Aggregate Supply Curve and Phillips Curve

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Roadmap

- Aggregate Supply Curve

- Phillips Curve

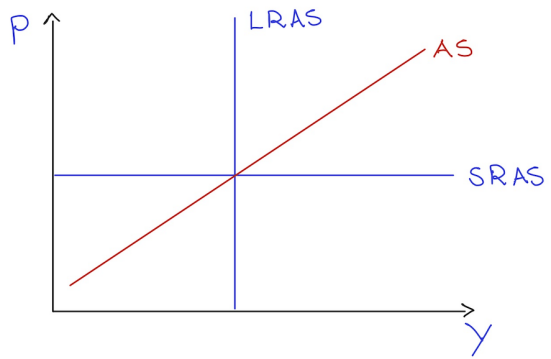
Aggregate Supply Curve

So far we have studied two extreme cases of the aggregate supply curve:

- Sticky Price Model (Keynesian Approach):
  - Prices are fixed in the short-run
  - The aggregate supply curve is horizontal.

- Flexible Price Model (Classical Approach):
  - Prices are flexible in the long-run
  - The aggregate supply curve is vertical.

We will now study an in between case: the aggregate supply curve is upward sloping!



Aggregate Supply Curve

What is the story behind the upward sloping aggregate supply curve?

This is a consequence of a model of imperfect information.

- There are many firms (suppliers) in the economy and each firm produces a single good.
- The number of goods is very large, so suppliers can't observe all prices in the economy at all times. (imperfect information)
- They pay close attention to the price of their own good, but not to the price of other goods.
- As a result, they might confuse a change in the overall level of prices with changes in relative prices.
- But why does a supplier need to know the overall price level?

Aggregate Supply Curve

Let's consider the decision of a tomato producer on how many tomatoes to produce.

She only sells tomatoes, but buy the goods from other suppliers.

If the tomato price increases, relative to the price of other goods, the producer will be motivated to work harder and produce more tomatoes.

But if the tomato price increase because all the prices in the economy are increasing, this should not change the decision of how many tomatoes to produce.

The problem: the producer can't keep track of all prices in the economy. She must rely on an estimate of the overall price level.

Then, the producer will produce more tomatoes if she believes the price of tomatoes has increased, relatively to her estimate of the overall price level.

This process is valid for all producers in the economy!

Aggregate Supply Curve

If we aggregate the decisions of all producers in the economy, then the output in the economy responds to unexpected changes in the price level.

This model implies the following aggregate supply curve:

$$Y = \bar{Y} + \alpha \cdot (P - P^e)$$

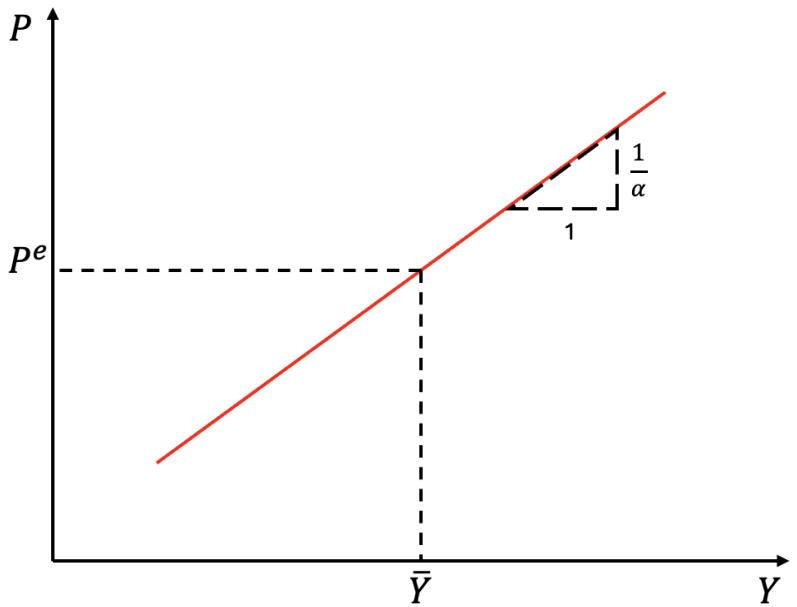
where:

- Y is the output in the economy.
- $\bar{Y}$ is the natural level of output.
- P is the price level.
- P^e is the expected price level.
- α is a parameter that measures how much output responds to unexpected changes in the price level.
  - The slope of the aggregate supply curve is $1/\alpha$.

Aggregate Supply Curve

$$Y = \bar{Y} + \alpha \cdot (P - P^e) \implies$$

$$\boxed{P = P^e + \frac{1}{\alpha}(Y - \bar{Y})}$$



Output deviates from the natural level when the price level deviates from the expected price level!

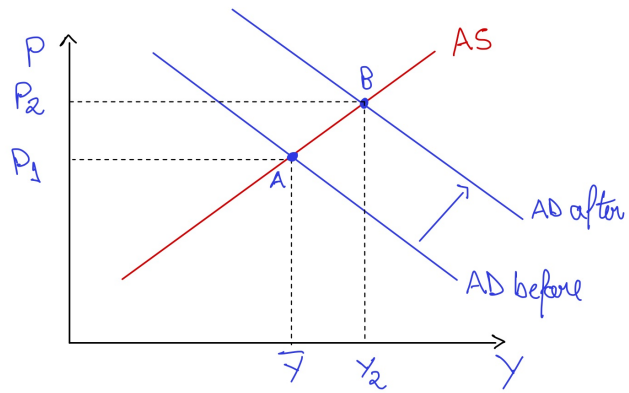
Monetary Expansion Analysis

The aggregate supply curve (AS) combined with the aggregate demand curve (AD) is a powerful tool to analyze the economy.

We refer to it as the AD-AS model.

We will use the AD-AS model to analyze the effects of a monetary expansion:

- Suppose, initially the economy has output equal to the natural level (Point A)
- The Central Bank then increases the money supply, shifting the aggregate demand curve to the right.
- The result is an increase in output and in the price level, moving the economy to point B.



Monetary Expansion Analysis

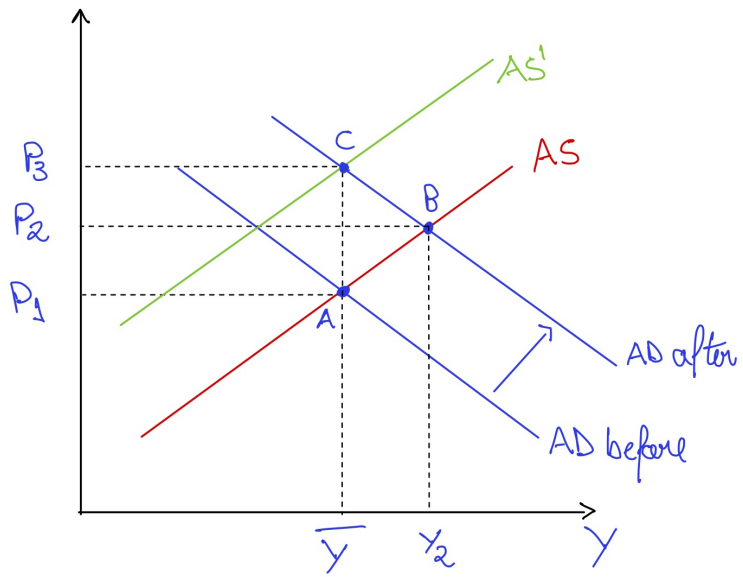
But now, the price level is higher than expected.

Over time, people will adjust their expectations, leading to an increase in the expected price level!

As a result, the aggregate supply curve will shift up.

The new equilibrium will be at point C.

The output returns to the natural level, but the price level is higher!



Monetary Expansion Analysis

Note that this model is consistent with the long-run neutrality of money and the short run non-neutrality of money!

The short-run non-neutrality of money is represented by the movement from point A to point B!

- Output increases in the short-run, as a result from the monetary expansion.

The long-run neutrality of money is represented by the movement from point A to point C!

- Nominal variables (M) do not affect real variables (Y)!

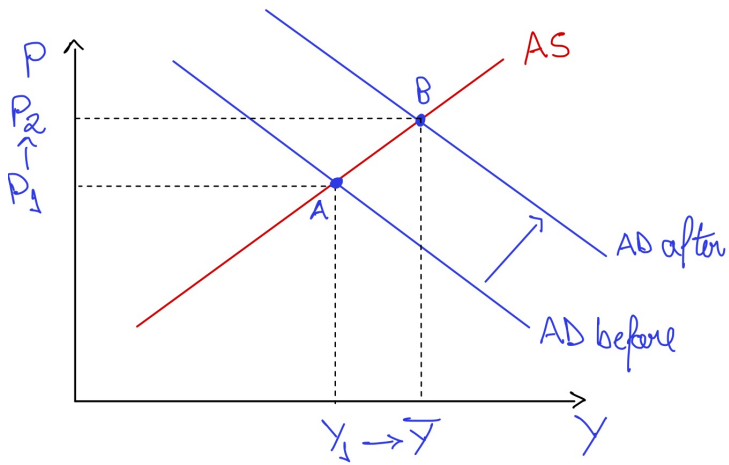
Inflation and Unemployment - The trade-off

We would love to live in a world with low inflation and low unemployment!

However, the AD-AS model tells us that there is a trade-off between inflation and unemployment.

Let's consider the following scenario:

- The economy is below the natural level of output. (Point A)
- Lower output, means higher unemployment, since firms need fewer workers to produce less output.
- The government decides to increase the money supply, to bring the economy back to the natural level of output.
- The economy moves to point B.
- Unemployment decreases, but the price level increases!



Phillips Curve

The Phillips Curve describes the trade-off between inflation and unemployment in the short-run!

The Phillips curve in its modern form is given by:

$$\pi = E\pi - \beta \cdot (u - u^n) + v$$

where:

- π is the inflation rate.
- $E\pi$ is the expected inflation rate.
- $\beta > 0$ measures how much inflation responds to unexpected changes in unemployment.
- u is the unemployment rate.
- u^n is the natural rate of unemployment.
- v represents supply shocks.

Phillips Curve

The inflation rate depends on three forces:

- Expected inflation rate: $E\pi$
- Cyclical unemployment: the difference between the actual and the natural rate of unemployment: $u - u^n$.
- Supply shocks: v

Supply shocks represent exogenous events that shift the aggregate supply curve. Some examples:

- Change in world oil prices in the 1970s, due to OPEC.
- Natural disasters.
- Covid-19 pandemic: supply chain disruptions.

The Phillips Curve can be derived from our aggregate supply curve.

In reality, both are different sides of the same coin!

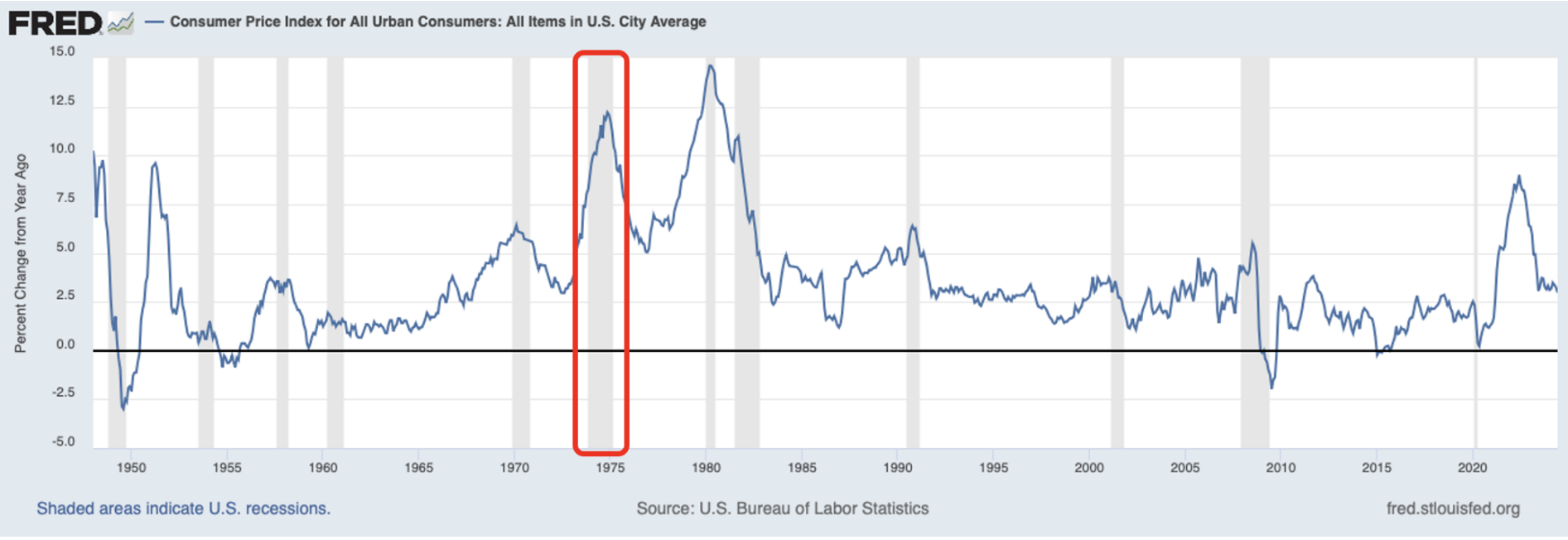
Phillips Curve

The Phillips curve predicts that, in the absence of supply shocks, unemployment is related to unexpected changes in inflation.

- If the unemployment rate is below the natural rate,inflation will be higher than expected. $u < u^n \iff \pi > E\pi$
- If the unemployment rate is above the natural rate, inflation will be lower than expected. $u > u^n \iff \pi < E\pi$

Then, we should expect that inflation would decrease during recessions. Is that the case?

Phillips Curve



It seems to be true, generally!

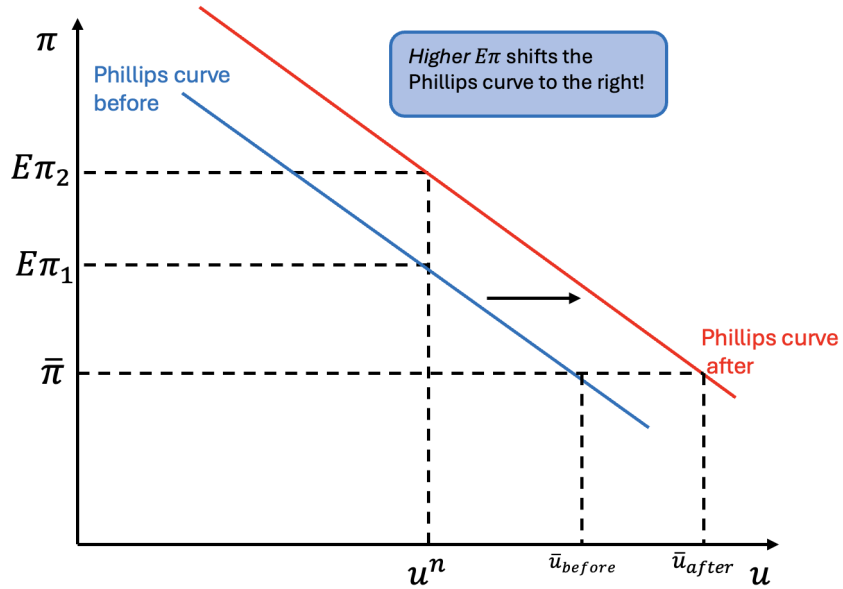
However, in the 1970s, we observe high inflation during a recession. Why?

- Supply shocks!
- The oil crisis in the 1970s led to a sharp increase in oil prices, leading to stagflation (high inflation and high unemployment).

The role of expectations

One of the forces that determine inflation is the expected inflation rate. This is really important.

A higher expected inflation means a shift in the Phillips curve.



If a policymaker wants to bring inflation down to $\bar{\pi}$, the amount of unemployment needed is higher, $\bar{u}_{after} > \bar{u}_{before}$, when expected inflation is higher!

Fighting inflation is more painful!

Adaptive Expectations

We will now take a look at how expectations are formed.

We will consider two different theories:

- Adaptive expectations:
  - We look at past inflation to form our expectations.
  - Backward-looking expectations.

- Rational expectations:
  - We use all available information to form our expectations.
  - Forward-looking expectations.

Each theory has different implications for the Phillips curve.

Adaptive Expectations

A simple and often plausible assumption is that people form their expectations based on recently observed inflation.

This is called adaptive expectations.

One form: people expect prices to increase at the same rate as they did in the past year:

$$\boxed{E\pi = \pi_{-1}}$$

The Phillips curve becomes:

$$\boxed{\pi = \pi_{-1} - \beta(u - u^n) + v}$$

Inflation depends on:

- The inflation rate last year.
- Cyclical unemployment.
- Supply shocks.

Adaptive Expectations

With adaptive expectations, we also refer to u^n as the nonaccelerating inflation rate of unemployment (NAIRU). Why?

- In the absence of supply shocks, if $u = u^n$ then inflation today will be equal to inflation last year.
- Inflation has inertia: inflation keeps going unless something changes.

Robert Solow when writing about high inflation in the 1970s:

> *Why is our money ever less valuable? Perhaps it is simply that we have inflation because we expect inflation, and we expect inflation because we've had it.*

Rational Expectations

The assumption of adaptive expectations is plausible, but it may be too simple.

A more sophisticated assumption is people have rational expectations.

- They use all available information to form their expectations.
- This includes information about the economy, government policy, and other factors.

A change in monetary or fiscal policy will lead to a change in expectations!

- Therefore, the policymaker needs to be aware of how people form their expectations when evaluating the effects of the policy.

A consequence of rational expectations is that inflation might be less inertial than with adaptive expectations.

- Fighting inflation might be less painful!

Let's see this through an example.

Rational Expectations

Example. Suppose current inflation is 5% and the central bank announces that it will reduce the money supply to bring inflation down to 2% next year. The Phillips curve is given by $\pi = E\pi - 2 \cdot (u - u^n)$.

1. Assume, people have rational expectations and believe the central bank will do what it says. As a result, they expect inflation to be 2% next year. How much cyclical unemployment is needed to bring inflation down to 2%? *Answer*: *Z-E-R-O*!
2. Assume, people have adaptive expectations and believe inflation will be 5% next year. How much cyclical unemployment is needed to bring inflation down to 2%? *Answer*: 1.5%!

This example also shows the importance of the credibility of the central bank:

- If people believe the central bank will do what it says, then the central bank can achieve its goals with less pain!

How can we be more precise about how painful it is to fight inflation? The sacrifice ratio!

Sacrifice Ratio

Sacrifice Ratio: the percentage change of a year's real GDP that must be forgone to reduce inflation by 1 percentage point:

$$\text{Sacrifice Ratio} = \frac{\text{Percentage change in output}}{\text{Percentage point change in inflation}} = \frac{\Delta Y/Y}{\Delta \pi}$$

How can we calculate it?

We can use the Phillips curve together with a slightly different form of Okun's law:

$$\frac{Y_t - \bar{Y}}{\bar{Y}} = -2 \cdot (u_t - u^n)$$

where:

- Y_t is the output in year t.
- $\bar{Y}$ is the natural level of output.
- u_t is the unemployment rate in year t.
- u^n is the natural rate of unemployment.

Sacrifice Ratio

The sacrifice ratio is always a positive number.

Remember that the Phillips curve tells you that usually, in order to bring inflation down, you need to increase unemployment.

The Okun's law tells you that an increase in unemployment means a decrease in output.

Therefore, $\Delta\pi$, the change in inflation in percentage points, and $\Delta Y/Y$, the percentage change in output, have the same signs!

$$\Delta\pi < 0 \implies \Delta Y/Y < 0 \implies \text{Sacrifice Ratio} > 0$$

Sacrifice Ratio

We first use the Phillips curve to find what is the cyclical unemployment needed to reduce inflation by $\Delta\pi$.

Then, we use the Okun's law to find the percentage change in output.

Finally, we divide the percentage change in output by the change in percentage points in inflation.

Example: Suppose the Phillips curve is given by $\pi = E\pi - 2 \cdot (u - u^n)$ and the Okun's law is given by $\frac{Y_t - \bar{Y}}{\bar{Y}} = -2 \cdot (u_t - u^n)$. Inflation today is 5% and output is equal to the natural level. Suppose the central bank wants to reduce inflation to 2%. The expected inflation is 5%. What is the sacrifice ratio? *Answer*: 1