The Phillips Curve - Part 1

EC 313, Macroeconomics

SM Shihab Siddiqui

Book Chapter 8

Overview

Overview

Monetary Goals

The Federal Reserve works to **promote a strong U.S. economy**.

Congress has directed **the Fed** to conduct the nation's monetary policy to support **three specific goals**:

1. Maximum sustainable employment. (**output - Y**)
2. **Stable prices. (price - P)**
3. Moderate long-term interest rates. (**implied by 2.**)

Note the second goal relates to our focus of this lecture.

Overview

Brief History

- In 1958, **A.W. Phillips** plotted the historical relationship between the **inflation rate** and the **unemployment rate** in the **United Kingdom** between 1861 and 1957.
- He found strong evidence of a **negative relationship between inflation and unemployment**.
- That is, when **inflation is high, unemployment is low**. And when inflation is low, unemployment is high.
- In 1960, **Paul Samuelson** and **Robert Solow** found evidence of the same relationship using **U.S. data**.

Overview

The Phillips Curve

- The **negative relationship** between the inflation rate and unemployment.
- **In the 1970s**, however, this **relationship broke down**. Both high inflation and high unemployment (stagflation).
- Phillips curve still is the **primary framework** for understanding and **forecasting inflation** used in central banks.

Inflation

Functions of Money

Before we start talking about price and changes in price (inflation), let's talk about money.

There are three functions of money:

- The medium of exchange.
- Store of value.
- Unit of account.

Functions of Money

Economists like to argue that money belongs in the same class as the wheel and the inclined plane among **ancient inventions of great social utility**.

Price stability allows that invention to work with minimal friction.

Why Stable Price

The Dual Role of Price Stability

- Price stability plays a dual role in modern central banking: It is both
- **An end (goal) of monetary policy**
- **A means of monetary policy**

Price Stability - Goal

- Fundamentally, price stability preserves the **integrity and purchasing power** of the nation's money.
    - People can hold money **without having to worry that inflation will eat away at the real value of their money balances**.

Price Stability - Goal

- Equally important, stable prices allow people to **rely on the dollar as a measure of value** when **making long-term contracts, engaging in long-term planning, or borrowing or lending** for long periods.
    - Price stability permits **tax laws, accounting rules** to be expressed in dollar terms without being subject to distortions arising from fluctuations in the value of money.

Inflation

Price Stability - Means

When price stability likely to

- **Enhance Long-term Economic growth** (related to goal 1)
- **Matain stable Long-term interest rates** (related to goal 2)

Price Stability - Means

Price stability helps maintain **long-term economic growth** by...

- **reducing concern** about unpredictable fluctuations in the purchasing power of money.
- **improving economic activities**
- **making sure markets operate efficiently**.

Inflation

Price Stability - Means

Price stability helps maintain **long-term economic growth** because

- The dollar provides a reasonably **secure gauge** of **real economic values** **only when inflation is low and stable**.
- High and variable inflation degrades the quality of the signals coming from the price system
- Producers and consumers find it difficult to distinguish **price changes arising from changes in product supplies and demands** from **changes arising from general inflation**.

Inflation

Price Stability - Means

Price stability helps maintain **long-term interest rate**.

To understand this, we need to understand **Fisher Equation**

Let i be the nominal interest rate, r be the real interest rate, and π be the inflation rate.

The Fisher Equation is:

$$i = r + \pi$$

Conclusion:

Stable π is necessary for stable i.

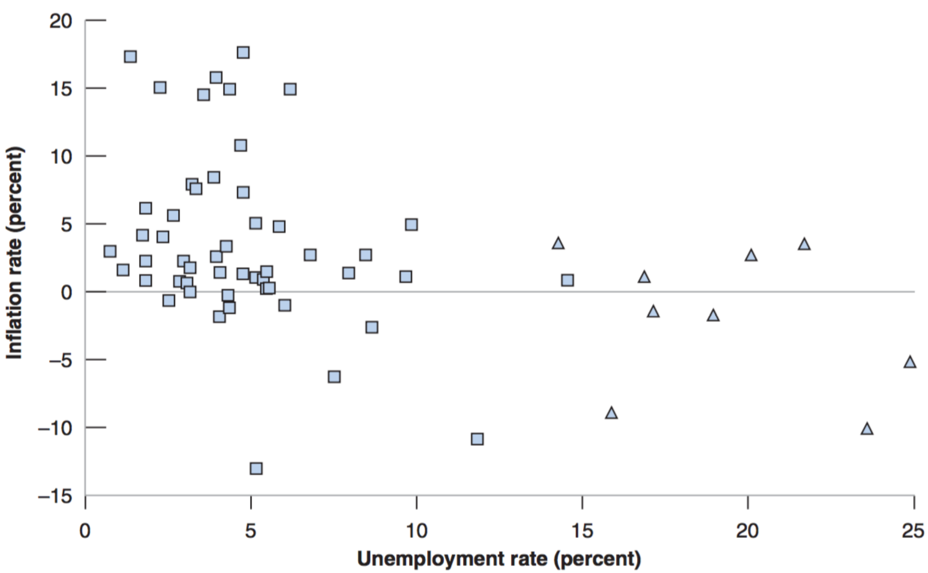
Phillips Curve

Phillips Curve

Empirical Discovery

During the period **1900–1960** in the United States,

- **A low unemployment rate** was associated with **a high inflation rate**
- **A high unemployment rate** was associated with **a low inflation rate.**



Phillips Curve

Empirical Discovery

Why is the Phillips Curve an important discovery?

- It states that there is a trade-off between the unemployment rate and the inflation rate.
- The Fed wants **a low sustainable unemployment rate**.
- The Fed wants **a low sustainable inflation rate**.
- The Phillips Curve gives the Fed **a guidance on how to reach a balance between these two goals**.

Phillips Curve

Theory

In Macroeconomics, we **can't run controlled experiments**; we rely on models to explain what we observe in the data.

The theory supporting the Phillips Curve is coming from the **Labor Market Equilibrium**. Assuming technology A = 1, we have labor supply (WS) and labor demand (PS):

$$\begin{aligned} \text{WS} : W &= P^e F(u, z) \\ \text{PS} : P &= (1+m)W \end{aligned}$$

The Labor Market Equilibrium states:

$$P = (1+m)P^e F(u, z)$$

Phillips Curve

Theory

The Labor Market Equilibrium states:

$$P = P^e(1+m)F(u,z)$$

Recall that $F(u,z)$ is a decreasing function in u and an increasing function in z.

To make life easier, we assume

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

where $\alpha > 0$.

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

Phillips Curve

Theory

We need to go from **price to inflation**. Recall inflation: **The growth rate in prices over time.**

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

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

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

We can perform the **same analysis** for expected inflation π_t^e at time t:

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

Phillips Curve

Theory

The Labor Market Equilibrium

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

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

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

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

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

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

I won't make you do this derivation in the exams.

Phillips Curve

Theory

Now we have our Labor Market Equilibrium written in terms of inflations.

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

- Increase in expected inflation --> Increase in actual inflation
- Increase in z --> increase in actual inflation
- Increase in m --> Increase in actual inflation
- Increase in unemployment --> decrease in inflation (Phillips Curve)

Phillips Curve

Theory

Incease in expected inflation --> increase in actual inflation

- **Expected Inflation increases**...
- The expected price is higher in the next period...
- Workers ask for a higher wage (**WS Relation**)...
- More costly for firms to produce goods because labor is more expensive...
- Firms set **higher price** in the next period (**PS Relation**)...

Phillips Curve

Theory

- **Increase in z --> increase in actual inflation**
- **Increase in z**...
- Workers ask for a higher wage (**WS Relation**) in the next period...
- More costly for firms to produce goods because labor is more expensive...
- Firms set **higher price** in the next period (**PS Relation**)...

Phillips Curve

Theory

- **Increase in m --> increase in actual inflation**
- **Increase in m**...
- Firms will set a **higher price** because firms have a **higher mark-up** in the next period.

Examples for **m**:

1. **Monopoly Power**.
2. **Higher Input Price**.

Phillips Curve

Theory

- **Increase in the unemployment rate --> decrease in inflation (Phillips Curve)**
- **Higher unemployment rate**
- Workers ask for a lower wage (**WS Relation**)
- It is less costly for firms to produce goods because labor is cheaper...
- Firms will set a **lower price** in the next period.

Phillips Curve

Theory

Recall the Phillips Curve is

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

We need to use **time indexes** so that we can refer to variables like inflation, or expected inflation, or unemployment, **in a specific year**.

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

The data doesn't tell us anything about the **inflation expectation** π_t^e.

The theory tells us how **inflation expectation** π_t^e influences the actual inflation rate.

Expectation Formation

Expectation Formation

Recall the Phillips Curve is

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

We need to use **time indexes** so that we can refer to variables like inflation, or expected inflation, or unemployment, **in a specific year**.

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

To connect the **theory to data**, we need to infer how expectations are formed.

- **Expectation formation is difficult to study.**
- **It's brain activity.**

Expectation Formation

Models

Eventually, we want to find the best mathematical model to describe expectation formation. Here is how we should proceed:

- Consider **a large selection of expectation selection models**
- Combine **each one of the expectation formation model** with the **theory**

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

- Back out how the model-theory combo **implies** π_t
- Check if the implied π_t **matches the data** or **makes sense** (rational).

Expectation Formation

Static Expectations

$$\pi_t^e = 0$$

- I observe the current price level
- I assume that future prices will be the same as they are today.

Expectation Formation

Adaptive Expectations

$$\pi_t^e = f(\pi_{t-1})$$

- Next year's inflation depends on this year's inflation.
- I expect inflation to be similar to what it was last period.

Expectation Formation

Rational Expectations (Not Required)

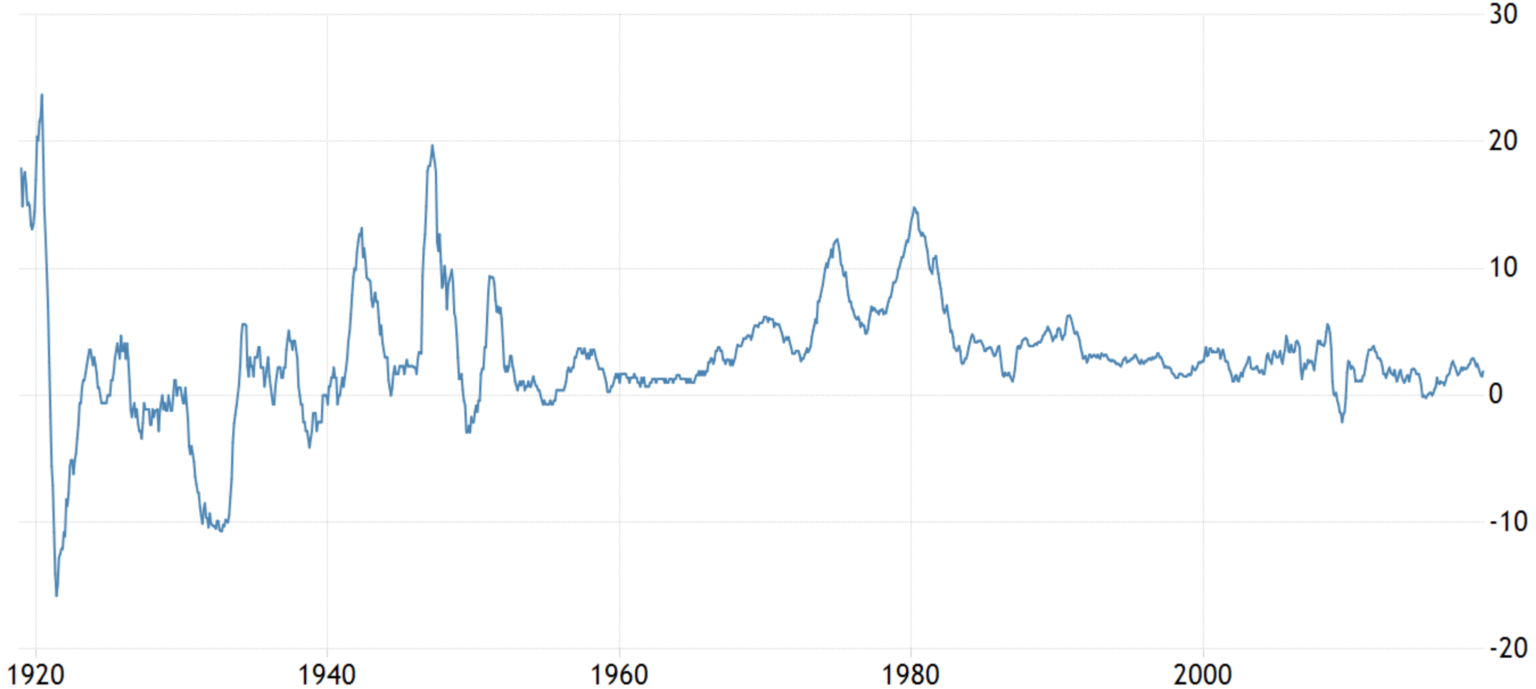
π_t^e is the **true, statistical expectation** of π_t.

- I know the entire distribution of possible inflation rates
- I know the probabilities of each of these rates occurring
- I can calculate the true expected inflation rate.

Modern Macroeconomic Modeling almost entirely relies on Rational Expectations!

Phillips Curve

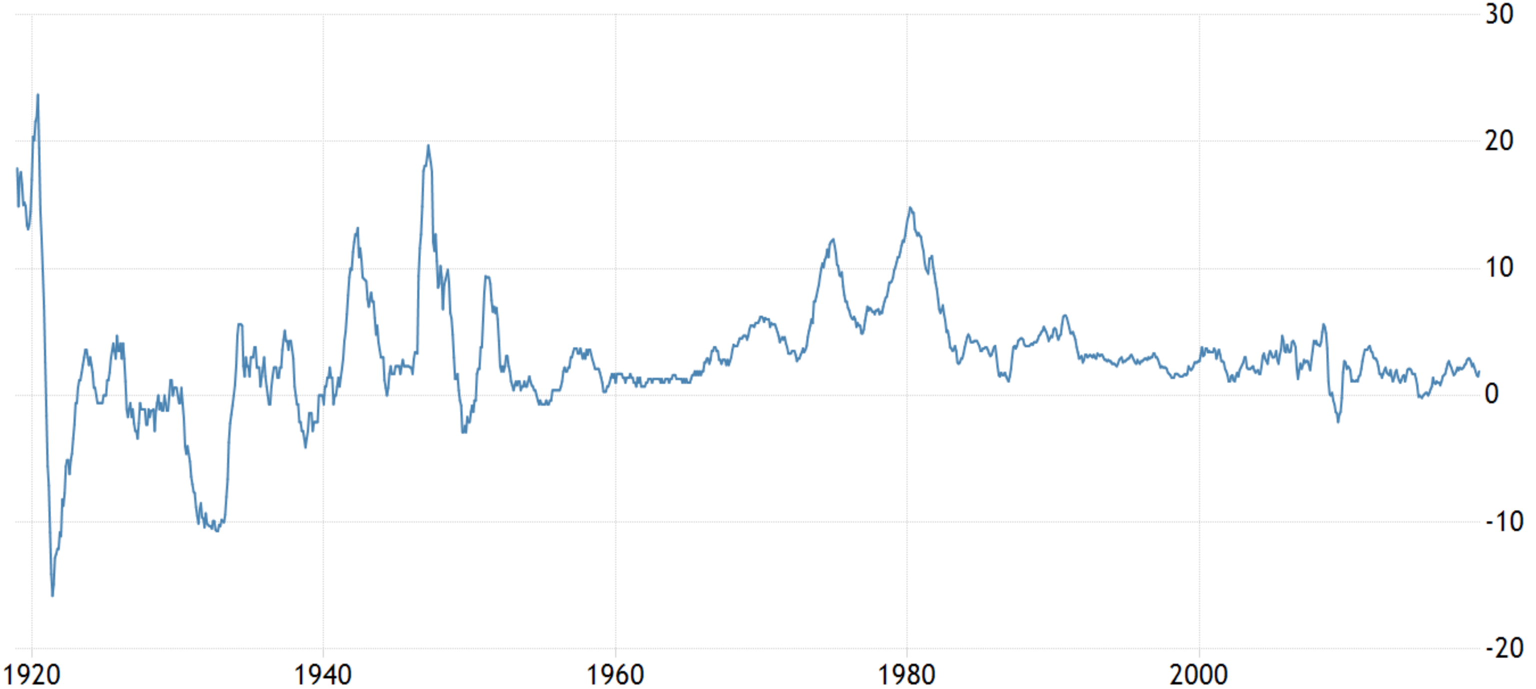
Inflation History



Note: **Before 1960** (when Phillips Curve was first discovered), inflation was positive in some years and negative in others, on average it was around zero.

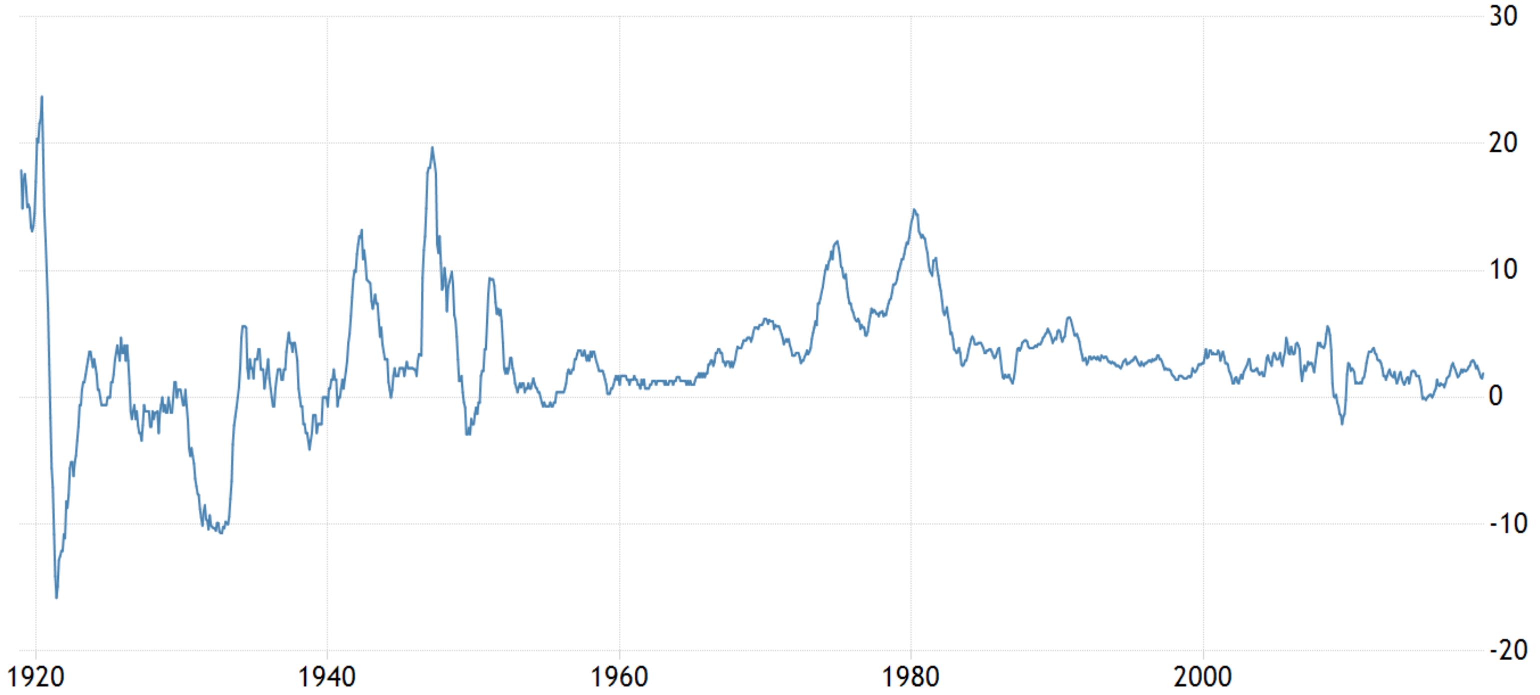
Phillips Curve

Inflation History



Note: **During the 70s** hit twice in the 1970s by **a substantial Increase in the price of oil**. Inflation, in general, maintained at a higher level.

Inflation History



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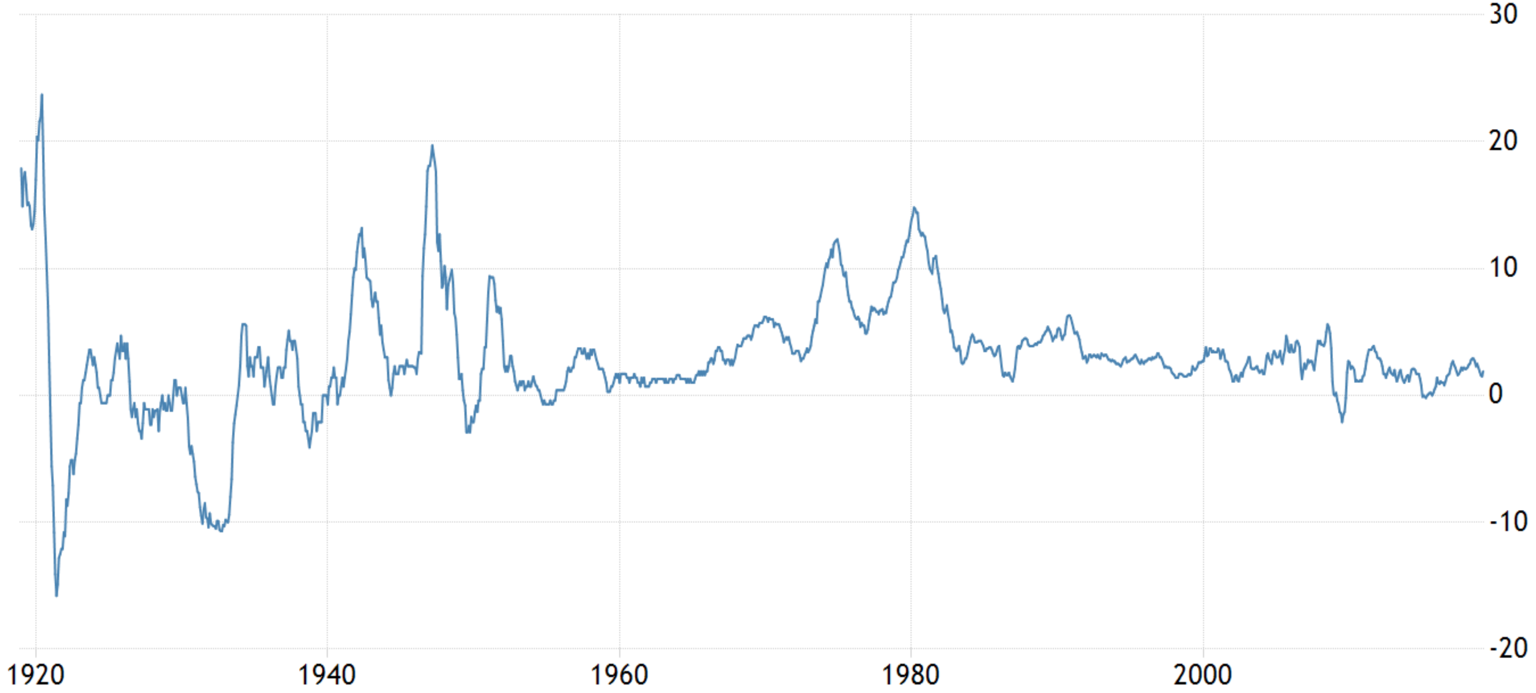
Phillips Curve

Inflation History



Note: **Since 1990** inflation, in general, has been **roughly stable at a lower level**. (Except for the year when great recession happened.)

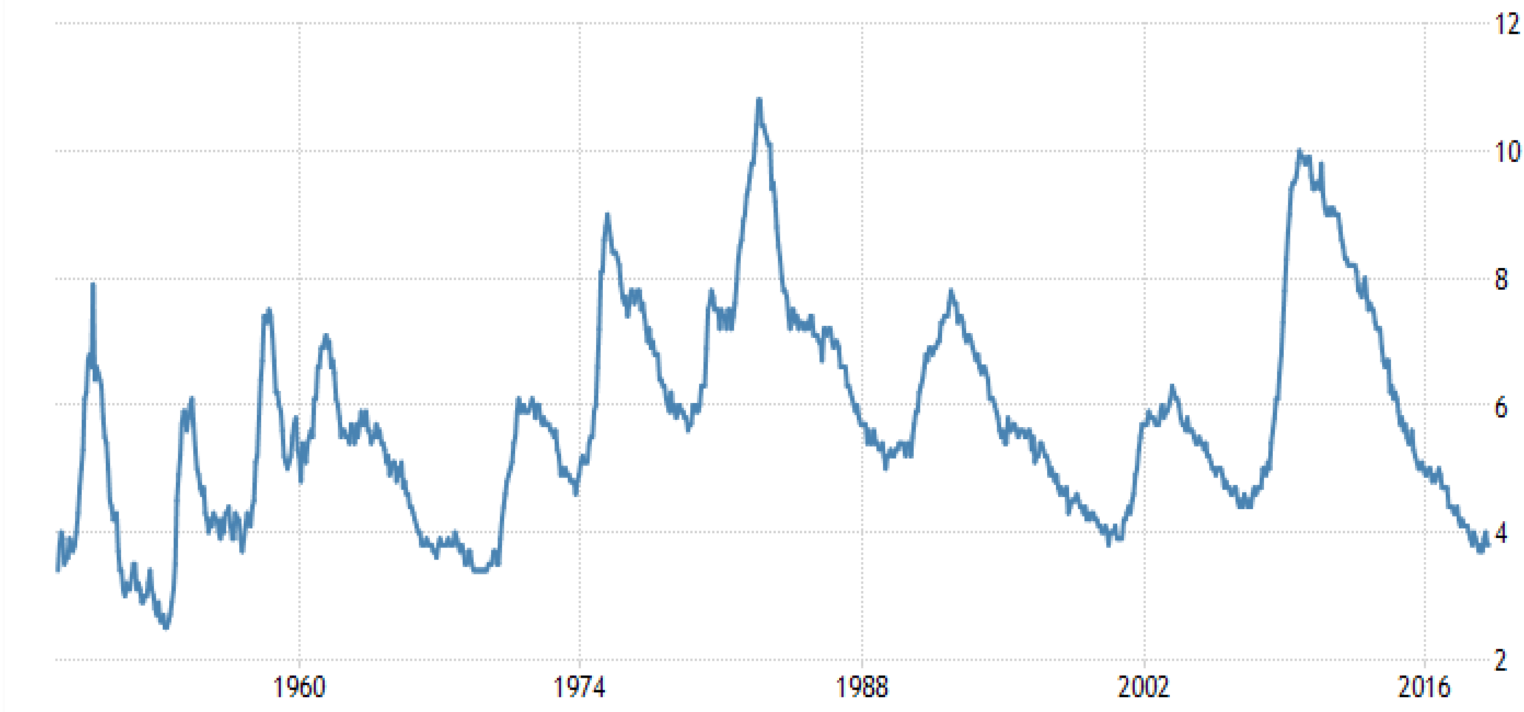
Inflation History

How do you think **people formed their expectations for inflation before the 60s**?

- **Before 1960** (when Phillips Curve was first discovered), inflation was positive in some years and negative in others, on average it was around zero.
- It is reasonable for people to expect that **inflation will be equal to zero over the next year** as well.

Phillips Curve

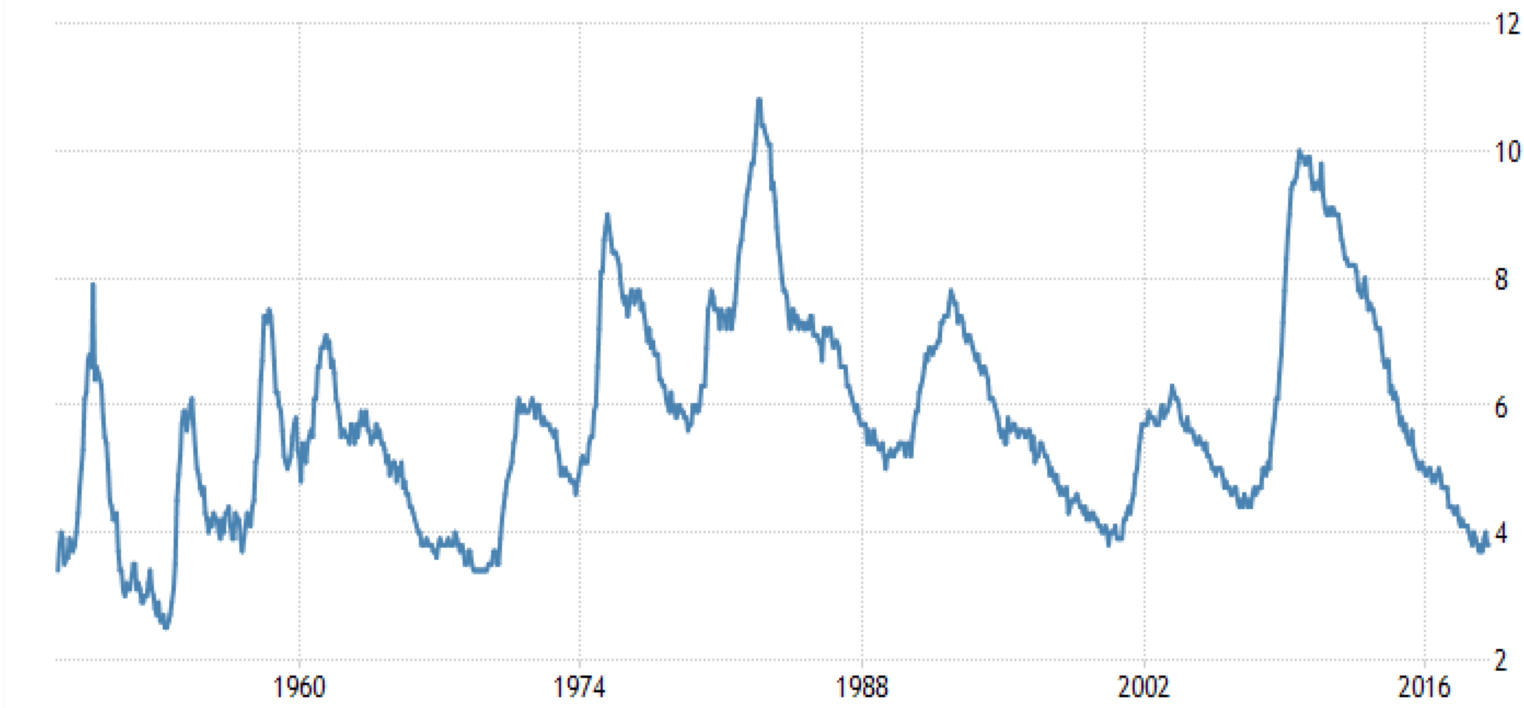
Unemployment History



Note: **During the 70s** hit twice in the 1970s by **a substantial Increase in the price of oil**. The unemployment rate increased.

Phillips Curve

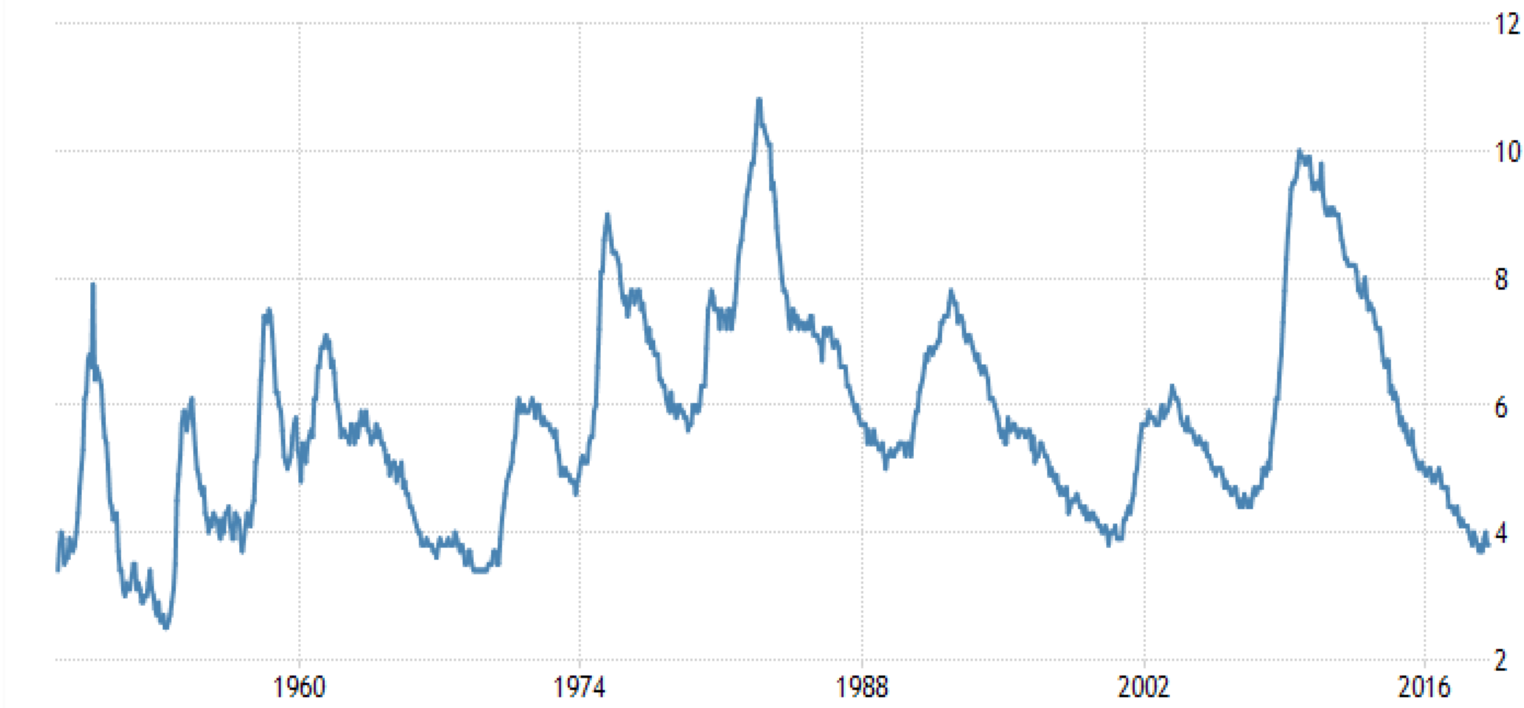
Unemployment History



Note: **In general**, we can see that there is a **business cycle** in terms of the unemployment rate.

Phillips Curve

Unemployment History



Note: **In general**, we can see that there is a **business cycle** in terms of the unemployment rate.

The Phillips Curve - Part 2

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Review

Review

Equation

In the last lecture, we derived **the Phillips Relation** from **the Labor Market Equilibrium**.

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

This Lecutre, we will use this Phillips Relation to explain the behavior of **inflation rate** and **unemployment rate** in the U.S. data. Specifically, we will discuss

- **the 60s and before**
- **the 70s and after**

Expectation Formation

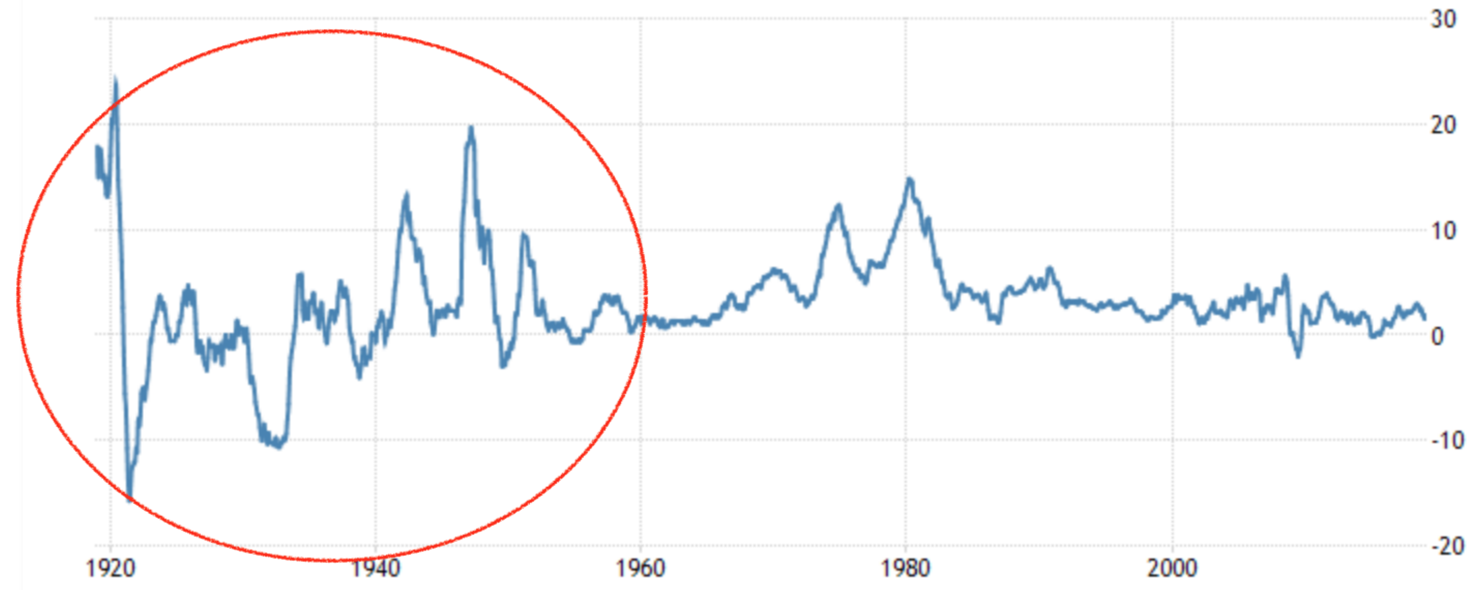
The Phillips Relation contains a term for inflation expectation. It is up to the modelers (us) to figure out how the expectation is formed. We mentioned that there are three types of expectation formations.

- **Static Expectations**
- **Adaptive Expectations**
- Rational Expectations (Not Required)

the 60s and before

the 60s and before

Inflation



- **Before 1960** inflation was positive in some years and negative in others, on average it was around zero.
- It is reasonable for people to **expect the inflation to be at the average level 0 next year**.

Inflation Expectation

Mathematically

$$\pi_t^e = 0$$

This can also be interpreted as:

People simply take **the expected price level** to be **last year's price level** $P_t^e = P_{t-1}$.

$$\pi_t^e = \frac{P_t^e - P_{t-1}}{P_{t-1}} = \frac{0}{P_{t-1}} = 0$$

Early Incarnation

Combining $\pi_t^e = 0$ with the **Phillips Relation**,

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

we get

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

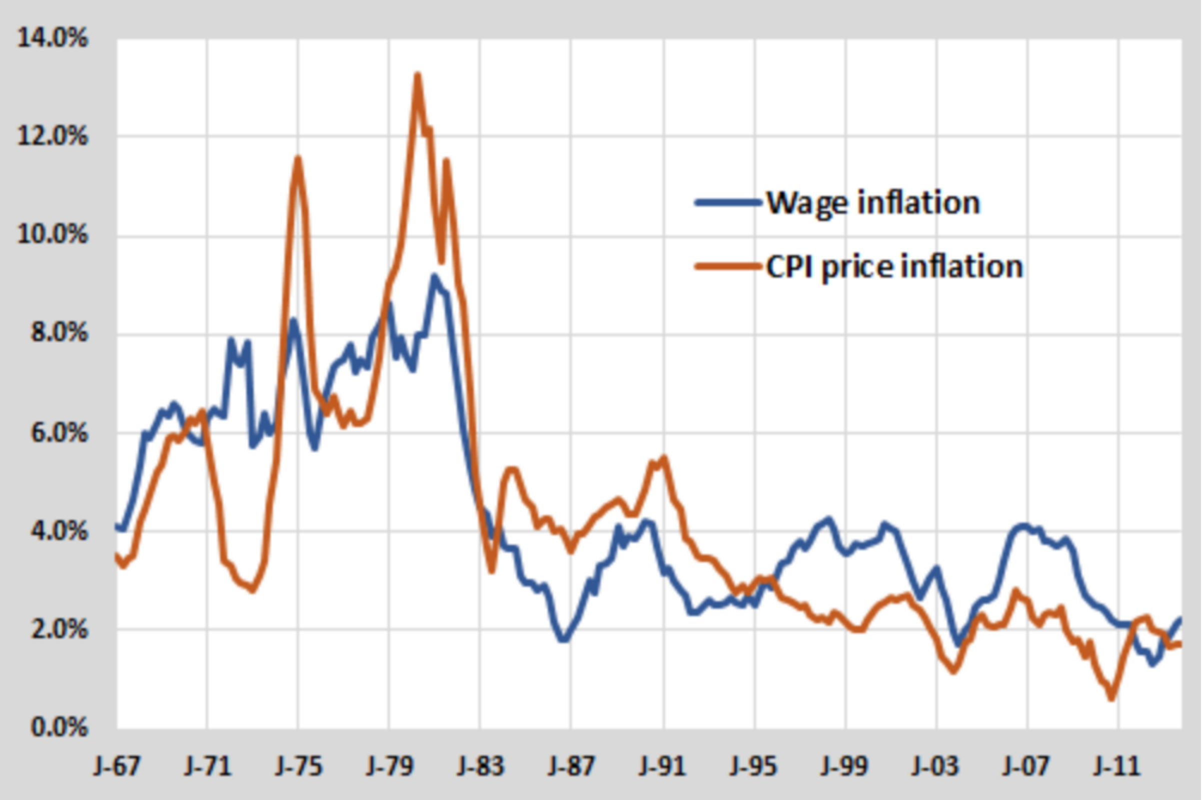
This equation above is called **the Early Incarnation of Phillips Curve**. It is also called **wage-price spiral**.

Wage-price Spiral

1. Low unemployment leads to **a higher nominal wage**.
2. In response to the higher nominal wage, **firms increase their prices**. The price level increases.
3. In response to the higher price level, **workers ask for a higher nominal wage** the next time the wage is set.
4. The higher nominal wage leads **firms to further increase their prices**. **Goes back to 2.**

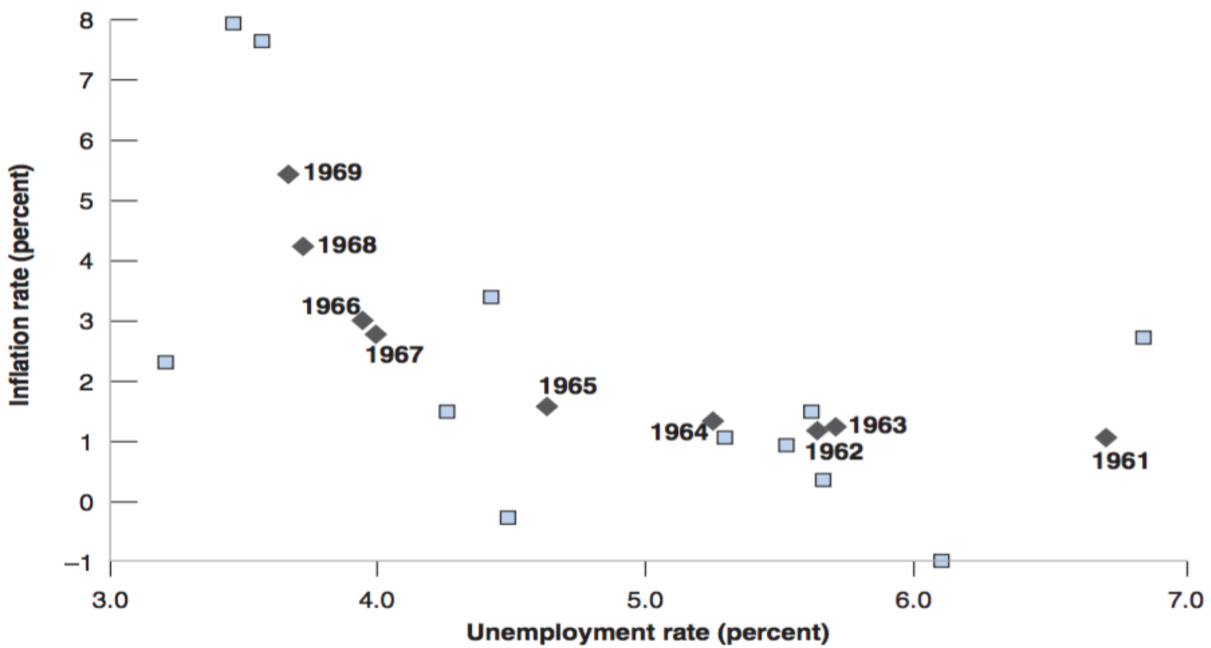
Wage-price Spiral

From the data, **Wage Inflation and CPI Price Inflation** are roughly aligned.



Theory Matches Data

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

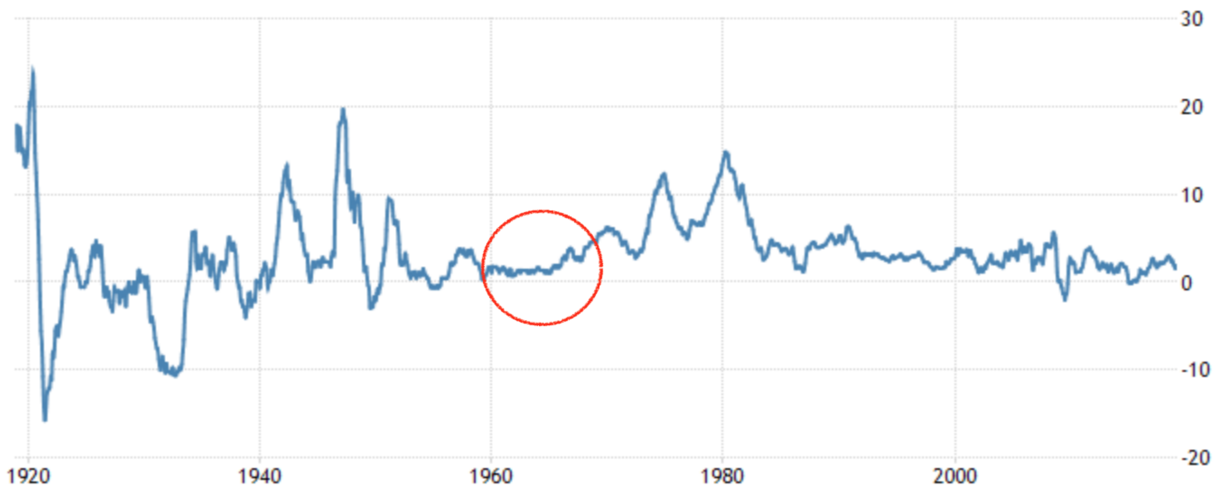


Static Expectation Revisited

Let's revisit our assumption about how expectation is formed:

$$\pi_t^e = 0$$

It says people expect the inflation rate to be zero. However, in the 60s, **the inflation rate was maintained above zero**.



Static Expectation Revisited

Q: **Would the static expectation formation still be a good assumption?**

A: **No!**

What are the alternatives?

1. $\pi_t^e = c$ and $c > 0$
2. $\pi_t^e = \theta \pi_{t-1}$

Alternative I

$$\pi_t^e = c, \text{where } c > 0$$

Combined with the **Phillips Relation**,

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

We would get

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

The **wage-price spiral** would still exist.

Alternative II: Adaptive Expectation

$$\pi_t^e = \theta \pi_{t-1}$$

Combined with the **Phillips Relation**,

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

We would get

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

We get a new negative relation between **the change in inflation rate** and **unemployment rate**.

Alternative II - Three Cases

We can study the second alternative in three different cases:

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

where

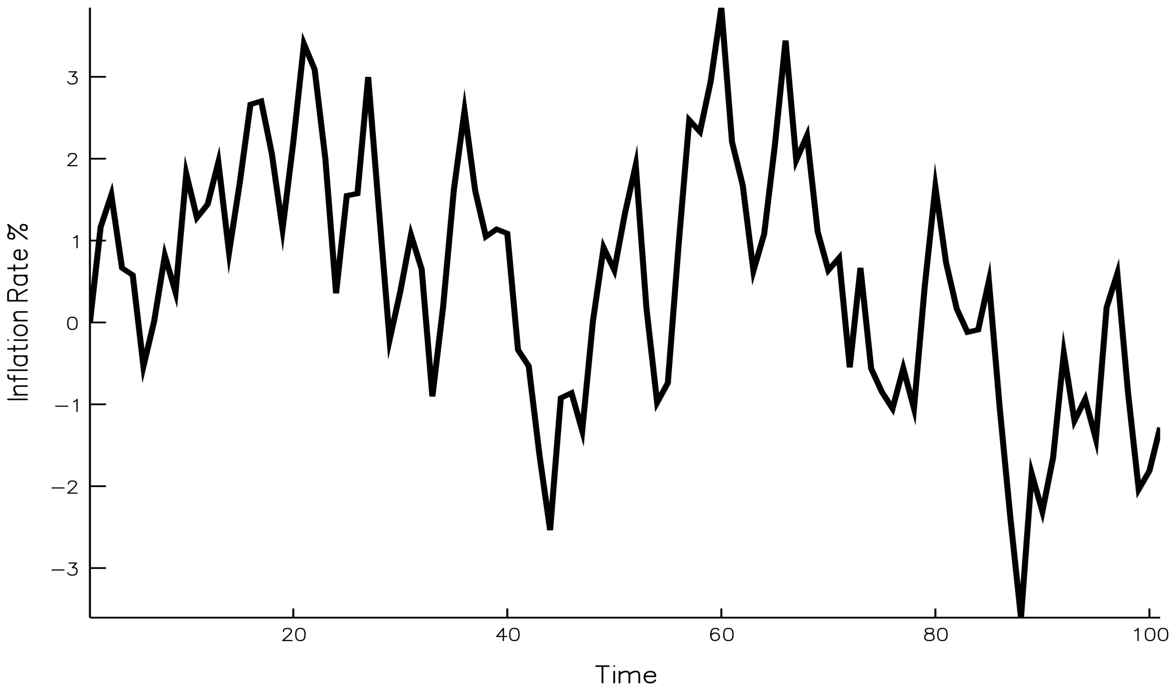
- $0 < \theta < 1$
- $\theta = 1$
- $\theta > 1$

The model-predicted inflation rates are drastically different depending on which case we are looking at.

Alternative II Case 1: $0 < \theta < 1$

Simulation with $0 < \theta < 1$ for

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

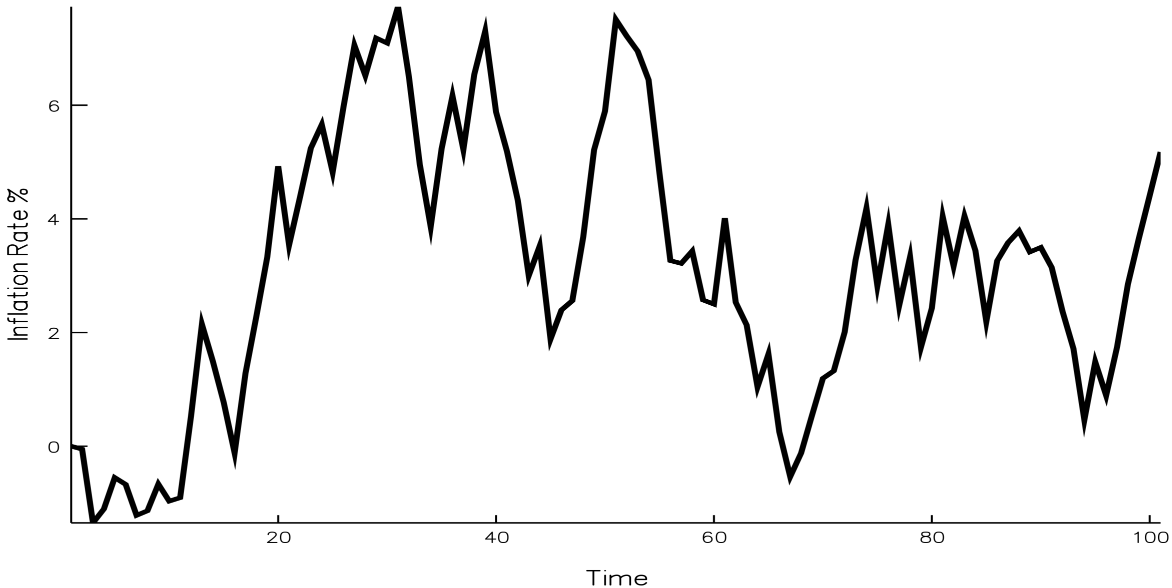


Alternative II Case 2: $\theta = 1$

This seems to be the case for the United States after the 60s!!

Simulation with $\theta = 1$ for

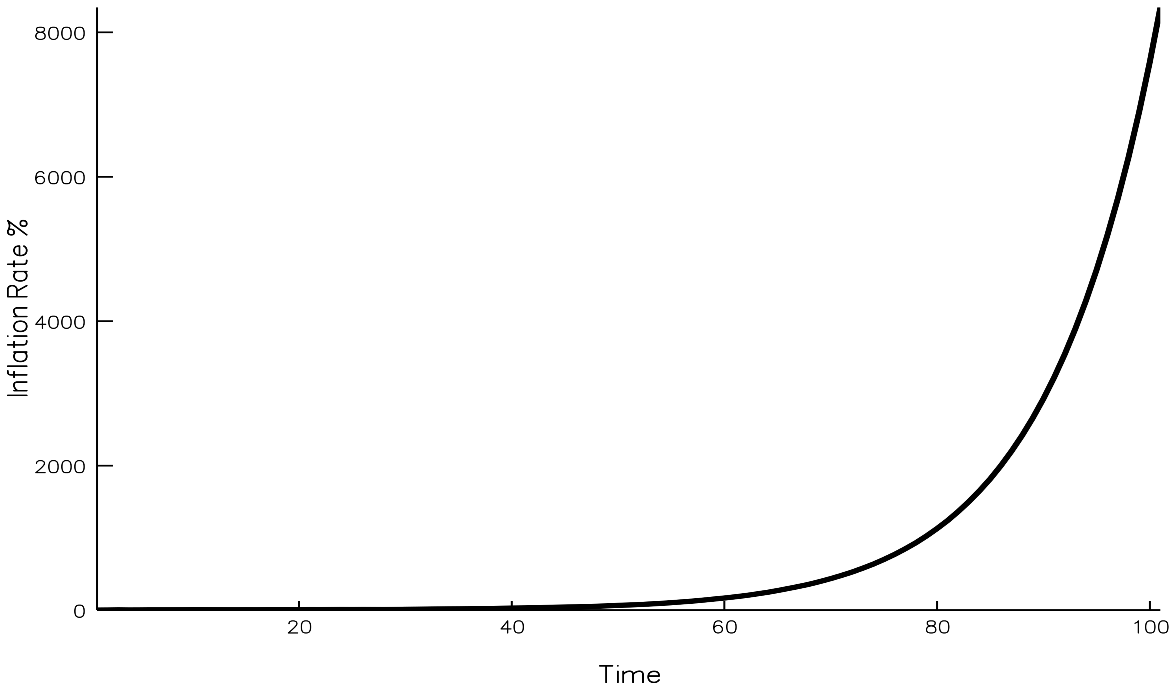
$$\pi_t = \theta\pi_{t-1} + (m+z) - \alpha u_t$$



Alternative II Case 3: $\theta > 1$

Simulation with $\theta > 1$ for

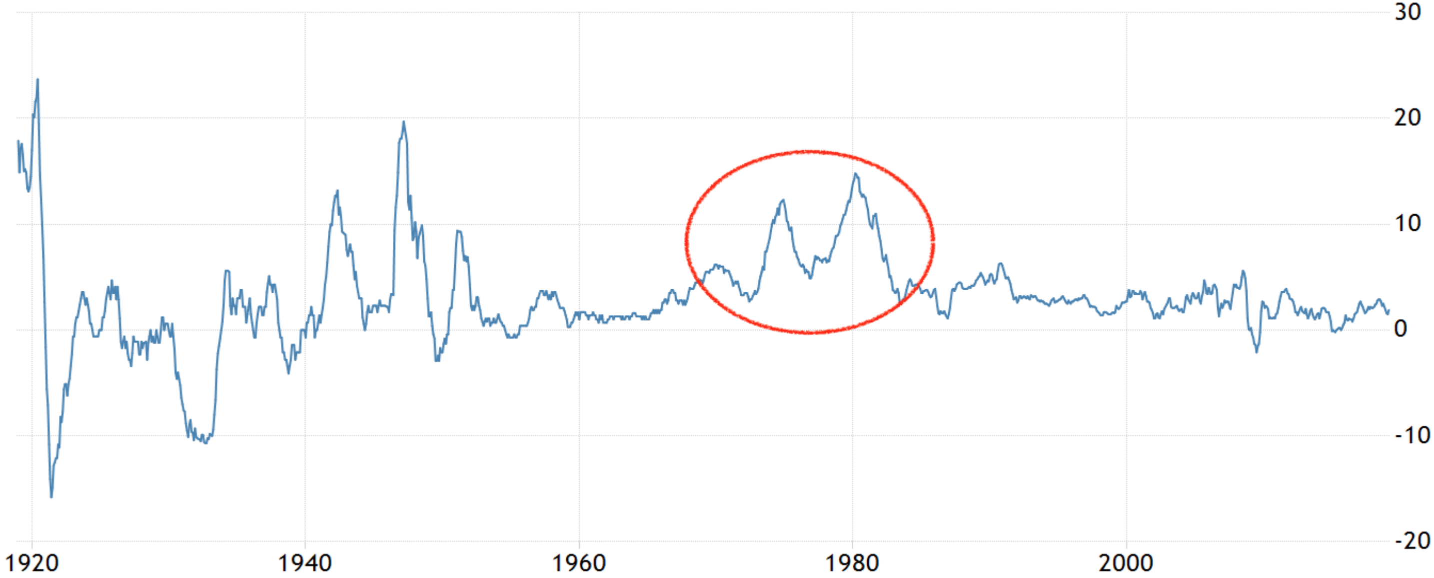
$$\pi_t = \theta \pi_{t-1} + (m + z) - \alpha u_t$$



the 70s and after

the 70s and after

Inflation



- Hit twice in the 1970s by **a large increase in the price of oil**.
- **Higher nonlabor costs** forced firms to increase their prices relative to the wages they were paying. **Or mark-up m increased**.

Inflation Expectation

Note that in the 60s, the inflation rate was maintained above zero. The **static expectation**

$$\pi_t^e = 0$$

can't hold any more. People would be making **persistent mistakes** using this expectation formaiton in the 60s. It is reasonable to think they changed the way they form expectations after the 60s.

Inflation Expectation

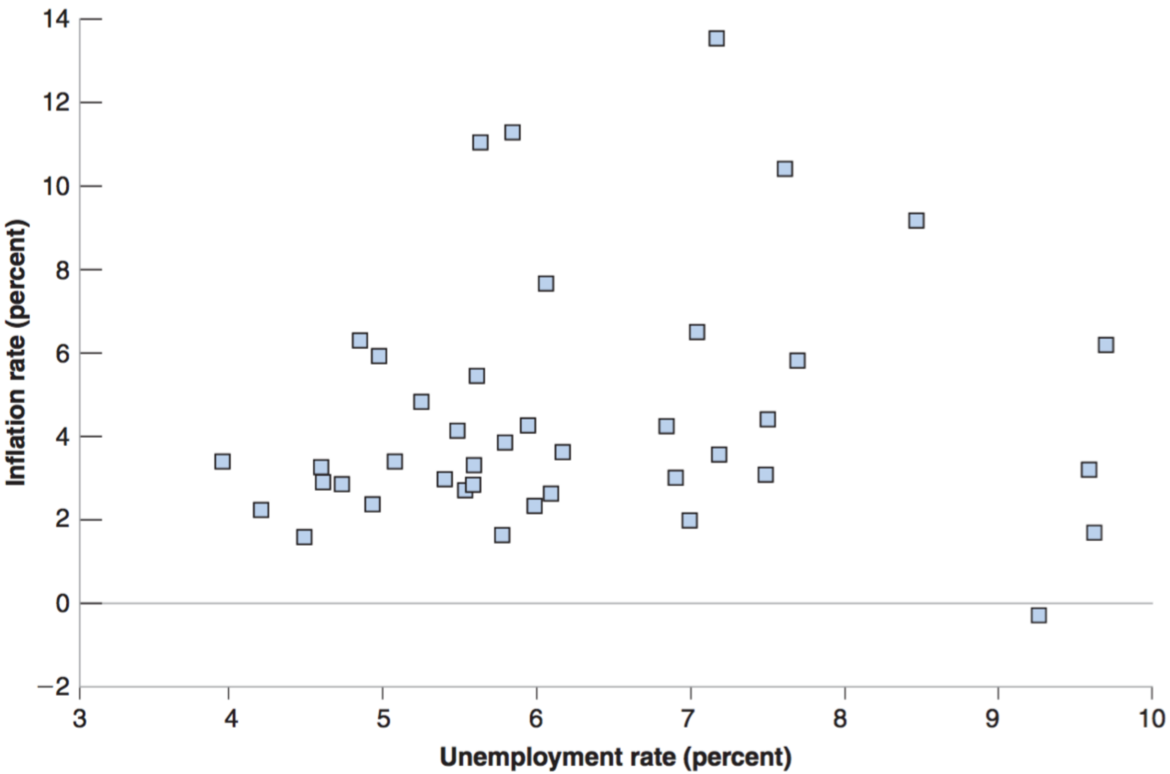
From the previous discussion, there are two possible alternatives:

1. $\pi_t^e = c, \text{where } c > 0$
2. $\pi_t^e = \pi_{t-1}$

Both would work in terms of matching the positive persistent inflation observed in the data. But which one makes more sense?

Inflation - Unemployment

There is **no correlation between the inflation rate and unemployment rate** from 1970 to 2010.



Alternative I

Alternative I $\pi_t^e = c$ would **still predicit that there is correlation between the inflation rate and unemployment rate** from 1970 to 2010:

Combine $\pi_t^e = c$ with the Phillips Relation

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

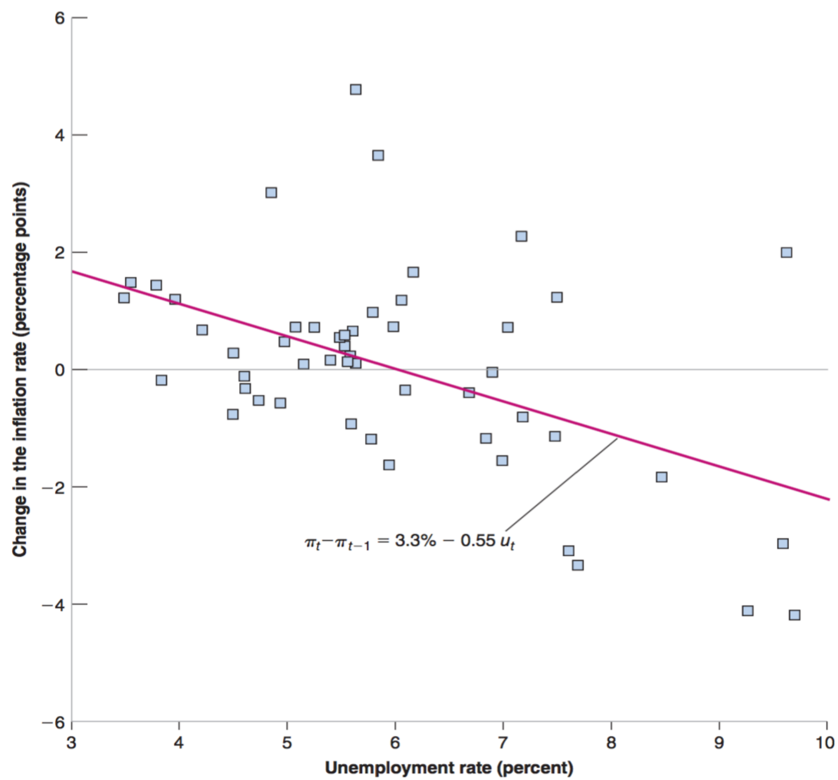
, we would get

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

Note that π_t and u_t would still be negatively correlated. Alternative I $\pi_t^e = c$ doesn't match the data.

Change in Inflation - Unemployment

There is correlation between **the change in inflation rate** and unemployment rate from 1970 to 2010.



Alternative II

Alternative II (case 2) $\pi_t^e = \pi_{t-1}$ would match this correlation between **the change in inflation rate** and unemployment rate from 1970 to 2010.

Combine $\pi_t^e = \pi_{t-1}$ with the Phillips Relation

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

, we would get

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

Note that **change in inflation**, $\pi_t - \pi_{t-1}$ and u_t would be negatively correlated. Alternative II $\pi_t^e = \pi_{t-1}$ matches the data.

Accelerationist Phillips Curve

Using a regression line to estimate the model implied by Alternative II, we get

$$\pi_t - \pi_{t-1} = 3.3\% - 0.55u_t$$

This Relation is also called **Accelerationist Phillips Curve**

Accelerationist Phillips Curve

One of the reasons why we want to figure out the Phillips Curve is because we can use it to predict inflation rate. Suppose the Accelerationist Phillips Curve holds in an economy:

$$\pi_t - \pi_{t-1} = 3.3\% - 0.55u_t$$

Let $\pi_{2017} = 2$, and unemployment rate for 2017 and 2018 are $u_{2018} = 4\%$ and $u_{2019} = 6\%$. What is the inflation rate in 2019 π_{2019}?

Contractionary Policies

Contractionary policies notably occurred in the early 1980s when the then-Federal Reserve chairman Paul Volcker finally **ended the soaring inflation of the 1970s**.

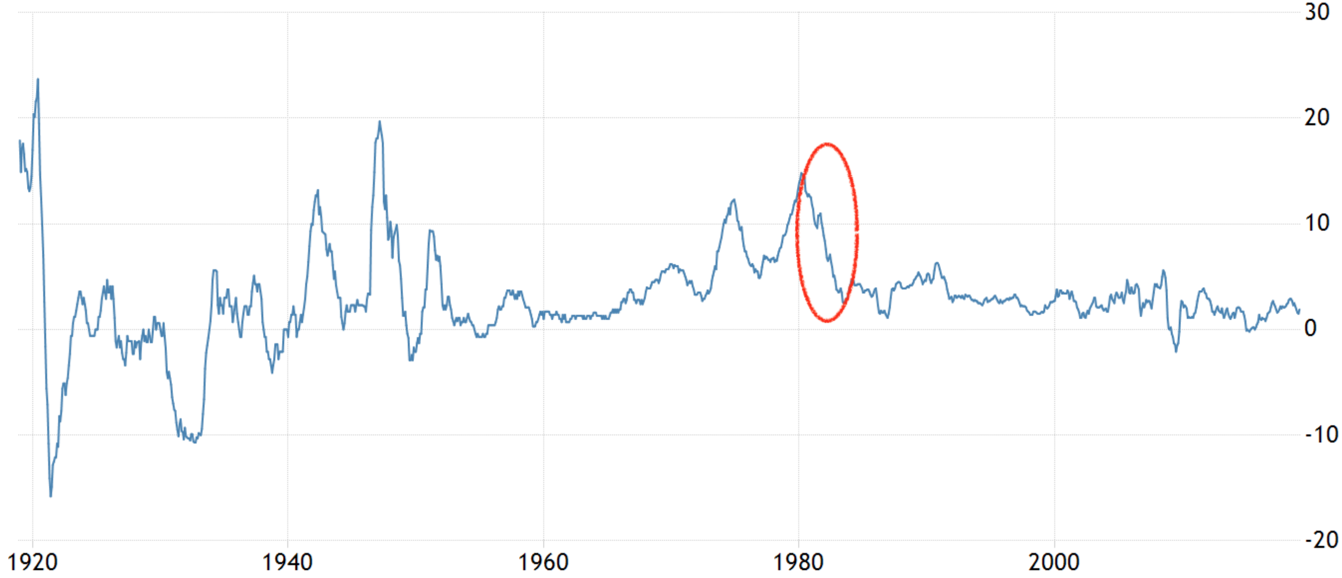
- Higher Tax and Lower Government Spending
- Less money supply (higher interest rate)

These two policies can be analyzed in the framework of IS-LM_PC model (Up next). The result is **lower output, higher unemployment rate, negative change in the inflation rate** (cool down the economy).

the 70s and after

Contractionary Policies

These two policies can be analyzed in the framework of ADAS model. The result is .lower output, higher unemployment rate, **negative change in the inflation rate** (cool down the economy).



Natural Rate of Unemployment

Natural Rate of Unemployment

Derive the Natural Rate of Unemployment

Recall that the natural rate of unemployment is the **Equilibrium Unemployment Rate from the Labor Market Model**.

The Labor Market Equilibrium can be written as

$$\begin{aligned} \text{WS}: W &= P^e F(u, z) \\ \text{PS}: P &= (1+m)W \\ F(u,z) &= 1 - \alpha u + z \end{aligned}$$

Or

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

Derive the Natural Rate of Unemployment

Let $P^e = P$, we have

$$1 = (1 + m)(1 - \alpha u_n + z) \approx 1 + m - \alpha u_n + z$$

We get

$$u_n = \frac{m + z}{\alpha}$$

Natural Rate of Unemployment

Rewrite the Phillips Relation

It is useful to rewrite the Phillips Relation in terms of the natural rate of unemployment.

$$\begin{aligned}
\pi_t &= \pi_t^e + (m+z) - \alpha u_t \\
\pi_t &= \pi_t^e + \alpha \frac{(m+z)}{\alpha} - \alpha u_t \\
\pi_t &= \pi_t^e + \alpha u_n - \alpha u_t \\
\pi_t &= \pi_t^e - \alpha(u_t - u_n) \\
\pi_t - \pi_t^e &= -\alpha(u_t - u_n)
\end{aligned}$$

Natural Rate of Unemployment

Rewrite the Phillips Relation

Static Expectation with $\pi_t^e = 0$:

$$\pi_t = -\alpha(u_t - u_n)$$

Adaptive Expectation with $\pi_t^e = \pi_{t-1}$:

$$\pi_t - \pi_{t-1} = -\alpha(u_t - u_n)$$

Natural Rate of Unemployment

Change Since the 80s

The natural rate of unemployment

$$u_n = \frac{m + z}{\alpha}$$

It appeared that the natural rate was around 5%, so roughly 2% lower than it had been in the 1980s.

Natural Rate of Unemployment

Questions

Suppose the natural rate of unemployment is 5%. This year the unemployment rate is 6%. The last year the inflation rate is 2%. $F(u, z) = 1 - \alpha u + z$ where $\alpha = -0.5$.

Q1: If the expectation formation is $\pi_t^e = 0$, what is this year's inflation rate?

Q2: If the expectation formation is $\pi_t^e = \pi_{t-1}$, what is this year's inflation rate?

Natural Rate of Unemployment

Questions

Q1: If the expectation formation is $\pi_t^e = 0$, what is this year's inflation rate?

A1: If the expectation formation is $\pi_t^e = 0$, the Phillips Relation can be written in terms of the natural rate of unemployment.

$$\pi_t = -\alpha(u_t - u_n) = -0.5(6\% - 5\%) = -0.5\%$$

Questions

Q2: If the expectation formation is $\pi_t^e = \pi_{t-1}$, what is this year's inflation rate?

A1: If the expectation formation is $\pi_t^e = \pi_{t-1}$, the Phillips Relation can be written in terms of the natural rate of unemployment.

$$\pi_t - \pi_{t-1} = -\alpha(u_t - u_n) = -0.5(6\% - 5\%) = -0.5\%$$

and

$$\pi_{t-1} = 2\%$$

then

$$\pi_t = 2\% - 0.5\% = 1.5\%$$

Natural Rate of Unemployment

The Great Depression

Let's use the Static Expectation Formation for Great Depression (1930s), the Phillips Curve can be written as

$$\pi_t = -\alpha(u_t - u_n)$$

Question: During the great depression, we see a very high u_t, but also we see a large deflation $\pi_t < 0$. How do we explain this?