Phillips 58 points out empirical relationship between wage inflation and unemployment in UK 1861-1957

Samuelson-Solow 60 popularize idea in US
Inflation and Unemployment in the UK

Inflation and Unemployment in the UK

During this time there were 61 fairly regular trade cycles with an average period of about 8 years. Scatter diagrams for the years of each trade cycle are shown in Figures 2 to 8. Each dot in the diagrams represents a year, the average rate of change of money wage rates during the year being given by the scale on the vertical axis and the average unemployment during the year by the scale on the horizontal axis. The rate of change of money wage rates was calculated from the index of hourly wage rates constructed by Phelps Brown and Sheila Hopkins, by expressing the first central difference of the index for each year as a percentage of the index for the same year. Thus the rate of change for 1861 is taken to be half the difference between the index for 1862 and the index for 1860 expressed as a percentage of the index for 1861.

This content downloaded from 128.59.165.222 on Fri, 26 Jan 2018 16:23:32 UTC
All use subject to http://about.jstor.org/terms

Source: Phillips (1958)
Inflation and Unemployment in the UK

Source: Phillips (1958)

Fig. 2. 1861-1868

Curve fitted to 1861-1913 data

Rate of change of money wage rates, % per year.

Unemployment, %.

Fig. 2. 1861 - 1868

Source: Phillips (1958)
INFLATION AND UNEMPLOYMENT IN THE UK

Fig. 3. 1868—1879

Source: Phillips (1958)
**Inflation and Unemployment in the UK**

![Graph showing the Phillips Curve fitted to 1861-1913 data. The graph plots the rate of change of money wage rates against unemployment. The curve is downward sloping, indicating a negative relationship between inflation and unemployment.](image)

*Fig. 5. 1886 - 1893*

Source: Phillips (1958)
Inflation and Unemployment in the UK

Curve fitted to 1861–1913 data

Fig. 6. 1893–1904

Source: Phillips (1958)
Phillips curve viewed as a menu of options

Policy makers can lower unemployment if they are willing to tolerate more inflation
Friedman 68 and Phelps 67:

- Policymakers cannot exploit a stable Phillips curve forever
- Workers will demand wage increases in excess of expected inflation
- As inflation rises, expectations of inflation will rise
- Changes in expected inflation will shift the Phillips curve
Inflation and Unemployment in the US

Inflation

Unemployment

1969

1961

Nakamura-Steinsson (Berkeley)

Phillips Curve

Sept 2021 11 / 68
FRIEDMAN AND PHELPS WERE RIGHT!

\[ \pi_t = \beta E_t \pi_{t+1} + \kappa (y_t - y^n_t) + \eta_t \]

- Three drivers of inflation:
  - Expected inflation: \( E_t \pi_{t+1} \)
  - Output relative to potential: \( y_t - y^n_t \)
  - Cost-push shocks: \( \eta_t \)

- Specific form above based on Calvo 83 sticky-price assumptions
  Details vary across specifications
  (e.g., sticky information yields \( \bar{E}_{t-1} \pi_t \))

- Structural equation originating from firm’s price setting decision
Estimating Slope of the Phillips Curve

\[ \pi_t = \beta E_t \pi_{t+1} + \kappa (y_t - y_t^n) + \eta_t \]

Object of interest: Slope coefficient \( \kappa \)

- How much does an increase in “demand” / “tightness” / “output gap” affect inflation
ESTIMATING SLOPE OF THE PHILLIPS CURVE

\[ \pi_t = \beta E_t \pi_{t+1} + \kappa (y_t - y^n_t) + \eta_t \]

Object of interest: Slope coefficient \( \kappa \)

- How much does an increase in “demand” / “tightness” / “output gap” affect inflation

Tricky identification issues:

- Expected inflation unobserved
- “Natural rate of output” (i.e., supply shocks) unobserved
- Cost push shocks (e.g., variation in desired markups) unobserved

All three may cause omitted variables bias
Expected Inflation

- Pre Friedman/Phelps Phillips curve: Change in output gap needed to change inflation

\[ \pi_t = \mu + \kappa (y_t - y^n_t) \]

- Same is true for accelerationist Phillips curve (i.e., Phillips curve with adaptive expectations)

\[ \pi_t = \pi_{t-1} + \kappa (y_t - y^n_t) \]
Expected Inflation

- Pre Friedman/Phelps Phillips curve: Change in output gap needed to change inflation

\[ \pi_t = \mu + \kappa (y_t - y^n_t) \]

- Same is true for accelerationist Phillips curve (i.e., Phillips curve with adaptive expectations)

\[ \pi_t = \pi_{t-1} + \kappa (y_t - y^n_t) \]

- Sargent 82: Hyperinflations end abruptly with little or no output cost

Clear violation of aforementioned Phillips curves
**Fig. 2.4** Wholesale prices in Germany.

Source: Sargent (1982)
In Calvo model, perfectly credible, unexpected disinflation can occur without any effect on output gap

- Expected inflation does all the work

Theoretical victory: Potential explanation for Sargent facts
**EXPECTED INFLATION**

- In Calvo model, perfectly credible, unexpected disinflation can occur without any effect on output gap
  - Expected inflation does all the work

- Theoretical victory: Potential explanation for Sargent facts

- Empirical headache:
  - Movements in inflation potentially completely unrelated to output gap
  - Even if output gap moves during disinflation, not clear what fraction of disinflation was due to shift in expected inflation

- Measurement of expected inflation crucial but hard
Supply Shocks

- Estimation of Phillips curve slope also complicated by classic simultaneity problem
- Need to isolate demand variation to estimate slope
- Supply shocks yield “stagflation” (i.e., positive correlation between unemployment and inflation)
- Bias slope estimates towards zero (or “wrong” sign)
Inflation Expectations + Supply Shocks

Unemployment vs. Inflation


Nakamura-Steinsson (Berkeley)

Phillips Curve

Sept 2021 19 / 68
Is the Phillips Curve Dead?

- Phillips curve often pronounced dead
  - Many economists think Phillips curve is an empirical disaster

- Prominent episodes:
  - Missing inflation in late 1990s
  - Missing disinflation in the Great Recession
  - Missing reflation in the subsequent recovery
  - Missing disinflation in the COVID crisis

- Seems like inflation is always going missing...
MISSING INFLATION IN LATE 1990s
MISSING DISINFLATION IN THE GREAT RECESSION
MISSING REINFLATION SINCE GREAT RECESSION
Are Phillips Curves Useful for Forecasting Inflation?

Answer: No

Methodology:

- Compare forecasts from Phillips curve models with “naive” no-change model
- Metric of fit: root mean squared error (RMSE)
- “Online” estimation using data from January 1959 onward
ATKESON AND OHANIAN (2001)

- Naive model:
  \[ E_t \pi_{t+12}^{12} = \pi_t^{12} \]

- Original Phillips curve:
  \[ E_t \pi_{t+12}^{12} = \beta(u_t - \bar{u}) \]

- NAIRU Phillips curve:
  \[ E_t \pi_{t+12}^{12} = \pi_t^{12} + \beta(u_t - \bar{u}) \]

- Stock and Watson’s (1999) NAIRU Phillips curve:
  \[ E_t \pi_{t+12}^{12} = \pi_t^{12} + \alpha + \beta(L)u_t + \gamma(L)(\pi_t - \pi_{t-1}) \]

(Their nomenclature)
### Why Use the NAIRU Phillips Curve?

**Ratios of Errors of NAIRU and Naive Model**

Forecasts of Inflation for 1984–99, Made With Alternative Indicators and Measures

<table>
<thead>
<tr>
<th>Inflation Indicator</th>
<th>Inflation Measure†</th>
<th>Range of Ratio of NAIRU/Naive RMSEs**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Minimum</td>
</tr>
<tr>
<td>Unemployment Rate</td>
<td>PCE Deflator</td>
<td>1.02</td>
</tr>
<tr>
<td></td>
<td>CPI</td>
<td>.99</td>
</tr>
<tr>
<td></td>
<td>Core CPI</td>
<td>1.06</td>
</tr>
<tr>
<td>Activity Index‡</td>
<td>PCE Deflator</td>
<td>1.04</td>
</tr>
<tr>
<td></td>
<td>CPI</td>
<td>1.06</td>
</tr>
<tr>
<td></td>
<td>Core CPI</td>
<td>1.33</td>
</tr>
</tbody>
</table>

*The NAIRU models are versions of Stock and Watson's (1999a) models. The naive model simply predicts that at any date inflation will be the same as it had been over the past year.

**RMSE** = mean squared error.

The PCE deflator is the implicit price deflator for personal consumption expenditures; the CPI, the consumer price index for all items; and the core CPI, the consumer price index for all items except food and energy.

*The activity index is the Chicago Fed National Activity Index.

Sources of basic data: U.S. Departments of Labor and Commerce, Federal Reserve Bank of Chicago macroeconomic data that were available to the public in the middle of each quarter, starting with the fourth quarter of 1965.

Our naive forecast is constructed as follows. Let \( P(t) \) denote the level of the GNP or GDP deflator in quarter \( t \). Then the forecasts that we construct are forecasts of \( P(t)/P(t) - 1 \). Thus, for example, the forecasts that we construct for the fourth quarter of 1988 are forecasts of inflation from 1988Q1 to 1988Q4. The naive forecast that we use is inflation over the previous four quarters measured in the historically available data as \( P(t-4)/P(t-5) - 1 \). This choice of timing in our construction of the naive forecast differs from the timing used in the simulated forecasting exercises. The difference arises from the fact that the price level in quarter \( t \) is not actually known until the next quarter.

We compile a series of quarterly forecasts of inflation over the subsequent four quarters from back issues of the Greenbook. Specifically, we select Greenbook forecasts prepared for FOMC meetings that occurred on or after November 13 for the fourth quarter of 1988. The 1988Q4 forecast is based on data through 1988Q3. We do not use 1988Q4 data for forecasting inflation in 1988Q5 because the Greenbook forecasts are made before the March data are available. We compare both the Greenbook and the naive model inflation forecasts against the data on realized inflation computed from the Greenbook's statistical appendix to the Greenbook. We strongly suspect that this finding would hold up if data from more recent years were included in our analysis.

We conclude from this historical record that the Phillips curve-based model which helps the staff at the Federal Reserve Bank of San Francisco is the Phillips curve-based model which helps the staff at the Federal Reserve Bank of San Francisco. We also conclude that this finding holds up for the past 15 years.

Stock and Watson (1999) NAIRU Phillips curve vs. Naive model with different lag lengths from 1 to 12 for both \( \beta(L) \) and \( \gamma(L) \).
Why So Hard to Forecast? (in levels)

Charts 1-2
The Breakdown in an Early Phillips Curve
Quarterly Unemployment as a Percentage of the U.S. Labor Force vs.
Changes in the Implicit Price Deflator for U.S. GDP Over the Next Four Quarters,
1st Quarter 1959-1st Quarter 1999

Chart 1 A Negative Relationship in 1959-69 . . .

Inflation Rate (%)

12
10
8
6
4
2
0
-2

Unemployment Rate (% of Labor Force)

2
4
6
8
10
12

Sources: U.S. Departments of Labor and Commerce

4
After 1970, however, many aspects of the economic environment changed. For example, inflation was both higher and more volatile. The relationship between unemployment and inflation became less stable, and the Phillips curve flattened out. This is shown in Chart 2, where the relationship between the two variables disappeared in 1970-1999.

The NAIRU Specification
Yet some still do. Economists have persisted in arguing that there is an empirical relationship of some kind between unemployment and inflation. The NAIRU (Natural Rate of Unemployment) is often used in macroeconomic models to forecast future changes in the inflation rate rather than the inflation rate itself.

Brayton et al. (1997) discuss how a Phillips curve of this kind was built into the early versions of the model developed by the staff at the Federal Reserve Board.

For a discussion of the intellectual history of the NAIRU, see the paper by Gordon (1997).
Why So Hard to Forecast? (in levels)

Chart 2... Disappeared in 1970–1999

Inflation Rate (%)

Unemployment Rate (% of Labor Force)

Sources: U.S. Departments of Labor and Commerce

The chart also shows a linear relationship with a negative slope that is clearly downward-sloping, which represents a definite negative relationship between the two variables during the 1960s.

After 1970, however, many aspects of the economic environment changed. For example, inflation was both higher and more volatile, and the Phillips curve broke down. This led to the idea of the "NAIRU" (Non-Accelerating Inflation Rate of Unemployment), which suggests that there is an "unemployment rate" below which inflation will rise. 

Chart 1... Negative Relationship in 1959-69

The exact specification has varied over time. For example, Lahiri and Phillips (1977) found that the Phillips curve had different slopes and intercepts for different years, indicating that it was not necessarily stable over time. 

Brayton et al. (1997) discuss how a Phillips curve of this kind was built into the early versions of the model developed by the staff at the Federal Reserve Board. 

For a discussion of the intellectual history of the NAIRU, see the paper by Gordon (1997).
Why So Hard to Forecast? (In Changes)


Change in Inflation Rate (% Points)

Unemployment Rate (% of Labor Force)

Sources: U.S. Departments of Labor and Commerce

Chart 3 illustrates a textbook specification of a NAIRU Phillips curve. In this chart we show on the horizontal axis quarterly data for the unemployment rate from the first quarter of 1960 and on the vertical axis the change in the implicit price deflator for U.S. GDP over the next four quarters and its change over the previous four quarters. The scatter plot shows a steep negative relationship, with unemployment rates at or near which, according to this regression, the inflation rate has no tendency to either rise or fall.

6 We follow Stock and Watson 1999b in showing a scatter plot of the unemployment rate against subsequent changes in the inflation rate as a simple presentation of the NAIRU Phillips curve.

7 Clarida, Gali, and Gertler (2000) discuss how monetary policy changed significantly in the early 1980s.
Why So Hard to Forecast? (in changes)

Chart 4 ... Flattened in 1984–99

Change in Inflation Rate (% Points)

Unemployment Rate (% of Labor Force)

1960–83

1984–99

Sources: U.S. Departments of Labor and Commerce

Chart 3 illustrates a textbook specification of a NAIRU Phillips curve. In this chart we show on the horizontal axis quarterly data for the unemployment rate from the first quarter of 1960 to the first quarter of 1999. On the vertical axis, we show the change in the implicit price deflator for U.S. GDP over the next four quarters and its change over the previous four quarters. This chart can be interpreted as a scatter plot showing the unemployment rate against subsequent changes in inflation. Chart 4 illustrates a shift in the textbook NAIRU Phillips curve. Chart 4 shows a scatter plot of the unemployment rate against subsequent changes in the inflation rate as a simple presentation of the NAIRU Phillips curve.

Note that the inflation forecast produced by this textbook NAIRU Phillips curve is quite similar to that produced by Stock and Watson (1999b). The unemployment rate is forecast to be 5 percent, inflation is forecast to rise at 0.6 of a percentage point over the next year.

Of course, there is no theoretical presumption that this NAIRU Phillips curve should be any less susceptible to being unstable since many aspects of the U.S. economy have changed since the 1980s: the business cycle, monetary policy, and inflation have all been less volatile since 1984 than they were in the previous 15 years.

We follow Stock and Watson (1999b) in showing a scatter plot of the unemployment rate against subsequent changes in the inflation rate as a simple presentation of the NAIRU Phillips curve.
Theory does not suggest that the Phillips curve would necessarily be useful for forecasting.

Phillips curve is a supply curve.

Useful for forecasting only if (when) demand variation is dominant (and inflation expectation stable).

Clearly not true in 1970s and 1980s.

Same as any other market:
- Supply curve for oil not necessarily useful to forecast price of oil.
THREE STRANDS OF PHILLIPS CURVE LITERATURE

1. Aggregate Variation with Adaptive or Survey Expectations
     Coibion-Gorodnichenko (2015)

2. Aggregate Variation with Rational Expectations
   - Gali-Gertler (1999), Sbordone (2002),
     Mavroeidis-Plagborg-Muller-Stock (2014)

3. Cross-Sectional Variation
   - Fitzgerald-Nicolini (2014), McLeay-Tenreyro (2019),
     Hazell-Herreno-Nakamura-Steinsson (2021)
Has the Phillips curve flattened?

Is there missing disinflation / reinflation?

Does “anchoring” of inflation expectations explain stability of inflation?

Is there a stable Phillips curve?
**Figure 1: Stock and Watson’s Changing Phillips Correlation**

Note: Black solid line is a regression line for 2000-2019. Dark grey broken line is regression for 1984-1999. Light gray dash-dot line is a regression line for 1960-1983. The year-over-year change in inflation is the 4 quarter change in the (backward-looking) 4 quarter moving average of headline PCE inflation. The unemployment gap is the 4 quarter (backward-looking) moving average of the gap between the unemployment rate and the natural rate of unemployment. Authors' calculations. The figure replicates Figure 1 from Stock and Watson (2019).

Recession then gave way to “missing reinflation” in the late 2010s as unemployment fell to levels not seen in 50 years, but inflation inched up only slightly. A similar debate raged in the late 1990s, when unemployment was also very low without this leading to much of a rise in inflation. Some have argued that the apparent flattening of the Phillips curve signals an important flaw in the Keynesian model.

There is, however, an alternative interpretation of these facts that emphasizes the anchoring of long-term inflation expectations in the United States (Bernanke, 2007; Mishkin, 2007). Figure 2 plots long-term inflation expectations from the Survey of Professional Forecasters. During the 1980s, long-term inflation expectations fluctuated a great deal. In particular, they fell rapidly over the period of the Volcker disinflation. In sharp contrast, since 1998, long-term inflation expectations have been extremely stable.

An alternative to the standard narrative of the Volcker disinflation is that the decline in inflation was driven not by a steep Phillips curve but by shifts in beliefs about the long-run monetary regime in the United States that caused the rapid fall in long-run inflation expectations we observe.
Why Might Phillips Curve Have Flattened?

- Inflation fell and prices became more sticky
  (as menu cost model would predict)

- Inflation expectations became better anchored
  - Output gap and change in inflation expectations correlated
    in 1970s and 1980s (biased estimates of Phillips curve slope)

- Some other structural change to the economy
To “see” the Phillips curve, must control for:
- Changes in inflation expectations
- Supply shocks

Stock and Watson (2010):
- The history of the Phillips curve “is one of apparently stable relationships falling apart upon publication.”
Empirical specification:

$$\pi_t = \pi_t^e + \alpha(u_t - u_t^*) + \epsilon_t$$

Focus on post-1985 period

Use “non-standard series”:
- Median inflation
- Long-run inflation expectations
- Short-term unemployment

Ignore endogeneity
Median Inflation

- Basic idea to get away from supply shocks
- More common to use core
  - Supply shocks important in food and energy
- Ball and Mankiw (1995):
  - Relative price changes (due to supply shocks) can affect aggregate inflation in a menu cost model
  - Firms in sectors with large shocks will adjust, while others will not
- Ball and Mazumder (2011, 2019): median inflation filters out movements in headline inflation due to large relative price movements in all sectors (not just food and energy)
Figure 3 illustrates the appeal of the weighted median by plotting this variable and CPIX inflation over 2000–15. We can see that CPIX inflation is more volatile at the quarterly frequency. The standard deviation of the change in inflation is 0.44 for the median and 0.64 for CPIX.

2.2 Specification

We consider a version of Friedman's expectations-augmented Phillips curve, equation (1), in which labor-market slack is measured by the deviation of short-term unemployment from its natural rate. Following Staiger, Stock, and Watson (1997) and Gordon (2013), we specify an equation for quarterly data with four lags of the unemployment term:

\[ \pi_t = \pi_e + 4 \sum_{j=1}^{4} \alpha_j (u_s t - j - u_s^* t - j) + \epsilon_t, \]

where \( \pi_t \) is the annualized rate of core inflation, \( \pi_e \) is expected inflation, \( u_s \) is the short-term unemployment rate, and \( u_s^* \) is the natural rate of short-term unemployment.

For parsimony, we assume that the coefficients on the four unemployment lags are equal, that is, that inflation depends on average short-term unemployment over the previous four quarters. When we test this restriction, it is not rejected (p-value for Wald test = 0.53). We can now write equation (4) as

\[ \pi_t = \pi_e + \alpha (u_s t - 1 - u_s^* t - 1) + \epsilon_t, \]

(5)
SHORT-RUN UNEMPLOYMENT

- Literature uses various different “slack” measures

- Rationale for short-run unemployment:
  - Long-term unemployed are on the margins of the labor force
  - Don’t put pressure on wages

- Largely co-linear with total unemployment prior to Great Recession

- Not so during Great Recession
  (smaller rise results in smaller fitted fall in inflation)
1.3 Short-Term Unemployment

The traditional Phillips curve includes the aggregate unemployment rate. A growing number of researchers replace this variable with the short-term unemployment rate—usually defined as the percentage of the labor force unemployed for less than 27 weeks—and argue that this modification helps explain the missing deflation.

The rationale for this specification is that the long-term unemployed “are on the margins of the labor force” (Krueger, Cramer, and Cho 2014). These workers are unlikely to find jobs because they are unattractive to employers and because they do not search intensively for work. As a result, only the short-term unemployed create an excess supply of labor and put downward pressure on wage growth and inflation.

Figure 2 shows how this reasoning helps explain the missing deflation. Long-term unemployment rose sharply over 2008–9, so the rise in total unemployment was unusually large compared to the rise in short-term unemployment. Long-term unemployment has continued to be unusually high relative to short-term unemployment even as total unemployment has returned to prerecession levels. Overall, labor-market slack since 2008 is less severe if it is measured by short-term rather than total unemployment, so the Phillips curve predicts a smaller fall in inflation in this case.
Which inflation expectations should be used?

Ball and Mazumder (2019) use long-run SPF inflation forecasts

Doesn’t New Keynesian model say one should use one-period-ahead inflation expectations?

Can one just pick whatever one want’s?

We will come back to this (when discussing cross-sectional papers)
This idea goes in the right direction for explaining the missing deflation. According to the accelerationist Phillips curve, a recession causes inflation to fall lower and lower as long as unemployment exceeds the natural rate. With anchored expectations, a period of high unemployment implies a low level of inflation but not an ever-falling level.

The idea of anchored expectations predates the Great Recession. The Fed announced a formal inflation goal of 2% only in 2012, but research as far back as Taylor (1993) finds that the Fed was implicitly targeting 2%. In the 2000s, Fed officials began to suggest that their commitment to stable inflation “in both words and actions” had produced “a strong anchoring of long-run inflation expectations” (Mishkin 2007).

An important detail: The Fed’s target of 2% applies to inflation as measured by the PCE (personal consumption expenditure) deflator excluding food and energy. Since 1980, this measure of core PCE inflation has averaged about 0.5% less than core CPI inflation (for both the weighted-median and ex-food-and-energy measures of core CPI). We should expect, therefore, that expectations of core CPI inflation are anchored at a level near 2.5%.

As many researchers have pointed out, the idea of anchored expectations receives striking support from long-term inflation forecasts in the SPF. For the period from 1985 through 2015, Figure 1 shows the mean SPF forecast of CPI inflation over the next 10 years, along with a four-quarter moving average of weighted median inflation. From 1985 until the late 1990s, SPF forecasts drift down along with the...
## TABLE 1

**An Expectations-Augmented Phillips Curve, 1985–2015**

\[
\pi_t = \pi_t^e + \alpha (\bar{u}_t^{s,\ast} - \bar{u}_t^{s,\ast}) + \epsilon_t
\]

<table>
<thead>
<tr>
<th>(\alpha)</th>
<th>-0.756</th>
</tr>
</thead>
<tbody>
<tr>
<td>(0.077)</td>
<td></td>
</tr>
<tr>
<td>DW</td>
<td>1.259</td>
</tr>
<tr>
<td>SE of Reg.</td>
<td>0.383</td>
</tr>
<tr>
<td>(\bar{R}^2)</td>
<td>0.824</td>
</tr>
</tbody>
</table>

**Note:** OLS with Newey–West (1987) standard errors in parentheses. \(\pi_t\) is median CPI inflation, \(\pi_t^e\) is the average forecast of long-term CPI inflation from the Survey of Professional Forecasters, \(\bar{u}_t^{s,\ast}\) is the average of the short-term unemployment rate from \(t - 1\) to \(t - 4\), and \(\bar{u}_t^{s,\ast}\) is the average of the natural rate of short-term unemployment from \(t - 1\) to \(t - 4\).
2.4 Short-term versus Total Unemployment

We depart from most previous research by including short-term rather than total unemployment in our Phillips curve. Here we examine whether the data support this choice by comparing three equations: our preferred Phillips curve with short-term unemployment; a variation that includes total unemployment instead, with CBO estimates of the natural rate; and a horserace regression that includes both short-term and total unemployment. We estimate these equations for the entire 1985–2015 sample and for the three subsamples we examined before.
2.4 Short-term versus Total Unemployment

We depart from most previous research by including short-term rather than total unemployment in our Phillips curve. Here we examine whether the data support this choice by comparing three equations: our preferred Phillips curve with short-term unemployment; a variation that includes total unemployment instead, with CBO estimates of the natural rate; and a horserace regression that includes both short-term and total unemployment. We estimate these equations for the entire 1985–2015 sample and for the three subsamples we examined before.
### TABLE 2

**STABILITY OF THE EXPECTATIONS-AUGMENTED PHILLIPS CURVE**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha$</td>
<td>-0.702</td>
<td>-0.781</td>
<td>-0.795</td>
</tr>
<tr>
<td></td>
<td>(0.094)</td>
<td>(0.228)</td>
<td>(0.109)</td>
</tr>
<tr>
<td>$DW$</td>
<td>1.492</td>
<td>1.043</td>
<td>1.286</td>
</tr>
<tr>
<td>$SE$ of Reg.</td>
<td>0.361</td>
<td>0.436</td>
<td>0.353</td>
</tr>
<tr>
<td>$\bar{R}^2$</td>
<td>0.764</td>
<td>0.316</td>
<td>0.755</td>
</tr>
<tr>
<td>$p$-Value for stability</td>
<td></td>
<td>0.813</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** OLS with Newey–West (1987) standard errors in parentheses. $\pi_t$ is median CPI inflation, $\pi_t^e$ is the average forecast of long-term CPI inflation from the Survey of Professional Forecasters, $\bar{u}_t^{s-1}$ is the average of the short-term unemployment rate from $t-1$ to $t-4$, and $\bar{u}_t^{s,*}$ is the average of the natural rate of short-term unemployment from $t-1$ to $t-4$. The reported $p$-value is for a Wald test of the hypothesis that $\alpha$ is equal in the three subsamples.
Anchored Expectations:

\[ \pi_t^e = 2.5 + \epsilon_t \]

Backward-Looking Expectations:

\[ \pi_t^e = \frac{1}{1 - \gamma^{40}}[(1 - \gamma)\pi_{t-1} + \gamma(1 - \gamma)\pi_{t-2} + \ldots + \gamma^{39}(1 - \gamma)\pi_{t-40}] + \epsilon_t \]

Nested Specification:

- Weighted average with weight \( \lambda \)
- Ball-Mazumder estimate this allowing for a break in \( \lambda \)
- Estimated break date is 1998Q1
TABLE 4
ANCHORED VS. BACKWARD-LOOKING EXPECTATIONS

\[
\pi_t^e = \lambda 2.5 + (1 - \lambda) \left( \frac{1}{1 - \gamma^{40}} \left[ (1 - \gamma)\pi_{t-1} + \gamma (1 - \gamma)\pi_{t-2} + \ldots + \gamma^{39} (1 - \gamma)\pi_{t-40} \right] + \epsilon_t \right)
\]

1985Q1–2015Q4 (with 1998Q1 Break in \( \lambda \))

<table>
<thead>
<tr>
<th>( \lambda_{prebreak} )</th>
<th>0.067</th>
<th>0.046</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \lambda_{postbreak} )</td>
<td>0.773</td>
<td>0.066</td>
</tr>
<tr>
<td>( \gamma )</td>
<td>0.875</td>
<td>0.018</td>
</tr>
<tr>
<td>( \gamma )</td>
<td>0.859</td>
<td>0.017</td>
</tr>
<tr>
<td>( DW )</td>
<td>0.357</td>
<td>0.018</td>
</tr>
<tr>
<td>( SE ) of Reg.</td>
<td>0.189</td>
<td>0.312</td>
</tr>
<tr>
<td>( R^2 )</td>
<td>0.940</td>
<td>0.203</td>
</tr>
<tr>
<td>( \bar{R}^2 )</td>
<td>0.930</td>
<td>0.095</td>
</tr>
</tbody>
</table>

NOTE: NLLS with Newey–West (1987) standard errors in parentheses. \( \pi_t^e \) is the average forecast of long-term CPI inflation from the Survey of Professional Forecasters, and \( \pi_t \) is median CPI inflation. The break date of 1998Q1 is the quarter that produces the largest Wald statistic for the hypothesis that \( \lambda_{prebreak} = \lambda_{postbreak} \).
This section discusses the anchoring of expectations in the context of inflation and unemployment rates. The figure illustrates the relationship between inflation expectations and actual inflation, showing how expectations have changed over time. The data indicates that inflation expectations became anchored in 1998, following a period of low unemployment and high economic growth. This anchoring helped to explain the muted response of inflation to the late-1990s boom and the post-2007 recession.

The reduced-form Phillips curve combines the expectations-augmented Phillips curve with the model of expectations, resulting in a relationship that relates inflation to its own lags and to short-term unemployment. The estimates of this equation are consistent with the underlying equations.
4.1 Deriving the Reduced Form

Equation (5) is our expectations-augmented Phillips curve, and equation (8) is our model of expected inflation. If we substitute (8) into (5), the expected inflation term is eliminated and we obtain:

$$\pi_t = \lambda_2 u + (1 - \lambda) \left[ \pi_{t-1} + \gamma (1 - \gamma) \pi_{t-2} + \cdots + \gamma^{39} (1 - \gamma) \pi_{t-40} \right] + \alpha (u_{t-1} - u^*) + \epsilon_t. \quad (9)$$

In this equation, inflation depends on short-term unemployment and on a weighted average of the constant 2.5 and an average of past inflation rates.

Equation (9) nests two common versions of the Phillips curve. If the parameter $\lambda$ is zero, then the inflation rate depends on past inflation rates, with weights that sum to one, and on short-term unemployment. This case is similar to the accelerationist Phillips curve of textbooks. If $\lambda$ is one, then the lagged inflation terms disappear and (9) becomes a relationship between the level of short-term unemployment and the level of inflation—what Blanchard (2016) calls a “back to the sixties” Phillips curve.

When we estimated our model of expected inflation, equation (8), we found that the parameter $\lambda$ shifts sharply in the late 1990s, from near zero to approximately 0.8. This means that expectations shift from fully backward-looking to mostly anchored. The shift in equation (8) implies a corresponding shift in $\lambda$ in equation (9): a change from an accelerationist Phillips curve toward a 1960s Phillips curve. We therefore test for such a shift.

---

Focus on “missing disinflation” during Great Recession

Argue that population explanations insufficient
  - Anchored inflationary expectations
  - Movements in natural rate
  - Flattening of the Phillips curve

New explanation:
  - Household inflation expectations rose in 2009-2013
  - If firm’s expectation the same, this can explain missing disinflation
\[ \pi_t = \beta E_t \pi_{t+1} + \kappa (y_t - y^n_t) + \eta_t \]

Baseline assumptions:

- Output gap measure: Unemployment rate
  \[ y_t - y^n_t = u_t \]
  (Ignore natural rate \( u^n_t \))

- Expectations of inflation: backward looking
  \[ E_t \pi_{t+1} = \frac{1}{4} (\pi_{t-1} + \pi_{t-2} + \pi_{t-3} + \pi_{t-4}) \]
  (Ignore discounting: \( \beta = 1 \))
\[ \pi_t - E\pi_{t+1}^{\text{Back}} = \kappa u_t + \eta_t \]

- Estimate by OLS for sample 1960Q1-2007Q4
  - Implicitly assuming that \( \eta_t \perp u_t \) (i.e., ignoring supply shocks)

- Consider alternative specifications later

- See whether Great Recession “sticks out”
Panel A. CPI inflation and US unemployment

Panel B. CPI inflation and predicted inflation from the Phillips Curve

Figure 1. The Missing Disinflation

Notes: Panel A shows the scatter plot of inflation surprises \( \pi_t - E_\pi_t \) versus unemployment rate. Empty circles show observations for 1960Q1–2007Q3. Filled circles show observations for 2007Q4–2013Q1. The solid line shows predicted inflation surprises as a function of the unemployment rate in the linear regression. The inflation surprise for 2008Q4 is outside the range of the figure and is not reported.

Panel B plots time series of the actual CPI inflation rate (annualized; solid thick line) and the CPI inflation rate predicted by the Phillips curve (equation (1); dashed line) which is estimated on the 1960Q1–2006Q3 sample.

Source: Coibion and Gorodnichenko (2015)
Panel B. CPI inflation and predicted inflation from the Phillips Curve

Figure 1. The Missing Disinflation

Source: Coibion and Gorodnichenko (2015)
movements during this period pushed inflation up despite the weak economy. The price of West Texas Intermediate (WTI) crude, for example, went from under 40 dollars per barrel in early 2009 to over 100 dollars per barrel in early 2011, precisely the period during which inflation was significantly higher than expected from historical Phillips curve correlations. To assess whether changing oil prices can account for the unusual inflation dynamics during this period via shifts in

Panel C. Core CPI inflation

Panel D. Core PCE inflation

Source: Coibion and Gorodnichenko (2015)
ALTERNATIVE SPECIFICATIONS

- Survey expectations
- CBO estimates of natural rate
- Oil shocks

Help address alternative explanations:
- Anchoring of inflation expectations
- Movements in natural rate
- Role of supply shocks
movements during this period pushed inflation up despite the weak economy. The price of West Texas Intermediate (WTI) crude, for example, went from under 40 dollars per barrel in early 2009 to over 100 dollars per barrel in early 2011, precisely the period during which inflation was significantly higher than expected from historical Phillips curve correlations. To assess whether changing oil prices can account for the unusual inflation dynamics during this period via shifts in oil price changes

$\pi_t - E\pi_t^{\text{SPF}}$

$\pi_t - E\pi_t^{\text{BACK}}$

Panel E. SPF inflation (CPI) forecasts

Panel F. Controlling for oil prices

Source: Coibion and Gorodnichenko (2015) – SPF forecast over next four quarters.
MISSING DISINFLATION: NATURAL RATE

Panel A. Missing disinflation with CBO unemployment gaps

Panel B. Changes in natural rate of unemployment needed to explain missing disinflation

Figure 3. Does the Missing Disinflation Reflect Structural Unemployment?

Notes:
Panel A plots quarterly levels of the unemployment gap (the difference between actual unemployment and the CBO estimate of the short-term natural rate of unemployment) against quarterly deviations of inflation from expected inflation (measuring the latter as the average inflation rate over the previous four quarters). The trend line uses data from 1960Q1 to 2007Q3. The predicted natural rate of unemployment in panel B is estimated as follows. First, \( U_E_t - U_E_t^n = \alpha + \beta (\pi_t - E_t \pi_{t+1}) + \varepsilon_t \) is estimated on the 1960Q1–2007Q3 sample, where \( U_E_t \) is the rate of unemployment, \( U_E_t^n \) is the natural rate of unemployment from the CBO, \( E_t \pi_{t+1} \) is the backward-looking measure of inflation expectations. Second, predicted value of the natural rate of unemployment is \( \hat{U}_E_t^n = U_E_t - \hat{\alpha} - \hat{\beta} (\pi_t - E_t \pi_{t+1}) \). The solid line shows the path of \( \hat{U}_E_t^n \), while the shaded region shows the 95 percent confidence interval for the predicted value. The solid line with circle markers is the natural rate of unemployment from the CBO. The dashed line shows the path of actual unemployment rate.

Source: Coibion and Gorodnichenko (2015)
Panel B. Changes in natural rate of unemployment needed to explain missing disinflation

Figure 3. Does the Missing Disinflation Reflect Structural Unemployment?

Notes:
Panel A plots quarterly levels of the unemployment gap (the difference between actual unemployment and the CBO estimate of the short-term natural rate of unemployment) against quarterly deviations of inflation from expected inflation (measuring the latter as the average inflation rate over the previous four quarters). The trend line uses data from 1960Q1 to 2007Q3. The predicted natural rate of unemployment in panel B is estimated as follows. First, \( U_t - U_{tn} = \alpha + \beta (\pi_t - E_{t+1}\pi_t) + \varepsilon_t \) is estimated on the 1960Q1–2007Q3 sample, where \( U_t \) is the rate of unemployment, \( U_{tn} \) is the natural rate of unemployment from the CBO, \( E_{t+1}\pi_t \) is the backward-looking measure of inflation expectations. Second, the predicted value of the natural rate of unemployment is \( \hat{U}_{tn} = U_t - \hat{\alpha} - \hat{\beta} (\pi_t - E_{t+1}\pi_t) \). The solid line shows the path of \( \hat{U}_{tn} \), while the shaded region shows the 95 percent confidence interval for the predicted value. The solid line with circle markers is the natural rate of unemployment from the CBO. The dashed line shows the path of actual unemployment rate.

Source: Coibion and Gorodnichenko (2015)
Expectations typically measured by SPF forecasts

But is this the way to go?

Perhaps firm expectations exhibit similar biases to household expectations

Show that household expectations (Michigan survey) have quite different properties from SPF
  - Overreact to gasoline prices
well-proxied by professional forecasts. While one might expect very large firms to have professional forecasters on staff or to rely on the services of professional forecasters to guide their economic decisions, this need not be the case for small and medium enterprises for whom the gains from having precise information about aggregate conditions may be small (especially relative to local or industry-specific conditions), as in Mackowiak and Wiederholt (2009). For such firms, household forecasts could very well be a better proxy of their beliefs than professional forecasts.

Does it matter for the Phillips curve and the missing disinflation whether one assumes that firms hold beliefs closer to those of professional forecasters or households? We showed in panel E of Figure 1 that using professional forecasts of inflation did not meaningfully affect the estimated slope of the historical Phillips curve or the presence of missing disinflation during the Great Recession. In panel B of Figure 6, we present the Phillips curve relationship between the unemployment gap and the difference between CPI inflation and household expectations of inflation. Several

Panel A. Inflation expectations for different economic agent

Panel B. Phillips Curve with household inflation expectations

Panel C. Counterfactual inflation (CPI) paths for different expectations

Panel D. Relative contribution of slopes and inflation expectations

Figure 6. The Phillips Curve and the Missing Disinflation with Household Inflation Expectations

Notes:
Panel B shows the scatter plot of inflation (CPI) surprises versus unemployment gap as well as fitted linear regressions for two subperiods. Panel C plots actual inflation rate (CPI) as well as inflation rate predicted by Phillips curves (equation (1)) estimated on the pre-Great Recession samples. Phillips curves are estimated with unemployment gap as the forcing variable. Panel D presents decomposition of differences between predicted inflation rates from Phillips curves (equation (1)) estimated with inflation expectations from the Michigan Survey of Consumers (MSC) and Survey of Professional Forecasters (SPF). "XYZ exp" denotes which inflation expectations are used (SPF or MSC), while "XYZ κ" denotes what data was used to estimate the slope of the Phillips curve. Phillips curves are estimated with unemployment gap as the forcing variable.

Source: Coibion and Gorodnichenko (2015)
well-proxied by professional forecasts. While one might expect very large firms to have professional forecasters on staff or to rely on the services of professional forecasters to guide their economic decisions, this need not be the case for small and medium enterprises for whom the gains from having precise information about aggregate conditions may be small (especially relative to local or industry-specific conditions), as in Mackowiak and Wiederholt (2009). For such firms, household forecasts could very well be a better proxy of their beliefs than professional forecasts.

Does it matter for the Phillips curve and the missing disinflation whether one assumes that firms hold beliefs closer to those of professional forecasters or households? We showed in panel E of Figure 1 that using professional forecasts of inflation did not meaningfully affect the estimated slope of the historical Phillips curve or the presence of missing disinflation during the Great Recession. In panel B of Figure 6, we present the Phillips curve relationship between the unemployment gap and the difference between CPI inflation and household expectations of inflation. Several

Source: Coibion and Gorodnichenko (2015)
Inflation Expectations

Three differences versus SPF:

- No evidence of flattening
- Flatter throughout
- No evidence of missing disinflation!
Large variation across sectors in correlation between inflation and cyclical component of real activity

Stronger correlation for well-measured, domestic components

In particular \textit{housing}

Median inflation measure used by Ball-Mazumder 19 ends up placing a lot of weigh on housing
Inflation measure for owner-occupied housing changed in 1983
- pre-83: Changes in house prices and mortgage costs (interest rates)
- post-83: Changes in rents

Makes a BIG difference for properties of CPI

CPI Research Series uses modern methodology back in time
(as do PCE and GDP deflators)
**What if we use old method for recent period?**

Figure B.1: CPI Inflation Using Pre- and Post-1983 Housing Methodology

Note: This figure plots overall CPI inflation in the US (gray line) and our attempt at estimating what CPI inflation would have been had the BLS not changed the methodology for calculating the shelter component in 1983 (black line). We present these results for the sample period 1972 to 2018. The difference between the gray and the black line before 1983 gives a sense for how accurately we can replicate the BLS's pre-1983 methodology.

**B.3.1 Sample Restrictions**

We restrict the sample we use in several ways. First, we exclude from our sample price relatives involving a product replacement when the size of the new product is unobserved. This reduces sampling error in our price indexes. Second, we Winsorize price relatives that are larger than 10 or smaller than 0.1. Third, we drop quote lines that include collected prices that are smaller than a tenth of a cent. A quote line includes all versions of a particular "quote-outlet" pair. Recall that a "quote-outlet" pair represents a specific product in a specific location, such as a 2L bottle of Diet Coke from the Westside Market at 110th Street in New York City.

Fourth, we drop observations associated with clearance sales at the end of a quote line. Intuitively, if products systematically go on sale, and then disappear from the data, this can lead to a sharply declining price index (e.g., for women's dresses) unless the product that exits is linked with a new comparable product (next season's similar women's dress). To be precise, we drop observations associated with clearance sales at the end of a quote line.