HE2002 Macroeconomics II
Lecture 6 The Phillips Curve, the Natural Rate of Unemployment, and Inflation

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1 Lecture Outline

- Inflation, Expected Inflation, and Unemployment
- The Phillips Curve and Its Mutations
- The Phillips Curve and the Natural Rate of Unemployment

2 Wage Determination Equation I

- Recall the wage determination equation (5.1):

$$W = P^e F(u,\ z) \qquad (5.1)$$

- Let's assume a specific form for F:

$$F(u,\ z) = 1 - \alpha u + z$$

- This equation captures the notion that (1) the higher the unemployment rate (u), the lower the nominal wage and (2) the higher the unemployment benefit (z), the higher the nominal wage. The parameter α capture the magnitude of unemployment on the wage.

3 Wage Determination Equation II

- As a result, we have

$$W = P^e(1 - \alpha u + z)$$

4 Price Determination Equation

- Also that we have

$$P = (1 + m)W \qquad (5.3)$$

- Previously, we assumed $P^e = P$ and derived the natural rate of unemployment u_n. We now explore what happens when we do not impose this additional assumption.

5 Price Level, Expected Price Level, and Unemployment Rate

- Substitute W in equation (5.3) by the specific form of equation (5.1), the relation between the price level, the expected price level, and the unemployment rate is:

$$P = P^e(1 + m)(1 - \alpha u + z) \qquad (6.1)$$

6 Inflation, Expected Inflation, and Unemployment I

- Let π denote the inflation rate and π^e denote the expected inflation rate. Then equation (6.1) can be rewritten as a relation in terms of inflation rate π and the expected inflation rate π^e and the unemployment rate u:

$$\pi = \pi^e + (m + z) - \alpha u \qquad (6.2)$$

Appendix: Derivation

7 Inflation, Expected Inflation, and Unemployment II

$$\pi = \pi^e + (m + z) - \alpha u \qquad (6.2)$$

- This equation that links inflation to expected inflation and unemployment is one of the most important equation in macroeconomics.

- How each variable affects the inflation rate?
  - An increase in π^e leads to an increase in π.
  - Given expected inflation π^e, an increase in markup m, or an increase in factors that affect wage determination z, leads to an increase in π.
  - Given π^e, a decrease in u leads to an increase in π.

8 Inflation, Expected Inflation, and Unemployment III

- To look at movements in inflation and unemployment, from here onward, it will be convenient to use time indexes, so that we modify equation (6.2) with a time index t to give:

$$\pi_t = \pi_t^e + (m + z) - \alpha u_t \qquad (6.3)$$

$$\pi_t = \frac{P_t - P_{t-1}}{P_{t-1}}, \qquad \pi_t^e = \frac{P_t^e - P_{t-1}}{P_{t-1}}$$

9 The Phillips Curve

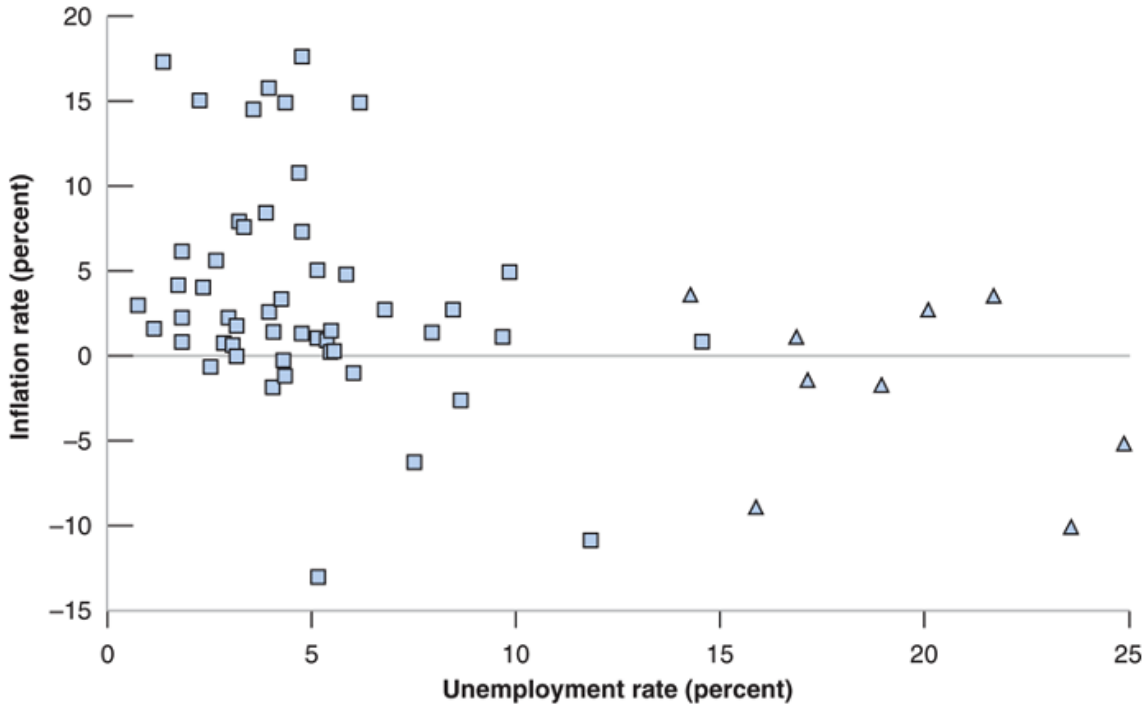
- The original Phillips curve:
  - In 1958. A.W. Phillips found a negative relation between inflation and unemployment.
  - Two years later, Paul Samuelson and Robert Solow labeled this relation the **Phillips curve**, which became central to macroeconomic thinking and policy.

Sample Question 1 (vevox ID: 137-603-335)

In the Phillips curve equation, which of the following will cause a reduction in the current inflation rate?

- A) a reduction in the expected inflation rate
- B) an increase in the unemployment rate
- C) a reduction in the markup, m
- D) all of these
- E) none of these

10 Inflation versus Unemployment in the United States, 1900 –1960



- During the period 1900 - 1960 in the United States, a low unemployment rate was typically associated with a high inflation rate, and a high unemployment rate was typically associated with a low or negative inflation rate.

11 The Original Phillips Curve

- Assume $\pi_t^e = \bar{\pi}$, so that equation (6.3) becomes:

$$\pi_t = \bar{\pi} + (m + z) - \alpha u_t \qquad (6.4)$$

  which is a negative relation between unemployment and inflation.

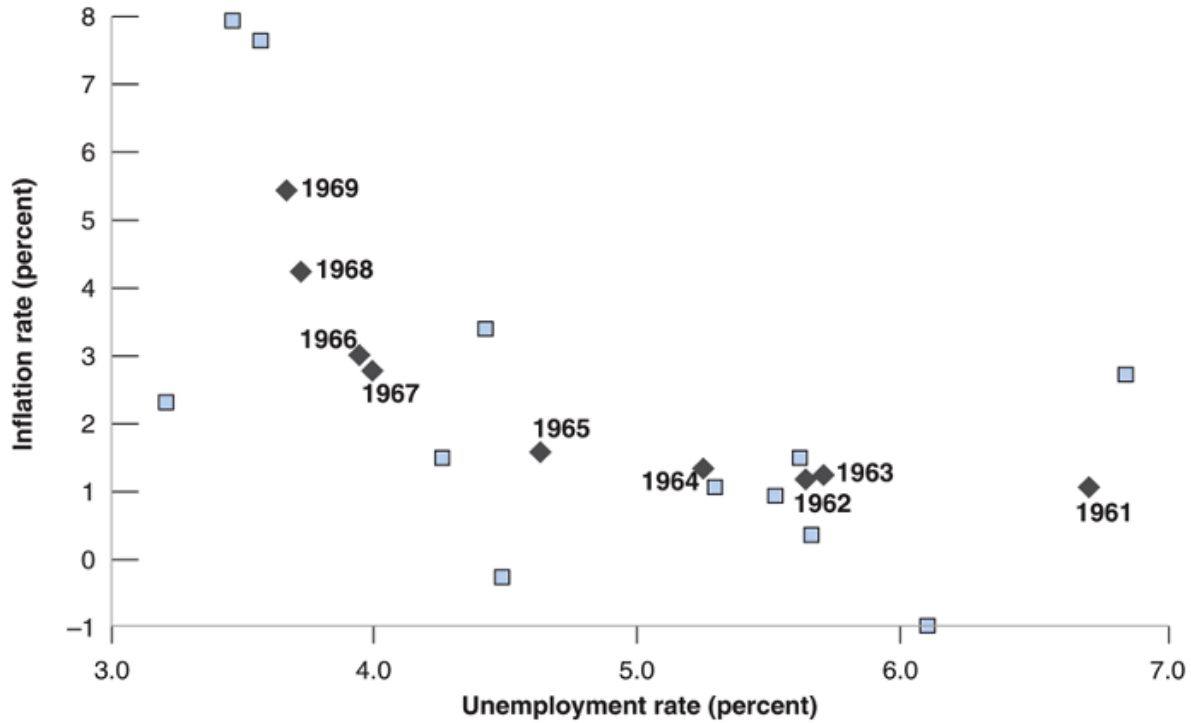
- This Phillips curve relation was observed in the United States in the 1960s.

- The relation vanished in the 1970s because wage setters changed the way they formed inflation expectations.

12 Economists' Initial Perceptions on the Phillips Curve

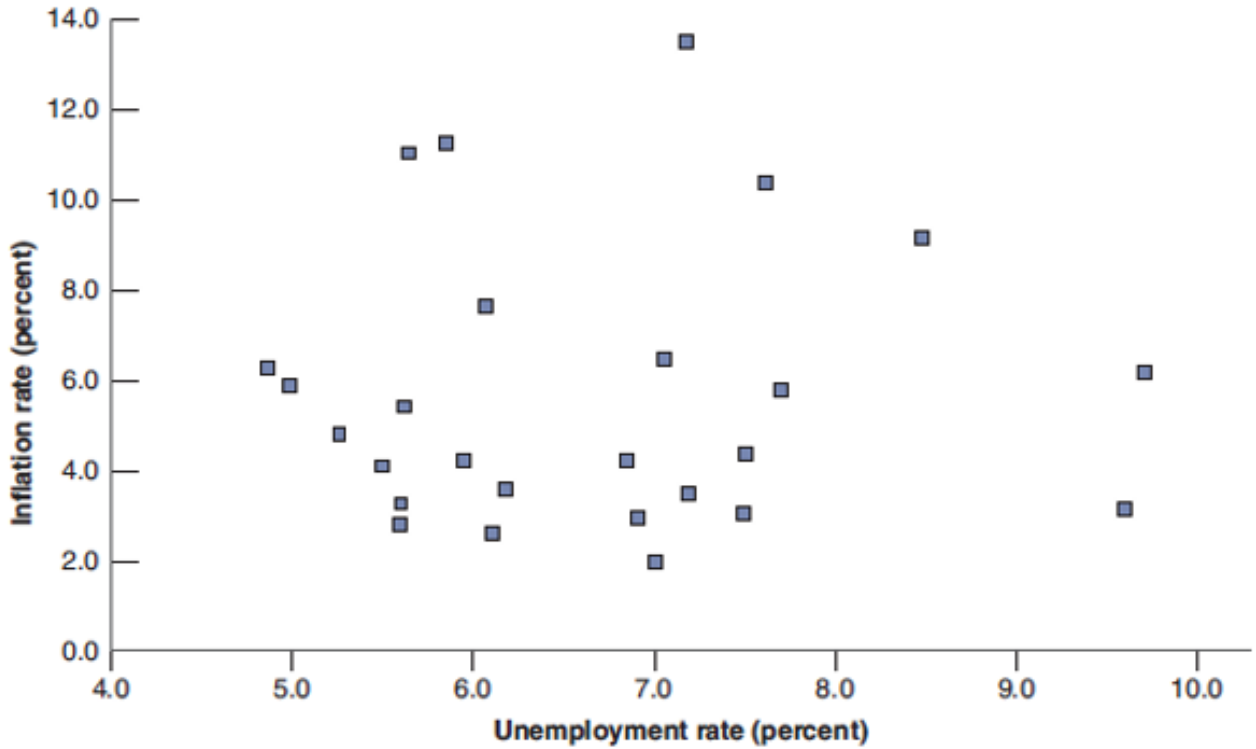
- When these findings were published, the economists suggested that policymakers faced a trade-off between inflation and unemployment.
- If the policymakers were willing to accept more inflation, they could achieve lower unemployment.
- This looked like an attractive trade-off. However, in the 1970s this relation broke down.

13 Inflation versus Unemployment in the United States, 1961 – 1969



- The steady decline in the U.S. unemployment rate throughout the 1960s was associated with a steady increase in the inflation rate.

14 Inflation versus Unemployment in the United States, 1970 – 1995



- Beginning in 1970 in the United States, the relation between the unemployment rate and the inflation rate disappeared.

15 The Phillips Curve and Its Mutations I

- Why did the original Phillips curve vanish?
- This trade-off vanished in the 1970s because wage setters changed the way they formed inflation expectations.

16 The Phillips Curve and Its Mutations II

- Higher inflation in one year became more likely to be followed by higher inflation next year. As a result, people, when forming expectations, started to take into account the persistent of inflation, and this change in expectation formation changed the nature of the relation between unemployment and inflation.

- In macroeconomic jargon, expectations that had been anchored (i.e. roughly constant) became de-anchored.

17 The De-anchoring of Expectations I

- Suppose expected inflation this year depends on a constant value $\bar{\pi}$ with weight $1-\theta$, and partly on inflation last year with weight θ:

$$\pi_t^e = (1-\theta)\bar{\pi} + \theta\pi_{t-1} \qquad (6.5)$$

- This equation means that expected inflation this year depends partly on a constant value, $\bar{\pi}$ with weight $1-\theta$, and partly on inflation last year π_{t-1}, with weight θ.

- The higher the value of θ, the more last year's inflation leads workers and firms to revise their expectations of what inflation will be this year, and so the higher the expected inflation rate.

18 The De-anchoring of Expectations II

- Substitute equation (6.5) into equation (6.3) gives:

$$\pi_t = (1-\theta)\bar{\pi} + \theta\pi_{t-1} + (m+z) - \alpha u_t$$

- Then the weight θ changes the inflation rate.

19 How the weight θ changes the inflation rate?

- When $\theta = 0$, we get the original Phillips curve such that

$$\pi_t = \bar{\pi} + (m + z) - \alpha u_t$$

- When $\theta > 0$, the inflation rate depends not only on the unemployment rate but also last year inflation rate:

$$\pi_t = [(1 - \theta)\bar{\pi} + (m + z)] + \theta\pi_{t-1} - \alpha u_t$$

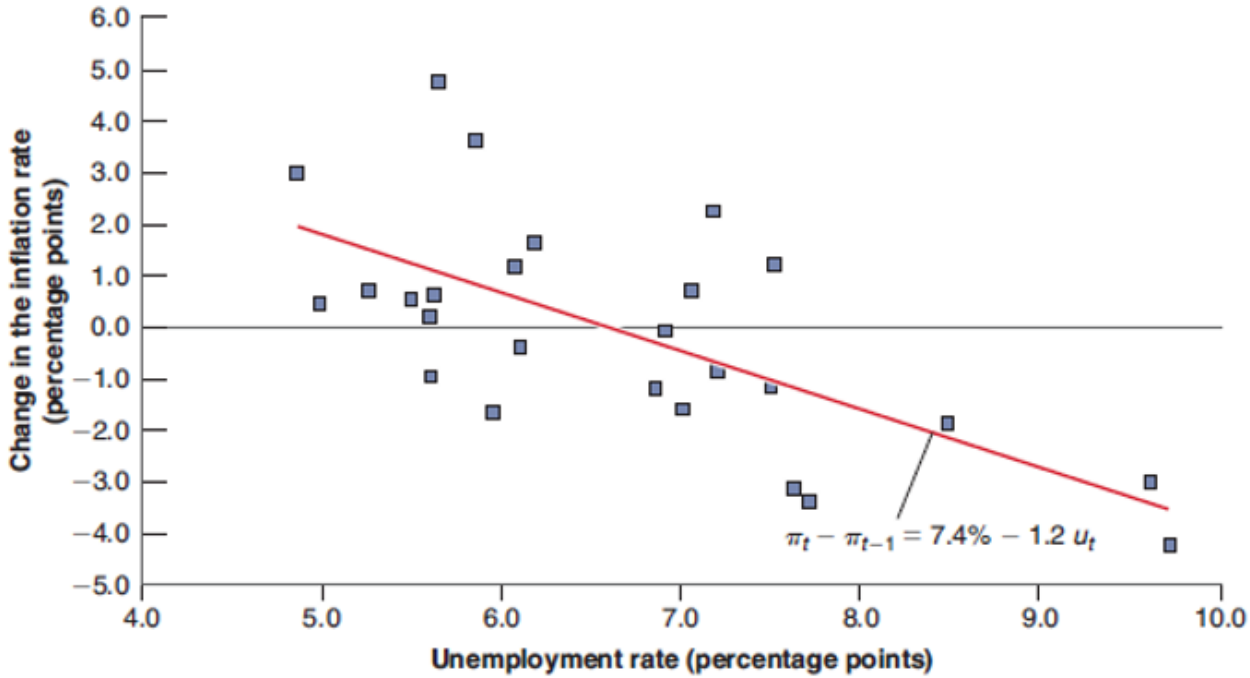
20 How the weight θ changes the inflation rate?

- $\theta = 1$, the relation becomes:

$$\pi_t - \pi_{t-1} = (m + z) - \alpha u_t \qquad (6.6)$$

So the unemployment rate affects not the inflation rate, but rather **the change in the inflation rate**. This means that higher unemployment leads to decreasing inflation, vice versa.

21 Change in Inflation versus Unemployment in the United States, 1970 – 1995



- From 1970 to 1995, there was a negative relation between the unemployment rate and **the change in the inflation rate** $(\pi_t - \pi_{t-1})$ in the United States.

22 The Accelerationist Phillips Curve

- So, instead a relation between the inflation rate and the unemployment rate, the Phillips curve took the form of a relation between the change in inflation rate and the unemployment rate.

- From 1970 to 1995, there was a negative relation between the unemployment rate and the change in the inflation rate in the United States.

- To distinguish this from the original Phillips curve, it became known as the **accelerationist Phillips curve**.

Sample Question 2 (vevox ID: 137-603-335)

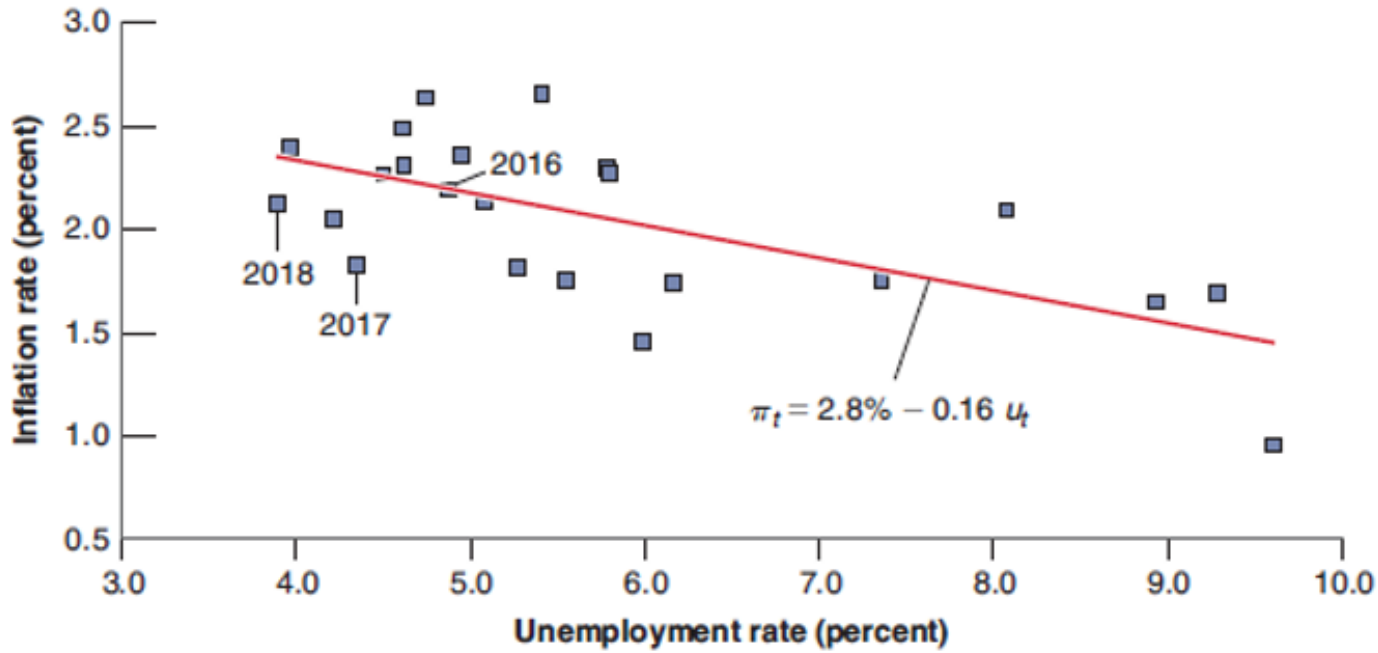
Assume that expected inflation is based on the following: $\pi_t^e = \theta\pi_{t-1}$. If $\theta = 1$, we know that

- A) reduction in the unemployment rate does not affect inflation.
- B) low rates of unemployment cause steadily increasing rates of inflation.
- C) the actual unemployment rate will not deviate from the natural rate of unemployment.
- D) the Phillips curve illustrates the relationship between the level of inflation rate and the level of the unemployment rate.

23 The Re-anchoring of Expectations

- In the 1990s, the Phillips curve relation changed again because of a change in monetary policy where from the early 1980s on, many central banks, including Fed, emphasized their commitment to maintain low and stable inflation.
- By the mid-1990s the Fed had largely achieved its goal of keeping inflation around 2%.
- Stable inflation changed the way people formed expectations yet again.
- Expectations of inflation that became de-anchored during the 1970s and 1980s became re-anchored in the mid-1990s.

24 Inflation versus Unemployment in the United States, 1996 – 2018



- Since the mid-1990s, the Phillips curve has taken the form of a relation between the inflation rate (π_t) and the unemployment rate (u_t).

25 Back to the Original Phillips Curve

- In terms of equation (6.5), θ went back down to zero and the Phillips curve returned to the relation between inflation and unemployment given by:

$$\pi_t = \bar{\pi} + (m + z) - \alpha u_t$$

- The figure also plots the line that best fits the scatter of points for the period 1996 – 2018 and is given by:

$$\pi_t = 2.8\% - 0.16 u_t \qquad (6.7)$$

26 The Natural Rate of Unemployment

- By definition (see Lecture 5), the natural rate of unemployment is the unemployment rate at which the actual price level is equal to the expected price level.

- Equivalently, the natural rate of unemployment is the unemployment rate such that the actual inflation rate is equal to the expected inflation rate.

- Suppose $\pi = \pi^e$ and solve for u_n in equation (6.3) gives:

$$\pi_t = \pi_t^e + (m + z) - \alpha u_t \quad (6.3) \quad \Longrightarrow$$

$$u_n = \frac{m + z}{\alpha} \qquad (6.8)$$

27 The Phillips Curve and the Natural Rate of Unemployment I

- Rewrite equation (6.3) as

$$\pi_t - \pi_t^e = -\alpha(u_t - \frac{m+z}{\alpha})$$

- Note from equation (6.8) that the fraction on the right side is equal to u_n, we have:

$$\pi_t - \pi_t^e = -\alpha(u_t - u_n) \qquad (6.9)$$

28 The Phillips Curve and the Natural Rate of Unemployment II

$$\pi_t - \pi_t^e = -\alpha(u_t - u_n) \qquad (6.9)$$

- This is an important equation that links the inflation rate, the expected inflation rate, and the deviation of the unemployment rate from the natural rate.

- It says that,
  - If unemployment is at the natural rate, then inflation will be equal to expected inflation.
  - If unemployment is below the natural rate, inflation will be higher than expected.
  - If unemployment is instead above the natural rate, inflation will be lower than expected.

29 A Rough Estimate of the Natural Unemployment Rate, 1996 – 2018

- Since the mid-1990s, expected inflation remained close to the target inflation of the Fed, 2%.
- The natural rate of unemployment during this period has been the rate of unemployment at which inflation was equal to 2%.
- Using equation (6.7) and putting $\pi_t = 2\%$ gives:

$$2\% = 2.8\% - 0.16u_n \Longrightarrow u_n = \frac{0.8}{0.16} = 5.0\%$$

Sample Question 3 (vevox ID: 137-603-335)

Suppose when there is an increase in the price of oil, firms tend to increase their markups and charge higher prices given same labor costs. An increase in the price of oil will likely cause which of the following?

- A) increase the markup in the Phillips curve equation
- B) increase the sum "m + z" in the Phillips curve equation
- C) increase the natural rate of unemployment
- D) all of these
- E) none of these

30 Exit Ticket (vevox ID: 126-325-157)

- One idea you learned today that was surprising or interesting to you.
- Are there topics you wish had been covered in more detail, or questions you feel are unanswered?

- **Any questions?**

You can find me at guangzhi.ye@ntu.edu.sg or by scheduling an in-person meeting through https://calendly.com/guangzhiye24.

Appendix

- First, introduce time subscripts for the price level, the expected price level, and the unemployment rate:

$$P_t = P_t^e(1 + m)(1 - \alpha u_t + z)$$

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- Next, go from an expression in terms of price levels to an expression in terms of inflation rate. Divide both sides by last year's price level, P_{t-1} :

$$\frac{P_t}{P_{t-1}} = \frac{P_t^e}{P_{t-1}}(1+m)(1-\alpha u_t + z)$$

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- Take the fraction P_t/P_{t-1} on the left side and rewrite it as:

$$\frac{P_t}{P_{t-1}} = \frac{P_t - P_{t-1} + P_{t-1}}{P_{t-1}} = 1 + \frac{P_t - P_{t-1}}{P_{t-1}} = 1 + \pi_t$$

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- Do the same for the fraction P_t^e/P_{t-1} on the right side, using the definition of the expected inflation rate ($\pi_t^e \equiv (P_{t-1}^e - P_{t-1})/P_{t-1}$):

$$\frac{P_t^e}{P_{t-1}} = \frac{P_t^e - P_{t-1} + P_{t-1}}{P_{t-1}} = 1 + \frac{P_t^e - P_{t-1}}{P_{t-1}} = 1 + \pi_t^e$$

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- Replacing $\frac{P_t}{P_{t-1}}$ and $\frac{P_t^e}{P_{t-1}}$ in the previous equation by the expressions we have just derived.

$$1 + \pi_t = (1 + \pi_t^e)(1 + m)(1 - \alpha u_t + z)$$

This gives us a relation between inflation π_t, expected inflation π_t^e, and the unemployment rate u_t. The remaining steps make the relation look more friendly.

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- Divide both sides by $(1+\pi_t^e)(1+m)$

$$\frac{(1+\pi_t)}{(1+\pi_t^e)(1+m)} = (1-\alpha u_t + z)$$

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- So long as inflation, expected inflation, and the markup are not too large, a good approximation to the left side of this equation is given by $1 + \pi_t - \pi_t^e - m$. Replacing the previous equation and rearranging gives:

$$\pi_t = \pi_t^e + (m + z) - \alpha u_t$$

The inflation rate π_t depends on the expected inflation rate π_t^e and the unemployment rate u_t. The relation also depends on the markup m on the factors that affect wage setting z, and on the effect of the unemployment rate on wages α.

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$$\frac{(1+\pi_t)}{(1+\pi_t^e)(1+m)} = (1-\alpha u_t + z)$$

- Or we can think about the approximation we used many times: $\log(1+x) \approx x$ when x is small. Take logs on both sides:

$$\log(1+\pi_t) - \log(1+\pi_t^e) - \log(1+m) = \log(1-\alpha u_t + z)$$

- Use $\log(1+x) \approx x$ on both sides:

$$\pi_t - \pi_t^e - m = -\alpha u_t + z$$

$$\pi_t = \pi_t^e + (m+z) - \alpha u_t$$

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