EMPIRICAL ASSESSMENT OF THE PHILLIPS CURVE

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Brief History of the Phillips Curve

- 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

A scatter diagram of the rate of change of wage rates and the percentage unemployment for the years 1861-1913 is shown in Figure 1. 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
INFLATION AND UNEMPLOYMENT IN THE UK

Source: Phillips (1958)

Fig. 3. 1868-1879

Curve fitted to 1861-1913 data
INFLATION AND UNEMPLOYMENT IN THE UK

Source: Phillips (1958)
Fig. 5. 1886-1893

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
INFLATION AND UNEMPLOYMENT IN THE US

- Inflation Rate
- Unemployment Rate

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FRIEDMAN AND PHELPS MAKE A PREDICTION

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
Friedman and Phelps Were Right!!
Modern Phillips Curve

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

Three drivers of inflation:
- Expected inflation: \( E_t \pi_t \)
- Output relative to potential: \( y_t - y^n_t \)
- Cost-push shocks: \( \eta_t \)

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

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- 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

- 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**

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

- Sargent 82: Hyperinflations end abruptly with little or no output cost
  
  Clear violation of aforementioned Phillips curves
GERMAN HYPERINFLATION

Fig. 2.4 Wholesale prices in Germany.

Source: Sargent (1982)
In Calvo model, perfectly credible, unexpected disinflation can occur without any affect 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** affect 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

- Slope of Phillips curve: Causal effect of output gap on inflation
  - But output gap is not directly observable

- Ideal experiment:
  - Shifts in output holding potential output and expected inflation constant
Supply Shocks

- Slope of Phillips curve: Causal effect of output gap on inflation
  - But output gap is not directly observable

- Ideal experiment:
  - Shifts in output holding potential output and expected inflation constant

- Shifts in potential output (or natural rate of unemployment):
  - Shift the Phillips curve
  - Potentially lead to negative correlation between output and inflation
  - Bias estimated slope of Phillips curve downward

- Cost push shocks cause similar problems
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

- Let’s take a closer look
Stagflation of the 1970s

Friedman and Phelps were right:
- Phillips curve shifted up in 1970s

But why did inflation rise at higher and higher unemployment rates as 1970s progressed?

Possible explanation: Rise in natural rate of unemployment
- Baby boon generation was entering labor force in 1970s
Volcker Disinflation

Inflation vs. Unemployment

- 1969
- 1980
- 1983
- 1989

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Phillips Curve
January 2018
MISSING INFLATION IN LATE 1990s
MISSING INFLATION IN LATE 1990s

- 1997-2000: Why doesn’t inflation rise?
- Maybe it was just starting to in 2000 but Fed nipped it in the bud
  - Maybe the Phillips curve is highly non-linear
MISSING DISINFLATION IN THE GREAT RECESSION

Inflation

Unemployment

1990

1992

2000

2007

1992

2010

2014
Is the Phillips Curve Dead?

- Why did inflation not fall more in Great Recession?
  - Actually rose in 2010 and 2011

- Why is inflation not rising now?
“Is the Phillips Curve Alive and Well after All?”

- Focus on “missing disinflation” during Great Recession
- Population explanations insufficient
  - Anchored inflationary expectations
  - Movements in natural rate
  - Flattening of the Phillips curve
“Is the Phillips Curve Alive and Well after All?”

- Focus on “missing disinflation” during Great Recession
- 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
  \[ y_t - y^n_t = u_t \]

- 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: \( \beta = 1 \)
Estimate by OLS for sample 1960Q1-2007Q4

- Implicitly assuming that $\eta_t \perp u_t$
- Similar to VAR timing restriction. (Why?)

Consider whether Great Recession conforms with earlier relationship
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. $E\pi_t$ is calculated as in equation (2). 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)
Figure 1. The Missing Disinflation

Panel A. CPI inflation and US unemployment

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

Notes:
Panel A shows the scatter plot of inflation surprises ($\pi_t - E_t \pi_t_{BACK}$) versus unemployment rate. $E_t \pi_t_{BACK}$ is calculated as in equation (2). 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.

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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

\[ \pi_t - E\pi_t^{BACK} \]

Panel A. PCE inflation

Panel B. GDP deflator inflation

Source: Coibion and Gorodnichenko (2015)
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\[ \pi_t - E\pi_t \]  

Panel C. Core CPI inflation

Panel D. Core PCE inflation

Source: Coibion and Gorodnichenko (2015)
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Source: Coibion and Gorodnichenko (2015) – SPF forecast over next four quarters.
Possible Explanations

- Does unemployment mismeasure forcing variable?
- Has the slope of the Phillips curve declined?
- Are inflation expectations by firms mismeasured?
More natural to think of $u_t - u_t^n$ as forcing variable

Perhaps the natural rate of unemployment changed during Great Recession
More natural to think of $u_t - u^n_t$ as forcing variable

Perhaps the natural rate of unemployment changed during Great Recession

Two approaches:
- Use CBO estimates of natural rate of unemployment
- Ask what natural rate consistent with observed inflation dynamics?
ACCOUNTING FOR NATURAL RATE

- Reestimating Phillips curve with unemployment gap has no effect on slope.
- CBO estimate of natural rate only rose by 1 percentage point in Great Recession.
- Minimal effect on missing disinflation.
Panel A. Missing disinflation with CBO unemployment gaps

The figure shows the relationship between the unemployment gap (the difference between actual unemployment and the CBO estimate of the short-term natural rate of unemployment) and 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, $U_E t - U_E t_n = \alpha + \beta (\pi_t - E_{\pi_t+1}) + \epsilon_t$ 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, $E_{\pi_t+1}$ is the backward-looking measure of inflation expectations. Second, the predicted value of the natural rate of unemployment is $\hat{U}_E t_n = U_E t - \hat{\alpha} - \hat{\beta} (\pi_t - E_{\pi_t+1})$.

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

Source: Coibion and Gorodnichenko (2015)
HAS THE PHILLIPS CURVE FLATTENED?

Panel A. Sample split in mid-1980’s, backward-looking PC

Panel B. Sample split in mid-1980’s, forward-looking PC

Panel C. Counterfactual in/flation paths from time-varying slopes

Figure 5. Time Variation in the Slope of the Phillips Curve

Source: Coibion and Gorodnichenko (2015)
Has the Phillips Curve Flattened?

Panel B. Sample split in mid-1980’s, forward-looking PC

Panel C. Counterfactual in/flation paths from time-varying slopes

Source: Coibion and Gorodnichenko (2015)
HAS THE PHILLIPS CURVE FLATTENED?

- Phillips curve appears to have flattened after 1985
  - Although statistical significance is weak
    (little variation in inflation after 1985)

- Can this account for missing disinflation?
where $I \geq 85$, $t$ is a dummy variable equal to one for periods from 1985Q1 to 2007Q3 and zero prior to 1985. The interaction of this dummy variable with the unemployment gap ($\gamma$) allows us to assess whether the slope of the Phillips curve changed around this period.

We report results from estimating this specification in Table 1 for several cases: CPI inflation and backward-looking expectations, GDP deflator inflation and backward-looking expectations, and GDP deflator inflation with forward-looking (SPF) expectations. In each case, we estimate the Phillips curve both by OLS and by IV, using as instruments a constant, one lag of unemployment, the dummy variable for post-84 periods, and the interaction of the dummy with the lag of unemployment.

The point estimates on the interaction term are always positive, so that the Phillips curve consistently appears to have flattened since the mid-1980s. However, the statistical significance of this effect varies by specification: we cannot reject the null of no change in slope using the CPI but can reject the null at least at the 5 percent level for all specifications with the GDP deflator, with almost no difference between OLS and IV estimates in any case. Thus, the evidence for a change in the slope is mixed. What is consistent across specifications, however, is that the change in the slope (if there was one) was relatively large: on the order of a 60–80 percent reduction in most specifications. Furthermore, we cannot reject the null that the slope of the Phillips curve since 1985 was zero, pointing to a weak link between real and nominal economic activity during this period, consistent with Atkeson and Ohanian (2001).

The absence of conclusive empirical evidence on a changing slope

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Panel C. Counterfactual inflation paths from time-varying slopes

Source: Coibion and Gorodnichenko (2015)
Inflation Expectations

- Perhaps inflation expectations of firms differ from backward-looking expectations and SPF forecasts
- Household expectations (Michigan survey) quite different
Inflation Expectations

Panel A. Inflation expectations for different economic agent

Source: Coibion and Gorodnichenko (2015)
Inflation Expectations

- Not clear whether firm expectations behave like SPF or like household expectations
- But if they do behave like household expectations, does it matter?
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.

Source: Coibion and Gorodnichenko (2015)
Inflation Expectations

Three differences versus SPF:

- No evidence of flattening
- Flatter throughout
- No evidence of missing disinflation!
Inflation Expectations

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

Source: Coibion and Gorodnichenko (2015)
Much of evidence for slope on Phillips curve comes from Volcker Disinflation

Details turn out to matter for results

- Important methodological change in CPI in 1983 (housing switched to rental equivalence)
- 12-month inflation versus quarterly inflation matters

No missing disinflation with 12-month PCE
## Missing Disinflation?

### Slope Coefficients ($\kappa$) from Different Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Pre-2008</th>
<th>Post-2008</th>
<th>Missing Disinflation?</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-quarter PCE inflation, SPF exp.</td>
<td>-0.09</td>
<td>-0.06</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>(0.05)</td>
<td>(0.06)</td>
<td></td>
</tr>
<tr>
<td>4-quarter core PCE, SPF exp.</td>
<td>0.27</td>
<td>-0.08</td>
<td>No</td>
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<tr>
<td></td>
<td>(0.03)</td>
<td>(0.05)</td>
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<tr>
<td>Quarterly PCE, SPF exp.</td>
<td>-0.29</td>
<td>0.02</td>
<td>Yes</td>
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<tr>
<td></td>
<td>(0.07)</td>
<td>(0.12)</td>
<td></td>
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<tr>
<td>Quarterly PCE, 4-quarter lagged exp.</td>
<td>-0.31</td>
<td>0.10</td>
<td>Yes</td>
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<tr>
<td></td>
<td>(0.05)</td>
<td>(0.16)</td>
<td></td>
</tr>
</tbody>
</table>

Source: Nakamura (2018): Discussion at AEA Meetings
MISSING DISINFLATION?

Source: Nakamura (2018): Discussion at AEA Meetings
DID $E_t \pi_{t+1}$ DO ALL THE WORK?

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