavily on two observations in the lower right of the graph: the first two quarters of 2010, which had the highest levels of unemployment in the sample and the lowest levels of CPIX inflation. If we exclude these observations, the Phillips curve slope is far from significant.

For the PCEX, the data since 2008 contain no evidence whatsoever of a Phillips curve. In the regressions, unemployment has no explanatory power for inflation ($\overline{R^2} = 0.001$ with a constant). Figure 8(a) confirms this result, and we also see that $\pi - \pi^e$ is almost always negative: inflation has persistently fallen short of its expected level. We understand why the behavior of PCEX, the Fed's preferred measure of core inflation, has puzzled economists.

Table 3. Phillips Curves for 1985–2017

$$\pi_t - \pi_t^e = \alpha\overline{(u{-}u^*)}_t + \varepsilon_t$$

a. CPI inflation

	Headline		*CPIX*		*Median*	
Constant		-0.715		-0.502		-0.183
		(0.397)		(0.100)		(0.102)
α	0.256	0.349	-0.399	-0.334	-0.699	-0.676
	(0.612)	(0.647)	(0.291)	(0.161)	(0.189)	(0.146)
$\overline{R}^2$	-0.068	-0.013	-0.487	0.178	0.543	0.601
S.E. of Reg.	2.628	2.561	0.743	0.553	0.476	0.445

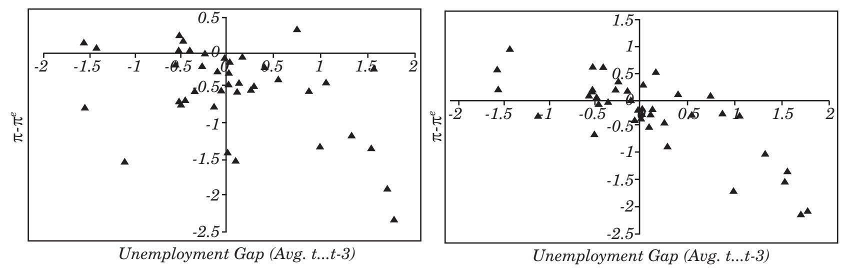
b. PCE inflation

	Headline		*PCEX*		*Median*	
Constant		-0.669		-0.544		-0.021
		(0.289)		(0.089)		(0.047)
α	0.215	0.303	-0.169	-0.098	-0.451	-0.448
	(0.433)	(0.455)	(0.241)	(0.116)	(0.079)	(0.074)
$\overline{R}^2$	-0.129	-0.006	-1.207	0.001	0.642	0.635
S.E. of Reg.	1.856	1.752	0.733	0.493	0.272	0.275

Source: Authors' calculations.
Note: OLS with robust (HAC) standard errors is used (standard errors in parentheses). The unemployment gap is the deviation of the unemployment rate from the HP filtered series, where the filter is applied over 1948–2017.

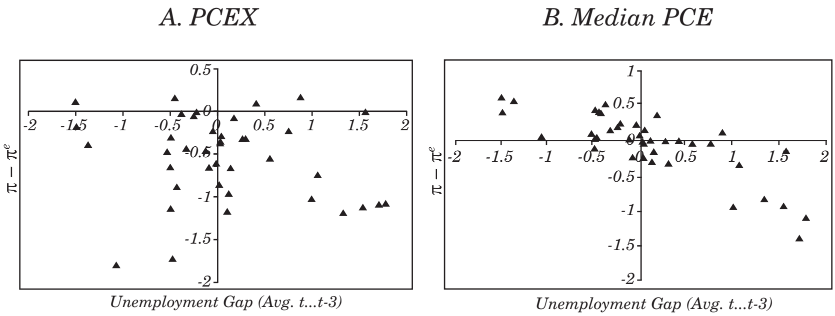
Figure 7. Scatterplots of $\pi - \pi^e$ vs. Unemployment Gap, CPI Inflation, 2008–2017

A. CPIX *B. Median CPI*



Source: Authors' calculations.

Figure 8. Scatterplots of π – πᵉ vs. Unemployment Gap, PCE Inflation, 2008–2017



Source: Authors' calculations.

5. Conclusion

The measurement of core inflation might seem like a technical subject of interest to a narrow range of specialists. We have seen, however, that a focus on a sub-optimal core measure, the inflation rate excluding food and energy, has contributed to perplexity about inflation behavior among economists, policymakers, and op-ed writers. The weighted-median measure of core inflation has a stronger theoretical foundation than inflation less food and energy and is empirically less volatile and easier to understand. In particular, we believe that fewer economists would puzzle over a breakdown of the Phillips curve if the weighted median received more attention.

In light of these findings, economists should do more research on the weighted median and related measures of core inflation. There are many open issues. Because the median is a non-linear function of industry inflation rates, it could vary significantly depending on the level of industry disaggregation. The weighted median is also sensitive to time aggregation; for example, a quarterly series computed by averaging monthly median inflation rates differs from the median of industries' quarterly inflation rates. Researchers should ask which version of the weighted median is the most useful measure of core inflation. We should also compare weighted medians to trimmed means of industry inflation rates, which also filter out large price changes.

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